

# **THE IMPACTS OF HUMAN SETTLEMENTS ON DRY LANDS ENVIRONMENT: A CASE STUDY OF LORROKI PLATEAU IN SAMBURU DISTRICT**

**By**

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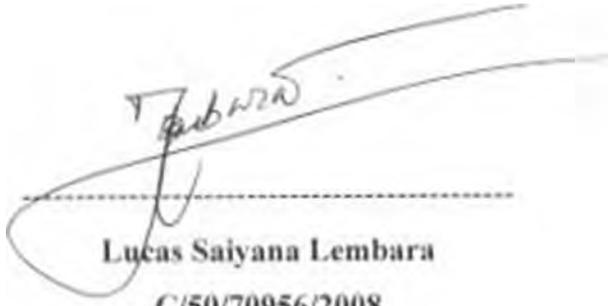
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## DECLARATION

This research is my original work and has not been presented for a degree in any university

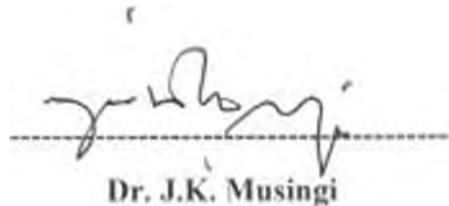
  
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This research project has been submitted for examination with our approval as University supervisors.

  
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## **Abstract.**

Natural factors like frequent droughts as consequence of weather variability bring about vegetation change. Ecosystems are only capable to recover from such perturbations, if human activities are controlled and sustainable utilization of natural resources is adopted. Vegetation changes, as a result of human orchestrated land uses that bring about permanent settlement, regular and concentration of human population in one location. Lorroki plateau is not inimitable from such perturbations. Such perturbations have had negative impacts to the local livelihoods, affecting the food security situation, access to water, pasture and occasionally causing natural resource base conflicts, due to competition. The objective of the study was to identify and describe the impacts of human settlement on the dry land environment of Lorroki plateau, and draw the appropriate recommendations for sound policies and decision making.

Ten settlements adjacent to the western part of Lorroki forest reserve were sampled. Multistage sampling technique was used that included: interviewing ten households per settlement, one focus group discussion per settlement, and sixty quadrant plots measuring 100x100m within the settled and control area were developed. Inventory of cedar and olive trees taken plus the measurements of diameters at breast height (DBH) for the two tree species within the plots, Soils samples from each plot were collected and delivered to soil labs Kabete for complete analysis. Data analysis was done by use of SPSS and MS-EXCEL sheets that enabled quantitative and qualitative statistical techniques. Research findings revealed that human activities around the settlements have had negative impacts to the environment and most importantly the vegetation cover, where cedar and olive tree species were found to be the most endangered among the other biological resources. Deforestation of the two tree species were 16% higher around the human settlements as compared to the control area. Correlation analysis indicates strong positive correlation between the DBH and soils organic matter while the regression is non-linear. Deficiencies in soil macro-nutrients including nitrogen, potassium, and phosphorus were observed, more evidently around the human settlements.

In conclusion human settlement continues to impact negatively on Lorroki ecosystem, confirming the Malthusian theory on population and land use. The research recommends the need to mainstream environmental management strategies into the development process in Lorroki plateau. Promotion of sustainable utilization of natural resources is of paramount importance, in reversing the current utilization patterns.

## ACRONYMS.

- ALRMP:** Arid lands resource management Project
- ASAL:** Arid and Semi Arid lands
- AWF:** African wildlife foundation
- CAP:** Community action plans
- CBS:** Central bureau of statistics
- CDF:** Consistency development fund
- DAO:** District Agricultural officer
- DBH:** Diameter at breast height
- DDC:** District Development committee
- DDP:** District development plan
- DEC:** District environment committee
- DFID:** Department for international development
- DPC:** District peace committee
- DSG:** District steering group
- ITDG:** Intermediate technology development Group
- KFSSG:** Kenya food security steering group
- KVDA:** Kerio Valley development Authority
- NRT:** Northern Rangeland Trust
- SOE:** State of environment
- SWF:** Samburu Wildlife forum
- SWOT:** Strength, Weakness, Opportunity, and Threats
- UNDP:** United Nations development program

# CHAPTER ONE: INTRODUCTION

## 1.0 Introduction

Chapter one gives an insight on basic information regarding pastoral livelihood, and general transformation witnessed affecting the pastoral livelihoods in Lorroki plateau. The chapter highlights key information to the dynamics of the study. Clear understanding on general changes in terms of socio-economic and environmental trends forms the basis for research. Basic information regarding the transitions experienced by the pastoral livelihood over time is equally important to provide in depth and the scope of current human activities in the study area and their interaction with the environment. Planning and implementation of developmental activities calls for integrated developmental approaches that embrace on the pillars of sustainable development that include, socio-cultural, economic, and environmental concerns.

## 1.1 Background to the study

Pastoralism as a production system has been facing various challenges globally due to transformations that have been taking place since 1950s, when green revolution development started. Enhanced livestock productions systems achieved through technological advances replaced traditional livestock production systems. In developed countries, pastoralism was replaced by intensive production systems that optimize production inputs for maximum returns. Pastoralism has been under criticism and perceived as unsustainable system where herders roam from one place to another in search of pastures. In several attempts, pastoralists were confined to one place to graze their livestock (*Levy, 1983*).

Government's policies worked against the production system suppressing its traditional functional management practices. Increase in human populations that led to changes in land use patterns as a result of human settlement, Agriculture, and many other economic activities thus influenced land uses (*Fratkin, 1997*). Pastoralism has been a livelihood practice among the Aromanians of Balkans, Bedouin of North Africa, Arabian Peninsula, Dhangars of India, Kuchis of Afghanistan, Maasai of East Africa, Navajo of North America, Sarakatsani of Greece, Somalis of the Horn of Africa, Tuvans of Mongolia, Yörük of Turkey, Gaddis of Himachal Pradesh, Raikas of TamilNadu, Tuareg of the west-central Sahara, Fula people of Sahelian West Africa, Toubou of Niger and Chad among others (*Lees and Bates, 1974*).

In developing countries, particularly in Africa, land available for pastoralism has been shrinking due to emerging diversity of economic activities, and compounded by increase in human population. Delineation and opening up of wetlands in the rangelands for crop cultivation have had negative impacts to land utilization by pastoralists, affecting their traditional management systems, hence limited scope of drought coping mechanisms. This situation was best illustrated by the Sahel drought of 1968-1973 that saw pastoralists impoverished by the effects of drought, due to mismanagement of the natural resources supporting human settlements, expansions in agricultural production and many other activities that affected land uses. Traditional management systems that enhanced pastoralists to migrate to areas that had better pastures facilitated rangelands equilibrium (Fagan, 1999). Wet and dry season grazing areas were designated and managed through functional traditional institutions.

Various criticisms later came into play disregarding pastoralism as unsuitable system due to high risks or 'tragedy of commons' commonly associated with common property rights. Socio-economic politics behind marginalization and control of pastoralist's movement, by Governments have continuously weakened strong traditional institutions that enhanced pastoralists to manage their natural resources effectively. Sahel zone drought in Africa, where human mismanagement by pastoralists was blamed for desertification and depletion of resources, ought to have provided lessons to the development actors and governments to understand the dynamics of pastoralism as a livelihood. Land privatization encouraged more intrusion and the transfer of land from tribal peoples to the state or to individuals. However, modernization and privatization programs negatively affected the livelihood of the pastoralist societies and actually worsened the ecological impact. (Hardin, 1968)

In East Africa land available for pastoralists have always been assumed to be idle land and hence available for other economic activities. Land policies remained rigid and unable to address emerging land uses demands that do not take into account the need to set aside grazing fields for pastoralists. This has been an opportunity for Governments to facilitate changes in land uses for human settlements, agricultural activities, and many others. A good example is the displacement of Barabaig pastoralists in Tanzania where the land they occupied was used for growing wheat (Lowe 1996). Traditional management systems that enhanced the local communities' cohesiveness, in management of the rangelands by designating specific areas for dry and wet season grazing were weakened over time. Weakened pastoral communities capacities to manage

the available natural resources, contributed significantly to low resilience to cope with frequent and severe droughts induced by climate change. The same trends are also blamed for conflicts that have often characterized pastoralists and farming groups when they converge in resources utilization points (*Behnke 1993*)

In Kenya, increase in human population, led to increased demand for natural resources especially land for human settlement, agricultural production and other economic activities. Commercial ranching and wildlife conservation, claimed huge tracts of land initially available for pastoralism hence confining pastoralists to marginal lands. Expansion of agricultural activities to marginal areas occupied by the pastoralists affected the traditional management systems in practice making pastoralists more vulnerable to droughts. Extensive use of wetlands for crop production delineated the wetlands in the rangelands often leading to resources conflicts between the farmers and pastoralists (*Campbell et al 2000*). Utilization of Ewaso Nyiro and Tana rivers waters by farming communities for irrigation and domestic needs have been a source of conflicts between the farmers and pastoralist who are challenged by water shortages for their livestock during the lean season. Lorroki plateau of Samburu districts is not exceptional of expanded land uses.

### **1.1.2 Land use in the study area**

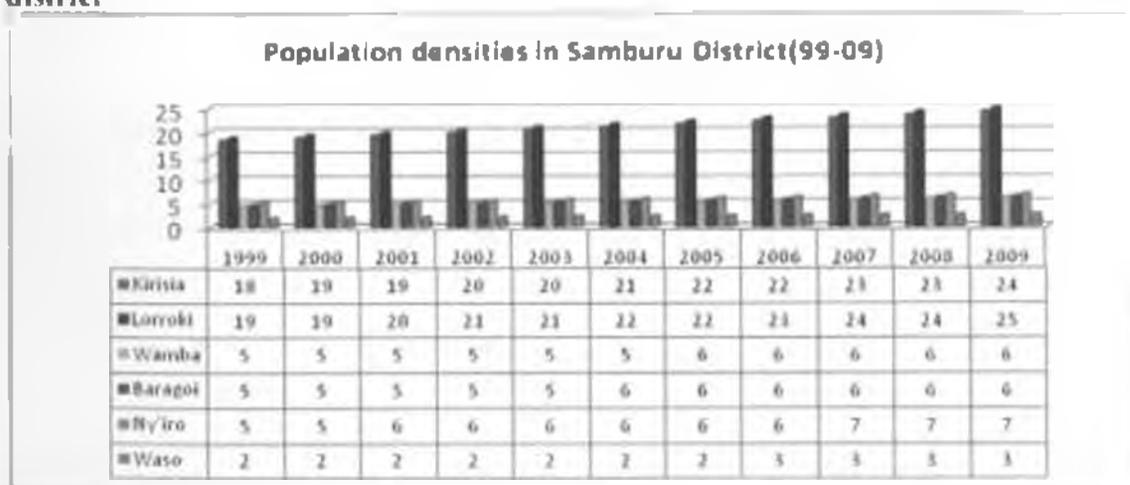
Lorroki plateau eco-system is rich in biodiversity, depicting its potentials in supporting production systems especially crop production. Land utilization in the upper parts of the plateau, changed from pastoral to crop production especially in high potential zones of the plateau that include Poro, Loosuk, Pura, Longewan and Logor-ate belt that are known for crop production including commercial wheat production in Lorroki and Kirisia divisions of the district. However out of the 140,000 hectares estimated to be arable, only seven percent of this is currently utilized (*GoK, 2005*).

Expansions of land for crop production saw increase in land degradation particularly soil erosion and deforestation activities along the catchment areas thus impacting negatively on production systems. Both livestock and crop livelihoods are currently characterized by low returns due to diminished land productivity. This situation forced herders who own large herds of livestock to seek alternative areas to move their livestock for better pastures. Mono-cropping practiced by over 80 percent of farmers in the plateau led to losses of soil macro-nutrients through leaching leading to declined yields (*GoK, 2005*). This situation coupled with increased rainfall variability

has continuously subjected households to high risks of food insecurity. Poor access to basic social amenities in other parts of the district, coupled with insecurity that rocked the eastern and western parts of the district in the late 1990s are the main factors attributed to increased human settlement in Lorroki plateau.

Experienced environmental degradation in Lorroki plateau associated with human settlements is already a threat to the local livelihoods mainly comprised of livestock and crop production. Ongoing transformations are engulfing pastoralism due to rising demands for land use particularly human settlements where demand for land utilization increases rapidly pushing away pastoralists to the more marginal, insecure, and drought prone areas. During the colonial era, pastoralists were restricted to the lowlands and strict grazing management plans in the plateau were instituted according to the range carrying capacity (*Baker 1963*). Human settlement was at the same time restricted to few numbers of households, but during the post colonial era, populations build up in the plateau started in the late 1990s being the turning point in the plateau where human settlement increased, leading to doubled demand for natural resources in form of energy, construction materials and many others whose depletion impacted negatively on production systems (*GoK, 2000*).

**Figure 1: Population densities per sq km in six administrative divisions of larger Samburu district**



Source: District statistics office-Samburu(2010)

Fig 1 above reflects population densities in the six divisions of the larger Samburu district. Kirisia and Lorroki divisions that constitute the plateau, depict high densities as compared to the other four divisions that are marginal. The two divisions sustained an increase in human population densities for the last ten years. Human settlement in the plateau doubled the demand

for the available natural resources in support of basic household needs. Deforestation activities doubled, due to the increase in demand for construction, fencing materials and wood fuel, exposing water catchment areas to high rates of evaporation and risks of siltation. Large scale wheat production in the upper parts of the plateau without proper soil conservation measures in place was counteracted by accelerated surface run-off during the rain seasons leading to siltation of Nontoto dam which is the only source of water for Maralal town. Floods frequency have increased around Maralal town during the rainy season, due to massive land degradation activities upstream leading to accelerated surface run-off (SOE, 2005).

Large scale wheat production in the upper belts of the plateau led to vegetation clearing for expanded crop cultivation. Extensive uses of inorganic farm inputs including the synthetic fertilizers, herbicides and pesticides among others, changed the soils chemistry thus affecting productivity. Vegetation cover in these fields totally changed and low quality cover replaced the highly palatable forage species. Though increase in drought frequencies may be attributed to weather variability, the effects for these droughts have been pronounced at the household level where severe food shortages have been common in Lorroki plateau. Declining trends in crops and livestock production systems are mainly associated with environmental degradation subjecting households to high risks of food insecurity. Economic situation at the household level is at its minimum, given the prevalence of insecurity in the western flank of the plateau a situation that has lead to increased destitution at the household level.

## **1.2 Statement of the research problem**

Current water deficits for both domestic, and livestock uses in the plateau are a major challenge to the households in the plateau. Experienced water shortages may be attributed to massive deforestation activities that have been rampant in the plateau. Available seasonal streams, shallow wells and other water sources dried up, leading to increase in water distances for both domestic and livestock requirements. Active members of the household particularly women, dedicate most of their productive hours in search of water. Long queue and long waiting hours is a common experience in the available boreholes. Human settlement has resulted to increase in denuded rangelands leading to poor pastures regeneration thus impacting negatively on livestock production.

Frequent livestock migrations outside normal dry season grazing areas to insecurity prone areas, and across the district boarders to areas like Mt. Kenya becoming a common phenomenon. In

areas where deforestation has been massive, successive growth by invasive species and other shrubs is common, leading to poor quality and quantity of pastures available for livestock thus impacting negatively on production. Currently *Croton dychogumus* is expanding to the upper parts of the plateau an indication of range degradation. The species inhibit pastures regeneration underneath leading to decline in perennial grass species in invaded sites a situation that has affected livestock feeding regime.

Deforestation, coupled with poor Agricultural practices, contributed to massive soil erosion where accelerated surface run-offs and large gully formations have been experienced. Washing away of top soil (humus) and leaching associated with soil erosion leading to deficiencies of soil macro and micro nutrients. Soils infertility has continuously impacted negatively on the production systems leading to high risks of food insecurity in the plateau. Two tree species that are of great economic value are threatened with extinction this includes, *Juniperus procera* (red cedar) commonly used for construction due to its resistance to termites and other pests. Fencing materials for crop fields are mainly from the same tree species. Over eighty five percent of the buildings in rural and urban centers are constructed using the cedar posts and timber from *Podocarpus gracillia* (Podo). *Olea Africana* (Olive) is the other species under extensive utilization for wood fuel especially charcoal burning. Olive has also been the main source of livestock fodder during the drought period subjecting it to over exploitation.

The research was therefore an attempt to look critically on immediate effects of human settlement on the dry lands environment and production systems with an aim of exploring the best options for sustainable development. The key issues the research work carried out concentrated on include:

- Changes in water availability.
- Effects of land degradation on livestock and crop production.
- The effects of human activities on olive and cedar tree species that are threatened by extinction
- Land degradation leading to soil infertility that affects production systems.

### **1.2.1 Research questions**

The research attempted to investigate how human settlement has impacted on environment. The research was therefore formulated on the basis of trying to answer the following research questions:

What are the main causes of the human settlement in Lorroki plateau?

Who are the development actors in Lorroki plateau?

What are the impacts of human settlement to the physical environment?

What are the recommended strategies for sustainable natural resource management in Lorroki plateau?

### **1.3 General Objective.**

To identify and describe the impacts of human settlements on the dry lands environment of Lorroki plateau in Samburu district.

#### **1.3.1 Specific objectives.**

1. To identify the main causes of human settlement in Lorroki plateau.
2. To identify development actors in Lorroki plateau
3. To identify and describe the impacts of human settlements on the environment.

### **1.4 Rationale/Justification**

Like any other arid and semi arid lands (ASAL) Lorroki plateau is faced with challenges ranging from population growth, growing demands for natural resources particularly expanding land use among others. Achievements in terms of development supported by various development actors in the district may be attributed to human settlement in the plateau. In the process the pillars of sustainable development that include socio-cultural, economic, and environmental concerns that should be at equilibrium are not taken into consideration.

This has been the case in the plateau where the interventions facilitate in equilibrium in the pillars of sustainable development. Lack of sound environmental management strategies have been a weakness among the development actors in ensuring balance between the development process and ecology. The research is expected to provide a road map towards sustainable planning, implementation, monitoring and evaluation process where sustainable utilization of natural resources forms the core values of the development process. Proper planning and collective decision making is key in management of Lorroki plateau ecosystem.

Lorroki plateau is an important ecosystem in the district whose potential has been of significance in enhancing the local communities' livelihoods through its fairly stable agro-climatic zones. Suitable agro-climatic zones favour both livestock and crop production providing a window for local households to diversify their food sources. Subsistence crop production was adopted across the two divisions. Human activities in the plateau intensified over time due to settlements and other extensive land utilization activities including large scale wheat production, degrading the ecosystem. This situation has been undermining local communities' resilience to hazards like droughts hence increasing vulnerability to food insecurity. Crop husbandry is also on the decline owing to unsustainable crop production techniques practiced by farmers. 140,000 hectares of land are reportedly arable in the plateau but currently it's only seven percent of the arable land that is under crop production. Unless conservation agriculture is adopted by farmers, land degradation will always be associated with crop production, making the production system unreliable.

In order for local communities to cope with weather variability effects, there is need to strengthen their capacities to manage their locally available resources sustainably. This can only be achieved through holistic management approaches where integration of sustainable strategies is important in planning and implementation of development activities. Lorroki plateau being endowed with rich biodiversity, requires concerted efforts by all development actors to provide balanced approach between development process, increasing human population of 2.8 percent per year (UNDP, 2006), and ecology.

Human activities have had detrimental effects to the environment and local livelihoods where production systems mainly livestock and crop sectors are on the verge of collapse. The wet and dry season grazing areas that existed and enabled the livestock keepers to manage their large herds of livestock are no more due to settlements. Residential settlements by households in the plateau impacted negatively on land utilization patterns where large tracts of land were fenced off and others placed under cultivation limiting land available for grazing. Expansion of land for cultivation and human settlement claimed large tracts of land including catchment areas, leading to drying up of most seasonal streams and springs. Mono-cropping and other poor crop production techniques led to soil erosion and decline in soil nutrients hence declined crop yields (GoK 2006). Siltation of the main dam downstream has been associated with crop production in the upper parts of the plateau. In 1998, the district environmental committee was forced to intervene to ensure that residents of Maralal town had access to quality water that was safe from

synthetic fertilizers and pest/herbicides used by large scale wheat farmers in the upper belts of the plateau (GoK 1998).

Pastures continue to diminish forcing livestock to concentrate within insecurity prone areas outside local communities' administrative boundaries. Olive tree within the conserved forest have experienced high pressure during the drought period utilized as the main source of fodder for livestock. Over twenty pastoralists were reported to have lost their lives through accidents in the process of pollarding the trees for livestock feeds. Diminished feeds within the plateau forced livestock keepers to drive their herds too far away to areas like Mt. Kenya, Suguta valley and other areas that are characterized by insecurity, during the peak of the drought. Livestock mortalities are normally associated with these movements as livestock succumb to drought stress during migrations. Collapse in livestock and crops production systems impacted negatively on food security situation leading to high risks of malnutrition among the vulnerable categories at the household level (GoK 2006).

Poor performance in livestock and crop production systems undermines the local household resilience capacity based on endowment hence infringing on household's entitlement (Leach and mean 1991). Characterization of natural resources including the grazing areas needs an inventory of resources identifying constraints on access and control, information on likely users and numbers, current land tenure status and likely pressures for land use change that are currently eminent and their adverse effects on local livelihoods. Local communities must be involved in the research process, in order to enhance planning proceeds from a common understanding of present conditions and rising demand. Development of appropriate land use plans in accordance to upcoming land use demands is important for sustainability (DFID, 2001).

The research work looks forward to enhance the capacities of stakeholders in the plateau to engage in holistic management where all pillars of sustainable development are in equilibrium. This will create harmony, minimize competition and eliminate the negative attitude associated with pastoralism like the risks of 'tragedy of the commons' and instead being able to integrate environmental management strategies upstream hence avoiding 'end of pipe' management

## 1.5 Scope and Limitation of the study

The time factor and distances involved if one were to visit all the settlements within the plateau would make the cost of the study prohibitive the research therefore concentrated on ten communities living in the west part of Leroghi forest , this includes Angata-Nanyokie, Nkorika, Poro, I partuk, Milimani, Ngari, Lederu, Baawu, Mburigon, and I odokejek. As a result of this, the sample was assumed to be representative of the entire population in the plateau. Sample size of ten sub locations achieved thirty percent representation of the total thirty three sub locations. Transects of two and half kilometer radius were developed to guide the sampling framework.

The sampled communities were not necessarily equal in terms of area, population densities, and many other factors that are important in sampling. The samples used were assumed to be representative; however the areas that are closer to urban areas where many factors are in play including the nature of livelihoods diversifications options, could be source of error. Drought situation affected timing of data collection process especially the focus group discussions and household based interviews where productive members of the community were engaged in drought coping activities.

Limited research work has been conducted in the ASALs in regard to the changes in natural resources utilization particularly land use, thus making it difficult for the research work to borrow more from other works done through research in pastoral areas. Ten households sampled per community were assumed to be representative of the populations living in these areas especially in sub locations that are densely populated around the urban areas. Socio-cultural values had impact on the answers generated from the research instruments particularly on issues regarding livestock ownership which is treated as confidential information by community members. It proved difficult to come up with time frame, to base upon the study. Vegetation analysis was much easier if the research was based on homogenous stands but indigenous heterogeneous stands proved difficult to determine age or period.

## 1.6 Definition of terms/Concepts

The following terms were used in the course of the study.

**Land:** means the terrestrial bio-productive system that comprises soils, vegetation other biota and the ecological and hydrological processes that operate within the system (*Darkoh, 1996*)

**Degradation:** Implies diminution or destruction of biological potential (resource potential) by one or combination of factors acting on land. Land degradation is broader than soil degradation as it deals with the whole ecosystem including the soils. The process of land degradation includes water erosion, wind erosion, and sedimentation by these agents leading to long term vegetation and diminution of many plants and animal populations. Land degradation is further described as reduction or loss of the biological or economic productivity and complexity of the land (*ICCD, 1994*) Human activities include over cultivation, overgrazing, deforestation poor irrigation practices and any other inappropriate land use practices.

**Desertification:** land degradation in arid, semi arid and dry sub humid areas resulting from various factors including climatic variations, and human activities (*UNEP, 1992*).

**Sedentarization** Adoption of permanent settlement by pastoralists from their nomadic lifestyles moving away from moving from one place to another in search of pasture but instead opt for settling. Nomadic movement has been restricted by changes in national policies that govern on access and control of natural resources especially land. Land tenure system is a typical example of policies that have inhibited nomadism through individual land ownership. Nomadism has been in existence under the umbrella of common property resource ownership where access, utilization and control is cemented by socio bonding both among the intra and inter community members. Year round sedentary sites are usually characterized by a strong demand of steady resources, and diminished resources trigger movements (*Elliot, 2005*).

**Livelihood** a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living by an individual or community (*DFID 1999*)

**Sustainable livelihood:** A livelihood is sustainable when it can cope with and recover from shocks, stresses, be able to maintain and enhance its capabilities and assets both in short and long term period, whilst not undermining the natural resource base.

**Sustainable development** is defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (WICD, 1987). Sustainability emphasis is based upon equality and equity of life. It is founded on three pillars of socio, economic and environmental.

**Integrated land use plan:** Development of utilization plan based on the available resources particularly land as to where and when. Resources inventory taking enhances good management plans development by local communities and all stakeholders. Land utilization patterns are therefore based upon the resource inventory and guided by the same resources. The concept emphasizes on sustainable resource utilization.

**Vulnerability:**

Characteristics that limit an individual, household, community, a city, a country or an ecosystem's capacity to anticipate, manage, resist or recover from the impact of a natural or other threat (often called a 'Hazard' or 'Natural Trigger') (HRR, 2005)

**Resilience:**

Refers to the household's ability to absorb and recover from shocks and stresses. (A household with well diversified assets and livelihood activities can cope better with shocks and stresses than one with a more limited asset base and few livelihood resources) (HRR, 2005)

**Diversification:**

This is a households attempt to reduce its vulnerability by having more than one livelihood activity. In a diversified household, if one productive activity does not provide enough, or fails completely, there are other sources of livelihood that the household can fall back on. Diversification enhances household's resilience.

## **1.7 Outline of chapters**

**Chapter one** Gives an introduction to research and other important parts that include the problem statement, research objectives, rationale/ justification, scope and definition of terms.

**Chapter two:** The second chapter is about literature review citing other studies that are relevant to the research. Conceptual framework is also articulated here where the research working hypotheses are formulated and both dependent and independent variables are highlighted.

**Chapter three** Outlines the methodology the research engaged in order to collect reliable data including the research design, sampling framework among others.

**Chapter four** The Key research findings

**Chapter five** Research, conclusions and recommendations.

**References** bibliography of the relevant research works conducted.

**Annexes:** The appendixes of the sets of instruments the research will utilize.

## CHAPTER TWO: LITERATURE REVIEW

### 2.0 Introduction

This chapter focuses on inter-linkages of various factors that facilitate human settlement, explaining the transformation pastoralists and agro-pastoralist are experiencing currently in the plateau, threatening their local livelihoods. The trends are far much below normal as compared to the situation in the last two decades where factors like population growth, insecurity, and competition for natural resources have contributed to sedentarization. This has impacted negatively on the environment and livelihoods a situation that is already compounding vulnerability levels among the communities living in the plateau. Destitution among these communities is increasing as highlighted in household's baseline survey 2006, in which over 60 percent of the population is below poverty line (GoK 2006). Clear understanding of linkages either positive or negative impacts are important to explore in order to be able to underscore the necessary mitigation measures where necessary.

Sedentarization of pastoralists in the plateau dates back to post-independence period after the withdrawal of colonial rule, but there after there are factors that came into play in the late 1990s, accelerating the rate of human settlement in the ecosystem. Population growth, commercialization and access to resources, services, and displacement due to insecurity are some of the key factors that accelerated growth in human settlement in the plateau (SoE 2006). Growing demand for natural resources will therefore continue to exert pressure on the available resources leading to formation of deserts in 'situ' if no remedial measures are put in place to mitigate elastic demand for natural resources.

### 2.1 Theoretical framework

There are evidence that the pastoralist way of life is an efficient system: one of the few ways of supporting a population in a difficult environment and representing a sustainable approach to land use. With traditional pastoralist strategies, the "tragedy" is avoided through the management practices facilitated by functional traditional governance systems (Lune 1996). One theory asserts that pastoralism followed mixed farming (rainfall-dependent agriculture with animal husbandry). A model presented by Bates and Lees (1996) suggests that it was the introduction of irrigation to farming which resulted in the selective pressures for specialization.

The increased productivity of irrigation agriculture ultimately resulted in population growth and pressure on resources, which lead to greater land and greater labour requirements for intensive farming. Marginal areas of land were often all that was left for animal rearing. To acquire enough forage, large distances had to be covered by herds. This resulted in a higher labour requirement for animal tending. As a result of the increasing requirements of both intensive agriculture and pastoralism, the two practices diverged and specialization took place. Both developed alongside each other, with continuing interactions. Other proponents of this view include (Levy, 1983) and (Hole 1996). This theory is further reinforced by developments in Green revolution where traditional agricultural production techniques were replaced by technological advanced production systems that sought to optimize the inputs for higher returns. Intensive production for both crops and livestock undermined the potential of traditional production systems. Demand for natural resources particularly land increased proportionally with intensive farming pushing pastoralism to marginal lands.

The first systematic understanding on utilization of natural resources verses growth in human population was introduced by Thomas Malthus in 1795. Malthus introduced simple clear and essentially a biological theory in 1798 in his book "essays on the principle of population growth, published in 1798. Malthusian theory outlined the negative impacts growth in human population has to the environment. Malthus lived during the period of industrial revolution in Europe. This was a period when there was massive poverty among the peasants and the middle class as opposed to land owners and businessmen called burgesses. Malthus was not happy the changes industrialization was impacting on society and environment (land and other resources). The development that came to be called green revolution which led to people being landless and increase in rural to urban migrations for alternative livelihoods. He did not foresee what future changes will be beneficial to society because of industrial development. His focus was on land and other natural resources, the natural capital resource base that was threatened by increase in human population.

Theoretical justification for the promotion of individual private ownership first came from Hardin's 'tragedy of the commons' claiming that each individual has unrestricted access to the common, and is motivated by wish to maximize his herd where tragedy becomes inevitable (Hardin, 1968). Pastoralists herding livestock on a common, game theory suggests that each herder has an incentive to act as a 'free rider', and maximize the number of animals in his herd

even if it means the destruction of the resources. The so-called 'new paradigm' sees semi-arid ecosystems as being in permanent disequilibrium but persistent on broad temporal and spatial scales whilst many indigenous pastoral strategies are carefully adapted to these characteristics.

Globally pastoralists have been victims of marginalization due to the socio-political challenge they pose to governments. This is confirmed by one of the consequences of the break-up of the Soviet Union and the subsequent political independence and economic collapse of its Central Asian republics in the resurgence of pastoral nomadism. Taking the Kyrgyz people as a representative example, nomadism was the centre of their economy prior to Russian colonization at the turn of the 19<sup>th</sup> century, when they were settled into agricultural villages. The population became increasingly urbanized after World War II, but some people continued to take their herds of horses and cows to the high pasture (*jailoo*) every summer, i.e., a pattern of transhumance (Hole 1996). Since the 1990s, as the cash economy shrank, unemployed relatives were absorbed back on the family farm, and the importance of this form of nomadism has increased. The symbols of nomadism, specifically the crown of the grey felt tent known as the yurt, appears on the national flag, emphasizing the centrality of their nomadic history and past in the creation of the modern nation of Kyrgyzstan.

Sahel zone in Africa provides a good example, where human mismanagement by pastoralists was blamed for desertification and depletion of resources. The problems were actually due to previous interference and particularly severe climate conditions. However, Hardin's paper suggested a solution to the problems, offering rational basis for further privatization of land. This encouraged more intrusion and the transfer of land from tribal peoples to the state or to individuals; this led to dysfunctional traditional institutions that enhanced sustainable natural resource utilization. However, modernization and privatization programs negatively affected the livelihood of the pastoralist societies and actually worsened the ecological impact. Desertification that was taking place was mainly due to manmade activities and the deserts were being formed in 'situ' (Oba et al 1987). The Sahel drought situation is a good reference to series of drought period the pastoralists in the plateau have been experiencing and the lessons learnt in Sahel situation should form a good reference, in formulation of strategies to cushion pastoralists against livestock losses in Lorroki plateau.

The pastoralists of dry lands Africa demonstrate a diverse range of adaptations to the risk and uncertainty they face in daily life. Adaptation and risk avoidance are possible through maintaining mixed herds containing different herd species, being mobile, and developing other forms of income to supplement herding, including subsistence farming, wood products sales and petty trade among others (Swift 1996). Several longer-term forces provide a background against which are set processes of continual adaptation and change. Such forces include ecological and climatic trends, political and economic marginalization of pastoral communities, widespread alienation of areas formerly used for grazing and substantial shifts in animal ownership patterns. Such rapid and far reaching changes are already having a major impact on how pastoral systems operate in dry lands. Policies of neglect and of inappropriate project interventions within pastoral areas have further weakened the capacity of such systems to operate effectively and yet transhumant patterns of livestock production remain the most environmentally benign and effective means for using the highly variable grazing of dry lands areas (Scoones, 1996).

In East Africa, the transformation experienced in terms of socio, political, and economic have had upper hand in determining the access and control of the available natural resources by the pastoral groups. Changes in tenure and control undermined the functional institutions that ensured sustainable utilization of the natural resources among the pastoral communities. These trends have often been characterized by resource based conflicts among the user groups. Developmental activities planned by the governments and development agencies witnessed conflicting land use patterns with the pastoral groups. In Tanzania, land available for pastoralism was converted into wheat growing fields affecting land utilization patterns among the Barabaig pastoral community (Lane 1996).

In Kenya, grazing management systems were functional during the colonial era, with cohesive traditional management institutions that were able to govern the pastoralist on sustainable utilization of natural resources. During the post independence period most of the available institutions became dysfunctional and unable to cope with the rising demand for natural resources impacted by human population's growth in the marginal areas. This situation subjected the rangelands that are characterized by common property rights to the risks of 'tragedy of the commons'. Though there are no empirical studies conducted in the same area on human settlement and its effects on environment and livelihoods, similar studies were conducted in the

neighboring district of Marsabit confirming the negative impacts human settlement bears as pastoralists settle (*Adano 2008*).

In Kenya land uses are proving to disadvantage the pastoralist as the demand for the same is on the increase, pushing the herders to more marginal, insecure, and tsetse infested areas. Current research on rangeland ecology suggests that we have less to fear from pastoral land stewardship than was previously thought (*Lane 1996*). On the one hand, the natural environments exploited by pastoralists are generally robust and resilient. And on the other hand, pastoral techniques of land management are not as dysfunctional as was once widely assumed. While regulation of pastoral activity may be necessary in specific circumstances, there no longer exists a broad scientific mandate to control or modify almost every aspect of pastoral land use in order to preserve the environment (*Behnke, 2008*). Existing policies have not been able to cover comprehensively the pastoral resources utilization patterns and the need to be covered adequately especially in proposed new land policy. The research is bound to benefit from other studies carried out by other researchers. The research borrowed lessons from the works done in Marsabit District in northern Kenya among other research works that are found relevant in highlighting pertinent issues in arid and semi arid lands of northern Kenya.

### 2.1.2 Empirical Review

A number of related studies have been undertaken in the district, that includes, impacts of land privatization of Samburu pastoralists livelihoods strategies, which indicated that Siambu which had its land subdivided, registered increase in average per capita wealth in the year 2000 as compared to Mbaringon whose land remained communal (*Lesorogol, 2006*).

Pastoralism within land administration in Kenya was able to identify the need to designate particular migratory corridors at given time of the year, to facilitate the pastoralist migrations to Laikipia and other grazing areas (*Lengoiboni, M. et al 2009*). State of environment have been able to pinpoint particular pertinent issues impacting on ecological imbalance in the plateau (*NEMA, 2005*). Food security assessments provides the vulnerability updates in the larger district highlighting the affected sites and populations (*GoK, 2009*).

Natural resource vision and strategy is a kind of natural resource inventory that provides insight on the status of the available resources (*ALRMP 2005*). These studies have been able to identify the current imbalances in socio, economic and environmental issues affecting the households

living in the plateau bearing an impact on natural resources utilization patterns by pastoralists, hence impacting negatively on local livelihoods.

The research benefited from the study conducted in Machakos on environment, population growth and productivity which found that human settlement led to improved land management through innovation and adoption of sustainable systems (Tiffen *et al* 1994).

Lorroki plateau is a rich ecosystem, known for its biodiversity but over time human activities that engulfed the plateau are threatening the ecosystem and particular wildlife and plant species are currently threatened by extinction. Lorroki forest which has been a habitat to diverse species of wildlife witnessed rampant depletion and hence decline in species densities. The factors behind such trends are increase in human population, demand for arable land, encroachments of human settlements into protected areas, and unsustainable use of forest resources. The research carried out on the settlement of pastoralists around Mt. Marsabit depicts how pastoralist's sedentarization have had negative impacts on conservation of mount Marsabit forest ecosystem, which is considered as one of Kenya's most ecologically sensitive biodiversity hotspots. What is certain is that as populations grow, so does demand for the use of forest resources and ultimately ecological destabilization that translate to low resilience levels among the pastoral groups settling. Conservation and developmental policies that require being in place should therefore be able to incorporate the "buffer zones areas of significance" and the local communities needs for resources for their survival (Adano, 2008). The main objective of the research is to determine the impacts of human settlement on environment and its implications on livelihoods. It's therefore paramount to discuss environmental impacts.

In terms of resources consideration, pastoral communities consider livestock the ultimate resource and not land *per se*. As long as land has no pasture it's not considered useful. This means there are no land rehabilitation initiatives, degrade and abandon is the principle. This means the setting in of the desert cannot be controlled or reversed (Oba *et al* 1987). Accordingly, privatization of pastoral lands and the associated trend toward sedentarization of pastoralists appears to be a threat to the continued viability of pastoral production and livelihoods.

The changes that occurred in the plateau may be as old as the post independence period after the colonial rule where settlement started to take shape. Nomadism 'drop out' may have occurred over a long period due to the series of droughts and other hazards like insecurity and diseases. Compared to Marsabit situation where human population increased by ten- fold in 1970 (*Adano, 2005*) Increase in human population was accelerated by insecurity coupled with increased frequency of droughts in the late 1990s in Lorroki plateau. The growing plateau population has created stiff competition for natural resources making the plateau eco system an important area for settling nomads hence resources are simultaneously suffering from increasing pressure as a result of settlement.

'Over centuries, African pastoralist societies have crafted institutions that enable them to survive in their harsh, semi-arid environment. Effectively managing communally held land has been one key to their success and a cornerstone of their social organization. Over the last two decades, however, a number of pastoralist communities have sought to transform their land tenure systems from communal to private ownership. What accounts for this challenge to an important, well-adapted, and seemingly highly functional institution, which ensures sustainable natural resource management (*Lesorogol 2006*).

The district was hit by drought impacting negatively on the local livelihoods where over 40 percent cattle mortalities were registered across the district, the most affected were the herds from Lorroki plateau which succumbed to the stress while in dry season grazing areas within and across the district (*GioK, 2006*). Pastoralist's communities in Kenya's ASALs function with a delicate balance between population load and ecological capacity. Given the delicate nature of this balance, it is often difficult for these communities to absorb significant population growth. As a result, an increasing number of pastoralists continue to pursue other economic activities.

The situation is being exacerbated by the growth in sedentary farming activities, which reduces the amount of land available for pastoralism (*Ekaya et al 2005*) Pasture and browse has significantly improved in the cluster in both quality and quantity and is expected to be sufficient for livestock up to the next season. 'Most animals are currently within the wet season grazing areas except for livestock in Lorroki plateau in Samburu which have moved to Kisima and Kirimon due to insecurity in the area' (*GioK, 2007*)

Human-wildlife conflicts have escalated in semi-arid lands because of changes in various aspects, including land use, arable farming and sedentary life style of pastoralists in semi-arid

lands, inadequate wildlife control and ban on hunting of wild animals. The study highlighted the need for the government to revise existing policies on wildlife conservation and management in Kenya (Esilaba, et al 2007).

Lomoki Plateau in central Samburu acts as an important water catchment for the surrounding arid areas and serves as an area for dry season grazing for the Samburu people, who are pastoralists living in group ranches and whose trees and forests are managed as a communal resource providing grazing, firewood, building poles and medicines. Strong group rules enforced by appointed elders have traditionally been essential to the conservation and wise use of communal tree and forest resources. But these rules have been undermined by changes in resource management, forest use patterns, increasing population, overgrazing, displacements, droughts, cattle rustling and high urban demand for wood energy and building materials. These changes have led to desert conditions (Kasuya, 1997). Over grazing is thought to be a major cause of desertification, however over overgrazing does not necessarily amount to land degradation.

This apparent contradiction is resolved by defining it in terms of impacts on production systems. In this context degradation only occurs when there are irreversible ecological changes associated with substantial rate of soil loss. Vegetation changes that take place are simply adjustments to perturbation and are reversible as long as land is not used beyond the bounds of resilience. An important aspect of 'opportunistic' grazing strategies is the need for flexible responses to spatial variation in grazing resources. These can take the form of seasonal or inter-annual, movements to utilize different resources at different times. Reduction or withdrawal of any resources, particularly the most productive, can limit flexibility and constrain 'opportunistic' responses. This then may lead to reductions in productivity and ultimately in the sustainability of an entire land use system. Sedentarization therefore restrict the opportunistic grazing strategies available for pastoralists (Lane, 1996)

In non-equilibrium environments, stocking rates rarely reach levels that degrade resources (Ellis and Swift, 1988). Many cases of degradation are the result of the weakening destruction of traditional mechanisms of pastoral resource use by government policies, or actions; others are the result of expansion of agricultural activities into the marginal lands, and deforestation (Munger 1994). Observed changes in vegetation are natural transitions between states (Westoby et al 1989; Friedel 1991; Laycock 1991), rather than a result of high stocking rates. Overstocking is

frequently the result of a difference in production priorities between pastoralists and policies implemented by technicians. (Bartels et al 1990).

The research was therefore intended to identify pertinent issues that are instrumental in enhancing sustainable development where the settling pastoralists are able to sustain their production systems without degrading the environment. This at the same time will impact positively on the household's resilience levels to the natural hazards like drought, insecurity and diseases among others. A holistic approach to planning analysis is required here. This provides a sound understanding of production goals, systems variability, and relevant contingency strategies application in particular ecosystem taking into account dynamics involved in households livelihoods. Considerations of incentives and constraints operating at the management decision making level, households for the case of pastoralist then their contribution towards a broader aspect. The research will therefore borrow to relate findings of the study with other studies conducted that touches on the pastoralists lifestyles and the fragile ecosystems in arid and semi arid lands (ASALs). The study identified the gaps that exist in natural resources management strategies among the communities living in the plateau and other stakeholders with the aim of formulating a way forward on conservation strategies for the available natural resources and being able to sustain the local livelihoods. In essence the guiding principles are the sustainable development pillars of socio-cultural, economic, and environmental which must be at equilibrium for sustainability triangle to be complete. In order for Millennium development goals (MDGs) and vision 2030 to be realized the pillars must be at equilibrium.

### **2.1.3 Conclusion from literature review**

Cited literature provide deeper understanding on the dynamics involved in pastoralism both within and without the study area with the upcoming challenges that require attention in planning and appropriate decision making. It is crystal clear that existence of pastoralism as a livelihood is challenged by diversification options available for those household dropping out of pastoral livelihood either by design or default. Agro-Pastoralism is a new direction for these households settling in Lorroki plateau and production system demands participatory approaches to enhance local communities' capacities to utilize the available resources on sustainable basis.

Current socio-economic transformations experienced among the pastoral groups witnessed dysfunction in the traditional socio-liber which enhanced the communities' strong bond where socio-economic stratification was all accommodative. Unlike today where the socio-safety nets

available among the vulnerable members of the community are quite limited. The socio-economic stratification was not much pronounced like today. This situation now depicts the same trend in terms of access and controls of natural resources where the haves control while they have not are blamed for degradation. All these dynamics demand to be explored and highlighted for all development actors to update themselves on the pertinent issues affecting pastoralists in the century. Integrated approaches that emphasizes on active participation by all stakeholders including the marginalized groups of the communities should be accommodated for sustainable natural resource management. Government policies should be able to integrate the traditional natural resource management systems into the developed policies for sustainable natural resources management in the rangelands (Pratt et al. 1977)

#### **2.1.4 Gaps from literature review**

Malthusian theory outlined the effects of human population growth on the natural resources where population tends to increase the demand for resources leading to degradation. The challenge posed by human socio-economic development is a balance between economic growth and resource depletion rate which should be in equilibrium. The other theory which cited pastoralists' development to have had symbiotic relationship with farmers implies the conflict between the two production systems was minimal before due to strong traditional governance system that ensured equitable access and control of the available natural resources, thus complementary roles between the two livelihoods.

Currently traditional institutions are weak and unable to provide the necessary governance in terms of access and control of the available resources resulting to high competition where depletion and conflicts are inevitable. This has occasionally characterized the convergence zones where pastoralists and farmers meet. Weakened governance systems, exposes the commonly held property rights resources to high risks of the 'tragedy of the commons' a typical situation in Lorraki plateau currently.

Recently experienced changes in Government policies in regard to management of natural resources where local communities are perceived as key partners in management, require to be strengthened and adequate awareness creation provided which can properly be addressed through the research findings. What is important is a common understanding that each of us, no matter what path we have chosen to follow in life, makes decisions that in one way or other impacts the

health of our environment and the quality of other people's lives (Savory et al. 1999). Among the identified gaps the research work intends to address include:

- Provide a framework for sound planning and decision by policy makers, development actors, and other institutions including local communities, on sustainable natural resource utilization.
- Provide understanding on the performance of traditional institutions and strategies to strengthen governance systems among the pastoral communities and harmonizing the approaches in current conventional governance system, in order to enhance sustainable natural resource management.
- There is need to identify and understand emerging land uses that compete with Pastoralism over resources, in Lorroki plateau and coming up with integrated land use plans.
- Understand the quantities of construction materials used at the household level in order to project population growth verses demand for planning purposes. The need for alternatives in terms of construction materials for housing, energy sources or saving techniques that can be adopted by settling pastoralists.
- Pastoral system is complex in nature in terms of natural resources utilization which cannot with stand competition with other sectors for growth, and risks to be pushed out in the process of economic growth. Sustainable livelihoods diversification options available for the pastoralists need to be understood and promoted by development actors.

The research therefore explores the possible options for integrating smooth transition of lifestyles and livelihoods to a more sustainable end for the settling pastoralists. The research therefore seeks to highlight pertinent issues on environmental management in Lorroki plateau for informed planning and decision making by the policy makers, researchers, development actors and local communities.

## 2.2 Conceptual framework

Pastoralism is well adapted to the environments where it exists; it is a successful strategy to support a population with limited resources of the land. Important components of pastoralist adaptation include low population density, mobility, dynamism, and complex information systems that include strong traditional institutions of governance. Over the years pastoralism has co-existed with other production systems especially crop production where farmers exchange products for their domestic requirements. Pastoralism is recognized for its economic contributions to the wellbeing of local communities.

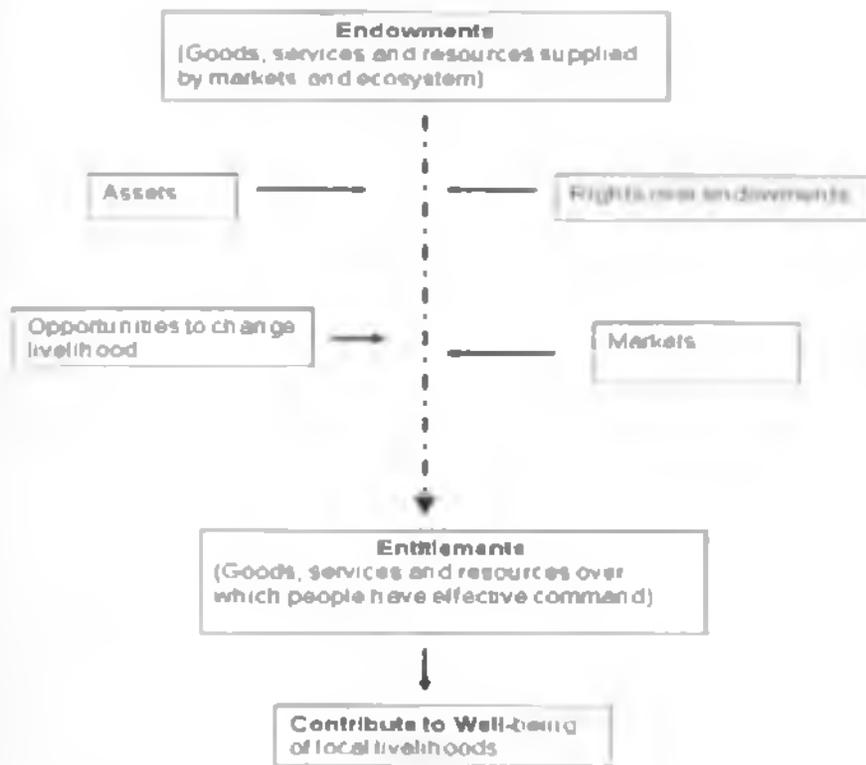
In Kenya pastoralism is the economic back bone of the communities living in arid and semi arid lands (ASALs) which covers over eighty percent of the country's land mass. The livelihood contributes to fifteen percent of gross domestic product depicting its economic viability (GOK 2006). Increase in human population galvanized changes in land uses patterns that threaten pastoralism by pushing it to more marginal lands, bringing productions to subsistence levels. Crop production is equally affected by deteriorating rangelands conditions in the plateau.

Pastoral livelihoods were sustained by local household's capacities to move from one place to another in search of pasture and water, being able to cope with drought effects. Growth in human settlements in the plateau continues to increase, particularly in zones that have higher agricultural potential. Land cultivation claimed substantial portions of what used to be grazing lands affecting the available lands for grazing during the dry season. Sedentarization induced high demand for natural resources utilization especially land where utilization patterns changed over time.

Poverty and environment relationship is explained by entitlement theory; by Amartya sen 1981- He used the entitlement theory to explain the relationship between poverty and famine. The theory highlights that environment provides resource as a result of ownership-lineage, community, tribe governed by communal land system. Sometimes ownership may come up due to one's social status. Ownership also obtained through social organizations or shares (Leach et al 1997). The ability to make effective use of resource bundles depends on a lot of other factors e.g. your position within the society. The amount of share and individual has access and control over. The position will help to mediate poverty by management of environment resources that are accessible to the individual or community. The theory strengthens understanding of the

existing relationship between vulnerability and local capacities to cope with the hazards or disasters (Leach and means, 1991).

Figure 2: Entitlements and Endowments model



Source: Sen. (1981) and Leach et al. (1997)

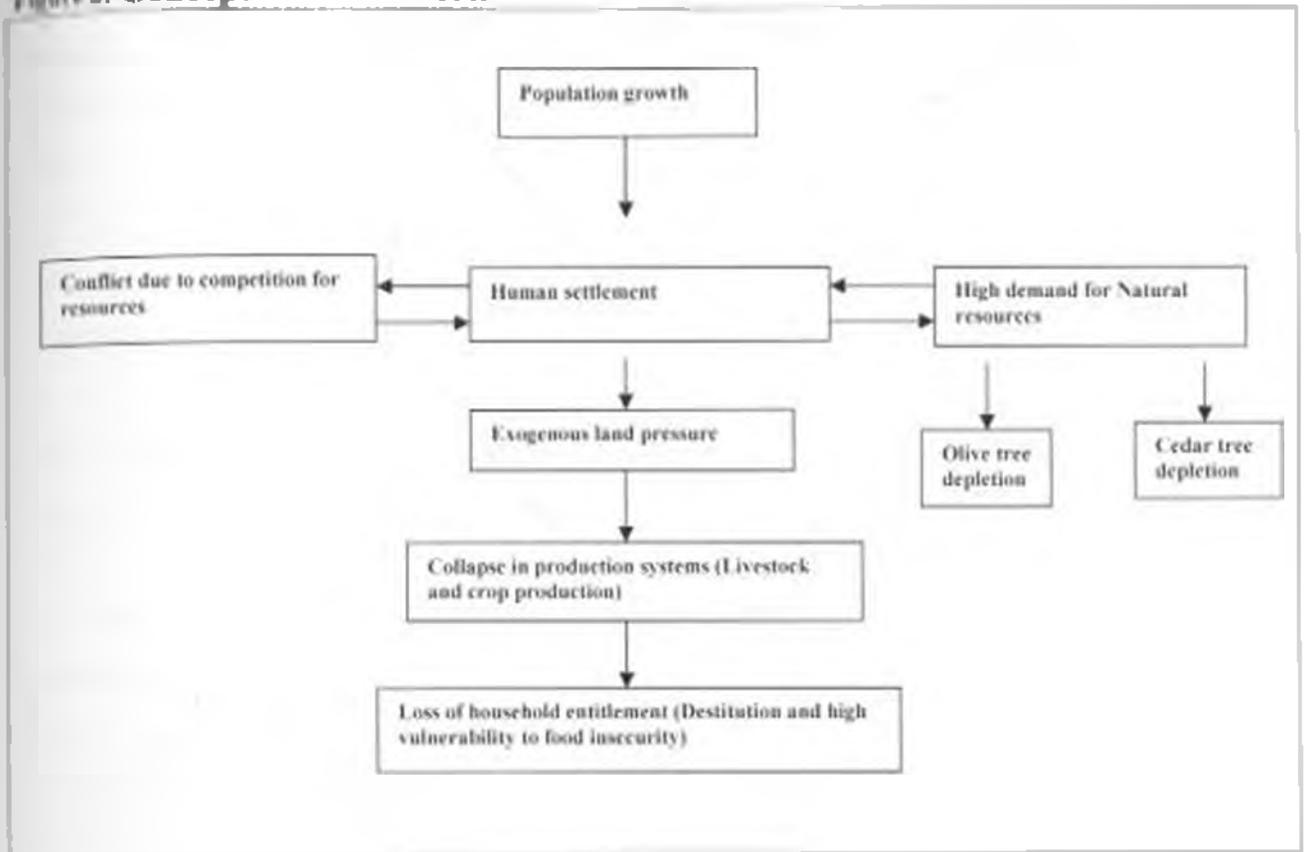
Fig 1 above outline the relationship between endowment in terms of better access to resources social economic services, and the contribution to well being of the household translates to better capacity to cope with droughts and other hazards. The opposite of the above scenario depicts susceptibility to risks of droughts and other hazards at the household level. Resource is not, they become, and they are not static but expand and contract in response to human wants and actions. Natural resources are influenced by mankind's perceptions, attitude, wants, technological skills, legal, financial, institutional arrangements and political custom. What is a natural resource in some culture or area may be a neutral resource in another. Resources are subjective, relative and functional depending on technological, cultural, education, political economic and natural endowment or potential (Zimmerman, 1951)

Increase in population led to expansions of human settlements where the available water catchment areas were degraded impacting negatively on water availability for domestic and livestock uses. High concentration of human population in the plateau due to insecurity, led to increased demand for resources in form of energy, construction, and land resources. This scenario exposed the fragile ecosystem to degradation. Land tenure system at the same time changed particularly in Poro sub location from communal land parcels to individual land parcel ownerships. A study comparing Siambu and Mbaringon communities both in Lorroki plateau in terms of land tenure system, revealed that Siambu which had privatized land in early 1980s enjoys better level of per capita wealth and income in the year 2000, as compared to Mbaringon whose ownership is still communal (*Lesorogol, 2005*). Meaning sustainable utilization of the available natural resources would be achieved at household level in an individually owned land parcel as compared to communally owned where community organization is weakened.

Overstocking rates for livestock especially sheep species in the plateau at the same time increased along with the human settlement coupled with natural resources depletion accelerating formation of deserts in 'situ'. All these scenarios compound the performance of local livelihoods to be able to with stand any slight shocks increasing destitution among the households living in these areas. In 2005/2006 drought, the district was hit by drought, impacting negatively on the local livelihoods where over 40 percent cattle mortalities were registered across the district the most affected were the herds from Lorroki plateau that were driven far away to the eastern part of the district in search of pastures after the depletion of pastures cattle herds succumbed to the stress leading to high losses (*GoK, 2006*).

Most parts of the plateau have been susceptible to drought effects whose frequency have increased to every five years and high numbers of cattle have always succumbed to drought stress at the pick of short droughts due to starvation and water shortages (*GoK 2006*). High percentage of plateau population adopted rearing sheep to supplement their income sources but it turn out to be the major source of degradation as they deplete the perennial grasses. High percentage of the local community members became pastoral 'drop outs' whose livelihoods diversification falls within a limited scale. Poverty increase in the plateau is therefore eminent and the households remaining in livestock herding are pushed away from the plateau due to consistent livestock starvation especially cattle. Cattle migrations outside the plateau increased to an average of eight months as compared to previous years of one to two months per year.

Figure 3: Conceptual framework



Source: (DFID, 2001)

Fig. 3 identifies the factors that tend to induce human settlement. Population growth is the main cause of human settlements, where other pertinent issues like high demand for natural resources, conflicts associated with competition are common and impact on exogenous land pressure leading to collapse in production systems epitomized by high rate of destitution among the households. From this conceptual framework, the key variables that are subjected to statistical tests are: mean diameters at breast height, mean soils organic matter levels, and establishment of the relationship and association of mean DBH and soils organic matter.

### 2.2.1 Research working hypothesis

The research had three working hypothesis based on the theoretical model and conceptual framework where impacts of human settlement on the physical environment are the key variables being tested statistically.

H<sub>0</sub>

There is no significant difference in means diameters at breast height (DBH) for *Juniperus procera* (cedar) in settled area of Lorroki plateau and DBH in control area (Lorroki forest reserve)

H<sub>1</sub>

There is no significant difference in means of soil organic matter levels around human settlements and control area.

H<sub>2</sub>

There is a relationship between cedar tree species DBH within the control area and soils humus levels.

The conceptual framework enables the research to establish the relationship between the dependent and independent variables. Livelihoods transitions among the communities living in the district, calls upon in depth understanding on the changes that are taking place in terms of land use, and the effects to the environment and livelihoods. Lorroki plateau is no exception of these areas that are witnessing the changes in terms of settlements, land use patterns, and increased demands for natural resources utilization hence exogenous land pressure (SoE 2005).

The impacts of these trends to the livelihoods are eminent, as local communities capacities to cope with frequent droughts and food shortages are compromised. Treating environmental issues as a standalone may not go along promoting the principles of sustainable development as envisaged in millennium development goals (MDGs) and in the national vision 2030. Environment being one of the pillars of sustainable development, calls for proactive measures being in place instead of reactive measures in managing the natural resources. (Ginkel 2002)

Socio-economic changes that may have taken place in the last two decades have had impacts in local lifestyles. Like many other research work conducted within and without the study area, the study was able to refill the impacts human settlement have had to the environment and local livelihoods. It's therefore expected that the study findings will provide more information to the stakeholders in Lorroki plateau to be able to promote sustainable utilization of natural resources for intergenerational equity as envisaged in national environmental management policies.

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.0 Introduction

Specific procedures to investigate the research problem are the issues highlighted in this chapter. This touches on the issues of information collection, measurement and data analysis process. It actually explains on the approaches that enhanced the researcher to conduct the investigations successfully. Providing guidance to the quality of data collected by highlighting on the sources and type of data collected the procedures of data collection and the methods of data analysis. This chapter is the back bone of the entire research as it stipulates on how the research work was conducted all the way to the analysis stage where the output is achieved. All these are outlined under: research sample, sample size, methods of data collection, and methods of data analysis.

## 3.1 STUDY AREA

### 3.1.1 Demography

The larger Samburu district had human population of 154,422 people. It was estimated that Lorroki plateau hosted 79,643 people, 52 percent of the district human population (GoK 1999). The figures for the 2009 census are yet to be shared officially.

Table 1: Decadal population growth rates in Samburu District

Year	Population	Growth rate %	Annual growth rate %
1979	79,908		
1989	108,834	36	3.6
1999	154,422	42	4.2

Source: District statistics office-Samburu (2009)

### 3.1.2 Administrative

Larger Samburu District is situated in the northern half of the Rift Valley Province in Kenya. It is bordered by five other Districts: Turkana (Northwest), Baringo (Southwest), Marsabit (Northeast), Isiolo (East) and Laikipia (South) respectively. It lies between Latitudes 0°40" north and 2°50" north of the equator and Longitudes 36°20" east and 38° 10" east of the Prime Meridian. It covers approximately 21,126.5 square kilometers. It is divided into six divisions, 39 locations and 108 sub locations. The larger Samburu district had six administrative divisions before the sub-divisions into three new districts. This includes Baragoi and Nyiro divisions that are currently Samburu North district, Wamba and Waso divisions currently constituting Samburu

East district. Lorroki and Kirisia divisions remained as Samburu central district. The plateau land mass covers close to 8,000 sq km

### **3.1.3 Socio-economic**

The larger Samburu district has three main livelihood zones, pastoral, agro-pastoral and formal employment/business/petty trade. The two divisions of Lorroki and Kirisia have ten locations, and thirty three sub locations. Though the plateau is ideal for crop production, Pastoralism remains the main livelihood with over eighty five percent of the population practicing and fifteen percent practicing Agro-Pastoralism and informal employment (GoK 2005). Land tenure systems in these sub locations are mainly communal land ownership through group ranches with exception of individual parcels in Poro location. Lorroki plateau is predominantly occupied by the Samburu people, Turkana, and other small ethnic groups in urban centers.

### **3.1.4 Physiography**

It is characterized by high level plateaus, hills and the Rift valley with an altitude up to 2000 m a.s.l. Over 85 percent of the district is rangeland while the other 15 percent is highland where crop and livestock production are practiced mainly in the plateau (Shuubani 1992). Lorroki plateau is characterized by agro-climatic zones that are suitable for crop production and large scale wheat production is practiced. The low lands are generally arid including the underlying valley like Suguta valley which is characterized by the Great Rift Valley land forms features.

### **3.1.5 Climate**

The rainfall is fairly erratic both in time and space. The rainfall pattern is generally bimodal, with the long rains occurring between March and May. While the continental rains which covers the plateau fall in between June and August, the short rains that cover the low lands sets in between October and December. In the low lands and basins the rainfall ranges between 250 and 500 mm per year. In the southwest plains and the Lorroki plateau receives between 500-700mm per year. While the higher elevation areas mainly the mountains of Kirisia, Mt Nyiro, Ndoto, and Mathew's ranges receive higher amounts of 750-1250mm annually. Temperatures vary with altitude and ranges between a mean annual minimum of 24 degrees Celsius and mean annual maximum of 33 degrees Celsius.

### 3.1.6 Soil types

Soil types are predominantly sandy loam, with parts of the plateau having the volcanic soils. The low lands are dominated by sandy loams soils with low water retention capacity.

### 3.1.7 Vegetation types

Loroki plateau supports evergreen forest, hush land, shrub land and semi deciduous shrub land. Deciduous bush, shrub and dwarf shrub grassland dominate the central plateau while deciduous hush land covers the eastern foot slopes and foot hills of the Kirisia hills (*Herlocker 1992*). The rest of the district is predominantly Savanna vegetation cover with exception of mountainous areas like Mt. Nyiro, Ndoto, and Mathews ranges that are characterized by forests, as reflected the map below.

#### Forest Lands in Samburu district



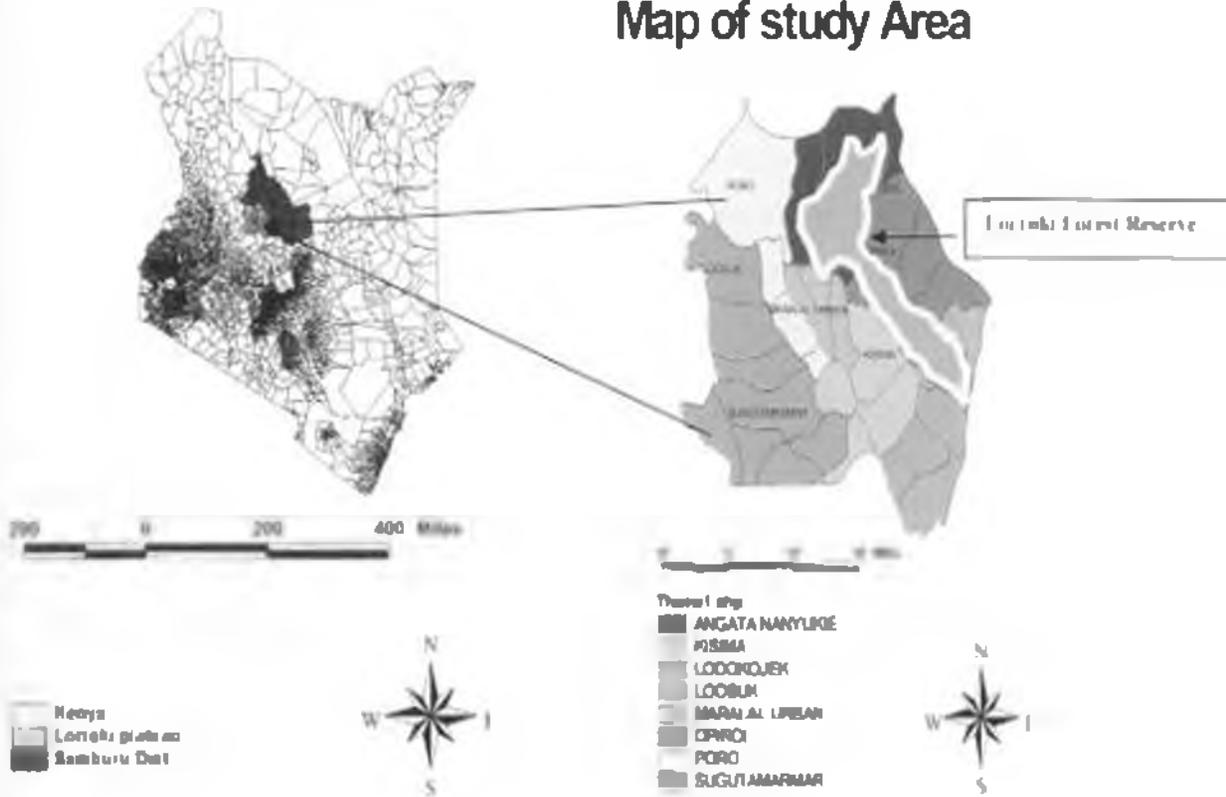
Source: African Wildlife foundation (2006)

This is further classified into three main ecological zones, zone II which is an arable zone; zone III which is suitable for mixed farming and the lower parts of the plateau that is mainly zone IV, which is ideal for pastoralism or ranching. The plateau is characterized by a rich forest

ecosystem Loroghi forest one of the largest indigenous forest ecosystem in the country 91,944.4 Hectors (GioK 1999).

## MAP OF STUDY AREA

### Location of Lorroki from Kenya Map



### 3.2 Field work preparation

Four enumerators were recruited to assist in primary data collection in the field. Fortunately Kenya Forest service had just concluded training few youth group members on community forest associations which forest measurements and data collection was part of the training. This made it easier to identify and recruit the enumerators from the same team. After two days training and field testing of the research instruments, the researcher led the team to the field for data collection after ensuring all research instruments are available for the enumerators.

The researcher wrote a letter to all target respondents and assistant chiefs informing them on the research and later sent a letter as reminder given the particular dates of the intended sample site visits. Prior visits to the sample communities were done by the researcher and fixing the dates for interviews after agreements with the community leaders. Communities' seasonal calendars were considered as critical factor especially during the drought period where people are on coping mechanism mode. This was a challenge the researcher encountered but did overcome through proper communities' mobilization in partnership with the local leaders

Inventory of the two tree species of economic value were conducted within the control area of Lorraki forest and sample plots in settled areas. Soil samples in settled and control areas were collected and delivered to soil test laboratories for complete soils analysis in Kabete national soil labs (KARI). Enquires were made on the cost implications for complete soil analysis. This was done through visits to the National soil labs to get updated price lists for the services available within the research station

### **3.3 Research design**

The research was structured in away to be able to utilize both the quantitative and qualitative designs in collection, measuring and data analysis. Generated data was used to generate information for testing the three research hypothesis developed. Standard format of quantitative research were observed where randomization of the study groups is important for a meaningful quantitative data.

#### **3.3.1 Sampling Area**

The area sample for the research included ten settlements that are adjacent to the western part of Lorraki forest reserve that include: Angata-nanyokie, Nkorika, Poro, Ipartuk, Milimani, Ngari, Ledero, Baawa, Mharingon, and Lodokejek. The forest reserve was taken as a control area to compare the scope of human activities within the reserve and human settlement area. Transect walk for a radius of 2.5Km and development of quadrants measuring 100m by 100m to facilitate inventory taking of cedar and olive inside the plots.

#### **3.3.2 Population sample**

Lorraki plateau covers two divisions comprising of ten locations that are composed of thirty three sub-locations. It was important for the research data collection to be localized at the lowest level of a community or sub-location. Population sample was from ten communities settlements

adjacent to the Lorroki forest reserve which was taken as a control area. The researcher developed thirty quadrants inside the control area and equivalent in the settled area. Further sampling of at least ten respondents and one Focus Group discussion (FGD) per settlement was carried out. This gave a total of hundred household's respondents and ten FGDs questionnaires completed.

Focus group discussion was conducted targeting opinion leaders from both genders, and the number of people were between five and fifteen for both men and women. The informal leaders were identified with the help of local assistant chiefs. Sessions were facilitated by the researcher with the guide of the developed checklist, prepared questionnaire and a number of participatory rural appraisal (PRA) tools were utilized to enhance participation.

This means 30 percent coverage of the study area. The researcher sampled the household heads that formed the respondents for the household based instrument. Depending on the set up of communities, random sampling was done to identify the households for interviews. Transects were established for inventory of olive and cedar in the control area and ten communities adjacent to the control area within 2.5Km radius. In total thirty plots within the settled and thirty in control were sampled for the two tree species inventory and soils sampling. Measurements of diameter at breast height (DBH) were taken for the two tree species. The findings of the data generated from these households were taken to represent the total population in Lorroki plateau.

### **3.4 Research variables**

#### **3.4.1 Human settlement variables**

*Causes of household's settlement in Lorroki plateau:* Data was collected through the developed questionnaire

*Changes in institutional framework:* This included the question being in the questionnaire for focus group discussion of the effectiveness of local institutions.

*Land occupied by human settlement* The questionnaire had question to determine the average acreage of land a respondent occupies in terms of settlement. Observation during the transect walk also assisted in determining the land under occupation. This assisted in off-setting the biases by interviewee and some being unable to translate the right land acreage

### **3.4.2 Pastoral livelihood variables:**

*Pasture and water* Household based instrument covered the distances livestock cover in order to access pastures and water in both wet and dry season grazing areas. Transect walk and direct observation was employed in estimation of distances. This was captured in the FGDs where historical trends/ timeline were the participatory tool utilized.

*Migration patterns* Establish the frequency of migration patterns in a year; this was covered in the household based interviews.

*Milk production and seasonality:* Number of milk bottles produced on daily basis and the seasonality of production in a year were captured in the household based instrument.

### **3.4.3 Crop production variables**

*Yields:* Households based questionnaire captured the yields for the last seasons.

*Land under crop production* The acreage under crop production per household

### **3.4.4 Environmental degradation variables**

*Vegetation depletion (Deforestation):* Inventory of two tree species of economic significance to the local communities carried out in the sampled quadrants.

FGDs questionnaire was designed to be able to focus more on the vegetation cover depletion more specifically on particular plant species that are threatened with extinction and their uses. The discussions encompassed the species within human settled areas and the forest reserve treated as a control. Secondary data collection was also engaged in determining vegetation cover changes. Line departments were consulted to look at the secondary data on vegetation depletion e.g. average losses in hectares for forest cover due to forest fires or bush clearing for settlement.

*Construction materials and fuel wood utilization* Household based questionnaire captured the information regarding construction materials used at the household level and its source. Where necessary the volumes for the used construction materials either in form of timber, poles, among others were determined. Quantities of materials used were asked in the questionnaire. Likewise for daily/weekly fuel wood utilization (No of sacks for the case of charcoal and stacks for the case of firewood)

*Income sources patterns:* Households were asked their main source of income and the deviations from the normal. The same was used in other research works while developing per capita income trend at the household.

*Denuded land* Soil physical properties analysis were carried out to determine the changes in soils fertility, properties e.g. texture, moisture holding capacity, among others. Thirty soil samples within the human settlement sample plots and the same number within the control area sample plots were collected and delivered to soil labs for analysis. Observation of degraded land during the transect walk was also done to complement the soil sampling technique.

### **3.5 Sampling technique**

Sampling technique adopted was ensured to be independent from the human judgment in order to provide the randomness required. Simple random sampling (SRS) technique was adopted by the researcher meaning all population samples were given equal chance of being selected to represent the rest. In order to ensure randomness, the researcher adopted transect walk maintaining 2.5 Km radius in human settled area and inside the forest reserve taken as control area for the research. Quadrant plots measuring 100 by 100metres were developed and inventory of all olive and cedar tree species recorded. The numbers of standing stumps for both species were counted. The researcher employed the same technique while sampling households for interviews. The households who were along the transect radius in all direction were picked for interviews and Focus group discussions of community members within the transect area conducted. Multistage sampling technique was used by the researcher for primary data collection. The sampled communities were assumed to be true representation of the population.

### **3.6 Research Instruments**

It's important to highlight the instruments that were utilized by the researcher to conduct the investigations. This included among others:

*Household based questionnaire* The instrument was developed and field tested after agreement with the supervisors on the range of questions that are ideal to represent particular variables. The instrument was administered to the household head. At least ten households were interviewed per sub-location.

*Focus Group Discussion questionnaire* FGD questionnaire was developed and administered at the community level where between five and fifteen men and same number of women were taken to respond on behave of the community. The instrument was developed on the basis that there are other variables that are cross cutting among the households and can easily be captured in a group discussion.

*Terms of Reference/Research checklist.* Along with the questionnaires, the researcher developed the terms of reference/checklist that provided guidance to the research work on specific variables that the research seeks to probe in order to answer the research questions.

*Global positioning system (GPS).* The gadget was used to locate the coordinates of the sample areas for further generation of spatial data.

*Measuring tape:* For measuring the diameters for Olive and cedar tree species within the sample plots

*Polythene bags* Soils samples collection was done by use of these bags

*Digital camera:* Observations information were captured and recorded in form of pictures.

### **3.6.1 Primary data collection (Interviews)**

The researcher administered the instruments in six communities and recruited four enumerators, trained and taken through the research instruments, and then dispatched them for data collection in four other sample sub-locations. This facilitated the researcher to off-set illiteracy problem that characterizes the populations in the area. The researcher took time to look at the data sets to ensure data quality control; together with the four enumerators till satisfaction point was reached of the data collected. The researcher also engaged in direct observation of particular variables to track on the changes that may have occurred due to sedentarization. This was achieved through the transect walk and contact with the actual variables under investigation. Primary data collection was mainly through utilization of the instruments, observations, inventory of plant species and soil samples collection. Measurements of diameters at breast height (DBH) were used to determine the variation in girth growth achieved by the two tree species in settled and control area. Low girth development indicates new regeneration stands while high reflects optimum growth girth achieved by the tree species.

### 3.6.2 Secondary data collection

Secondary data collection was part of the research data collection process, particularly at the district level where various stakeholders have secondary data available. Secondary data provided a rich input to the collected primary data and relevant data incorporated into the research findings. This was specific to the relevant line departments that are concerned with environmental, natural resources, livelihoods and settlement among other issues. Developed checklist guided in data collection process where the relevant sectors were consulted on the experienced changes in the area of study. Secondary data from other studies conducted in the related field, and other relevant data especially from central bureau of statistics was used

### 3.7 Data Analysis

After primary and secondary data collection in the field, data cleaning was carried out as a measure to ensure quality control. Then data entry commenced thereafter, where data was collated and tallied then transformed to data tables by tallying using MS- excel spread sheets and SPSS data management for ease analysis.

Collected data was collated and tallied by use of computer friendly packages that enhance analysis like MS-Excel spread sheets and SPSS data management packages. Descriptive statistics, frequencies and percentages, measure of central tendency were used to analyze the data. Inferential statistics, using parametric tests were used to test the significance of the results obtained on the impacts of human settlement on the environment.

The main statistical analysis utilized by the researcher includes: **student's t-test, Pearson correlation and simple linear regression**. Student's t-test was found to be robust and ideal test for small samples and assumes the population's normal distribution. Pearson correlation was utilized to establish relationship between the dependent and independent variables. While simple linear regression was used to establish the relationship and association between the dependent and independent variables. Research design allowed manipulation of only one variable at a time from a range of variables the research utilized.

### **3.8 Data Limitations**

The sampling framework was able to represent thirty percent of the population. It was critical for research instruments to be field tested prior to data collection in the field, in order to minimize errors. The vastness of the research coverage was a challenge to data collection taking into account the scope of the research where quadrants development, inventory, soil samples, DBH measurements and the interviews were to be carried out. It was an intensive research work that demanded a lot of dedication from the researcher and the enumerators. Data cleaning took time in the field as an effort to minimize errors.

The terrain was a major challenge in data collection as well, including moving up and down in the forest, carrying out measurements. Deformities in the two tree species especially olive which had low tapering as compared to cedar, affected DBH measurements. Interviews fatigue among the communities and households was experienced and response given by some respondents demanded more explanations for them to understand the interview questions. DBH measurements were rounded to the nearest decimal point.

## CHAPTER FOUR: RESEARCH FINDINGS AND DISCUSSIONS

### 4.0 Introduction

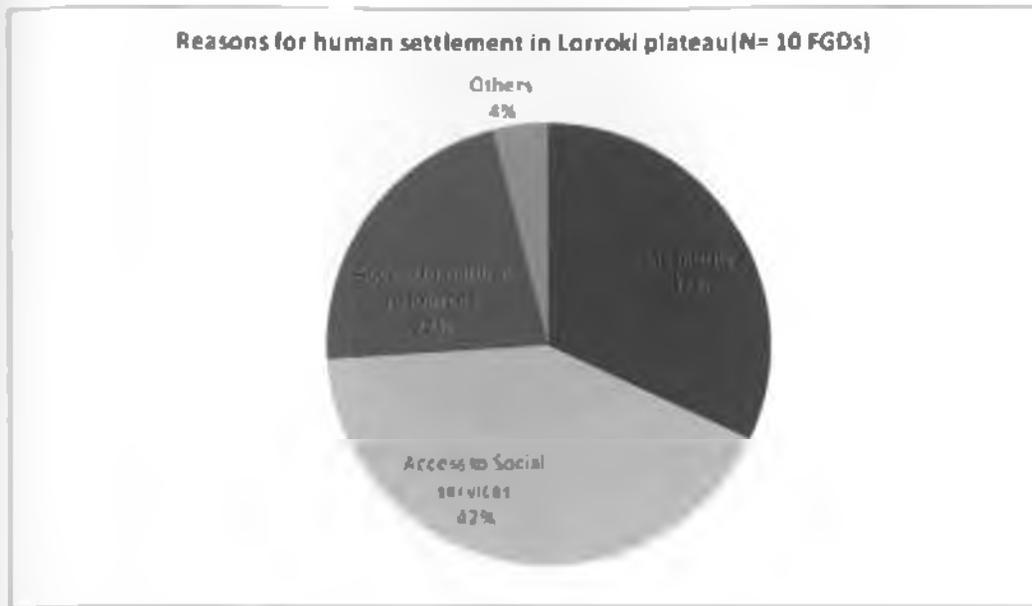
Chapter four highlights the data analysis, interpretation and the key findings of the research work conducted. Primary data collected provides a framework for answering the developed research questions. The chapter expounds on the actual findings of both primary and secondary data collected in the field and explaining the interpretations as inferred in various analyzed variables. Data interpretations are represented in various forms including tables, graphs and pie-charts among many others. Quantified data is illustrated through graphs; pie-charts and further explained in this chapter.

### 4.1 Causes of human settlement in Lorroki plateau

According to 1999 census, the plateau was estimated to host over 52 percent of the district population (*GoK 1999*). The research was able to identify the key factors that are attributed to the human settlement in this part of the district. Fig 4 indicates that the main reason given by 42 percent of the interviewed population, for settling in the plateau was due to access to social services. Insecurity caused 32 percent in terms of human settlement. Access to natural resources, where households pursue access to natural resources like pastures, land for cultivation, wood fuel for household incomes diversifications among others have also been able to trigger movements into the plateau, this caused 22 percent of the settlements.

There were also other minor reasons which included socio-cultural events like the circumcisions where households move and settle in clan-based clusters. Other cultural festivities like intergenerational transition (*Imuget*) ceremony also bring community members together where households join their kinship. The plateau being an Agro-pastoral livelihood zone is believed to have better opportunity for casual labour and other income generating activities that diversify household's income sources as compared to other remote parts of the district. Economic opportunities in the plateau are believed to be high as compared to the other marginal areas of the district hence attracting more human settlement.

**Figure 4: Reasons for Human settlement in Lorroki plateau**

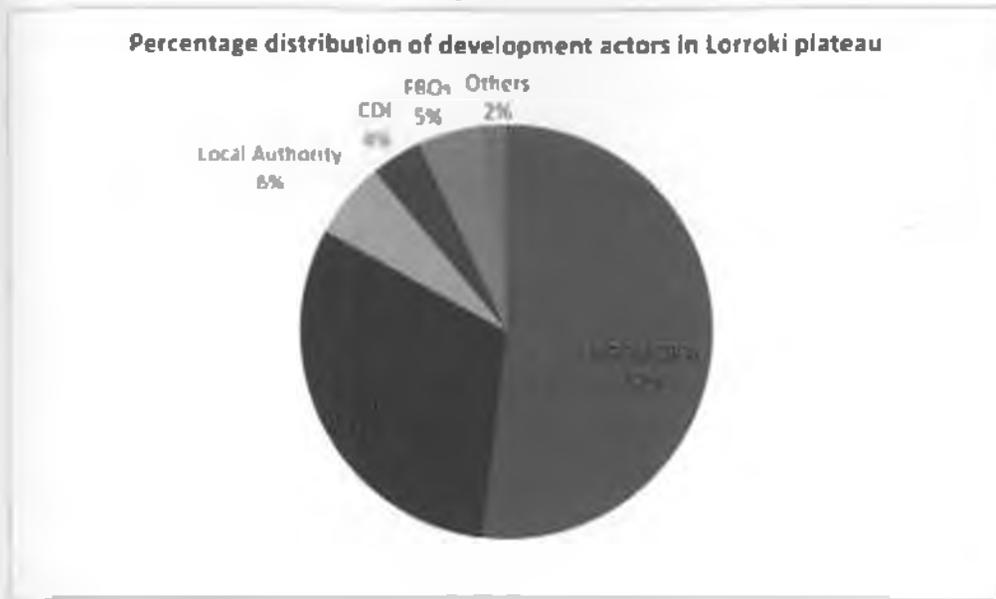


Source: Field data 2009

#### **4.2 The stakeholders in Lorroki plateau**

Fig 5 illustrates the distribution of various development actors in the plateau. Various NGOs and CBOs are the main actors facilitating development process in Lorroki plateau as reported by 52 percent of the interviewed households. A number of NGOs were found to be working with the communities in the plateau to implement social service delivery activities. Central Government and local Government were reported to facilitate 31 and 6 percent respectively. CDF 4 percent, IBOs 5 percent and others 2 percent. The venn diagram, participatory rural appraisal tool (PRA) was used to facilitate the community to understand the partners they work with.

Figure 5: The distribution of development actors in Lorrroki plateau



Source: Field data 2009

#### 4.3 Impacts of human settlement on Environment

In order to facilitate quantitative analysis, the researcher had to pick the variables that are measurable that can fast track environmental changes. Two tree species that are of economic significance were identified, that include the olive (*Olea africana*) and cedar (*Juniperus procera*). Though other species are equally important, but the actual situation in terms of utilization patterns in the plateau is determined by the two tree species. Other herbaceous and grass plants are affected especially those of medicinal values, but the research concentrated on the two tree species. In order to determine the effects of human settlement on the two tree species, the research carried out, population densities count within the quadrants, counts on the numbers of standing stumps and measurements of diameters at breast height (DBH).

Complete soil analysis was carried out to determine the level of soils degradation where soil fertility is critical. Humus forms an important soil profile thus being a key indicator in determining soil degradation. Comparative analyses of humus and macro-nutrient levels were carried out comparing the levels within the settled and control areas.

### 4.3.1 Impacts of human settlement on vegetation cover

#### 4.3.1.1 Hypothesis testing

$H_0$

There is no significant difference in diameters at breast height (DBH) for *Juniperus procera* (cedar) in settled area of Lorroki plateau and DBH in control area (Lorroki forest reserve)

Student's t-test was used to test the hypothesis

##### Paired Samples Test

	Paired Differences					t.c	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Settled and Control	35.407	62.8482	11.4745	58.875	11.939	3.086	29	.004

Since t-calculated is 3.086 and tabulated value is 1.699 at significant level of 0.05 or 5% and 29 degrees of freedom, we reject the hypothesis. Meaning there is significant difference in the means of diameters at breast height (DBH) of cedar trees within the settled areas and those of cedar trees within the control area.

The t-test confirms that there is a significant difference between the means of cedar trees within the settled area and control area. The hypothesis depicts the trends in terms of differences in the type of regeneration available within settled area and control area. This signifies that higher population densities of cedar in the control area have attained optimum girth growth unlike the trees around the human settlements where human activities are destabilizing the growth, including high rate of deforestation. In terms of population densities, some settlement areas recorded higher population densities per plot as compared to the control but the mean DBH is quite low in the settled areas as compared to the control area. This clearly indicates that the same generation of cedar, hardly reach optimum diameters within the human settlement areas unlike in the control area where over fifty percent of the regeneration reaches maturity girth.

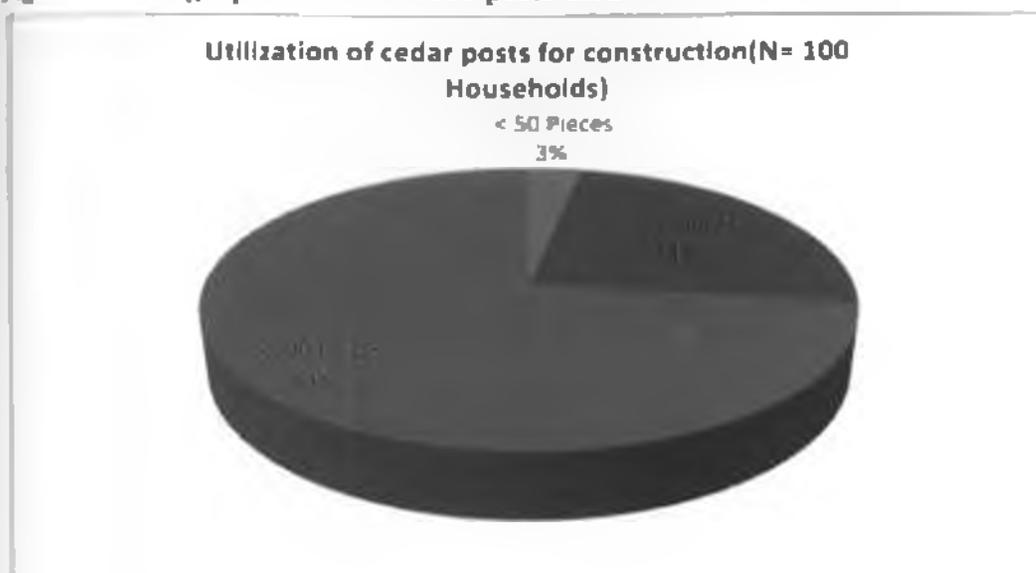
### 4.3.2 Demand for construction materials

Cedar and Olive populations are on the decline in both settled and control areas, but more rampant in the settled area. Lorroki forest which was the research control area has also been experiencing pressure due to increasing natural resources demand. Transitions of households from pure pastoralism to sedentary lifestyles especially along the peri-urban areas, witnessed changes in living standards by many community members where human settlement induced high demand for housing, and proportional increase in demand for construction materials.

Hundred percent of interviewed households reported use of cedar to construct their housing structures. The above categories of utilization are only representation of housing requirements at the household level. During the transect walk, it was observed that cedar is also the sole roof thatching material for rural dwellings. Debarking is a common practice where most of the ring barked cedar trees die then utilized for posts thereafter. Utilization for farm land fencing and livestock structures have not been factored in as part of household requirements. Farm lands are fenced using cedar off cuts all round. If a household has on average two acres of land under crop cultivation the perimeter fence is made of cedar off-cuts. This situation doubled the demand for cedar posts where each household requires on average five hundred to one thousand cedar off-cuts (*Field data 2009*). Livestock pens are constructed using the same forest resource meaning domestic demand for cedar tree keeps on surging.

Fig 6 reflects that only 3% of the interviewed households use less than fifty cedar posts to construct their houses. 24% use one hundred pieces while 73% reported to use over one hundred pieces of cedar posts to construct their houses. This signifies that higher percentage of households use over one hundred cedar posts meaning that as population continues to settle, the demand for cedar will proportionally be increasing with the emerging settlements.

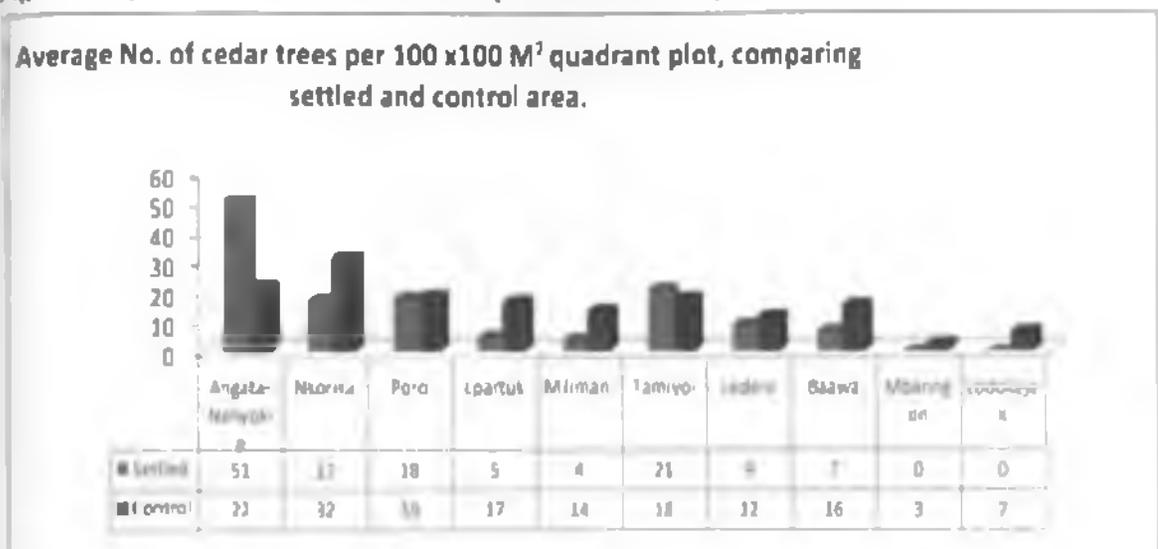
Figure 6: Average quantities of cedar posts used for house construction.



Source: Field data 2009

Fig 7 indicates a variation in cedar tree population densities in quadrant within the settled area as compared to control area. Angata-Nanyokie, Nkorika, Poro and Tamiyoi indicate fair population densities of cedar trees within the human settlement areas. Angata Nanyokie accounts for 39% of the average cedar populations in settled area. The lower zones of Baawa, Mharingon and Lodokejek recorded no standing trees within the plots around human settlements. Reasons were, vegetation cover around the settlement is mainly shrub land unlike in the control area which is mainly closed canopy forest. Nkorika had an average number of 32 stems per plot followed by Angata Nanyokie with average of 22 and Poro had 19 in the control area plots.

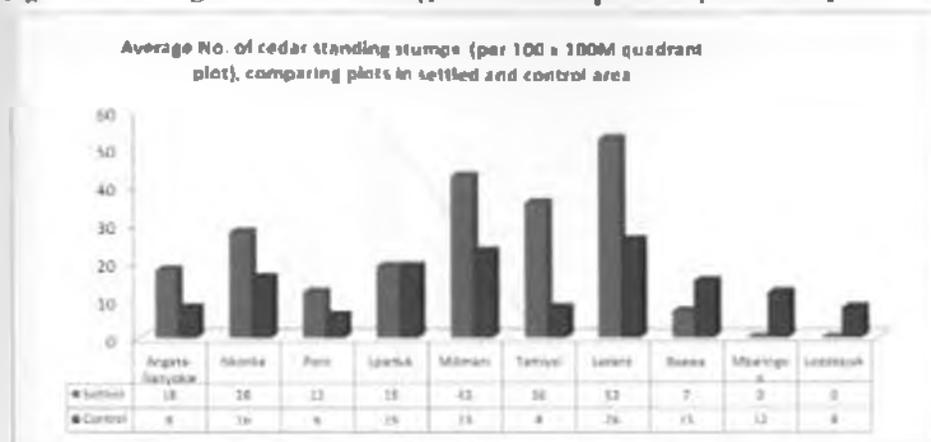
Figure 7: Population densities of cedar trees per 100x100m, comparing settled and control area.



Source: Field data 2009

Fig 8 identifies rampant deforestation rate in human settlement areas of I partuk, Milimani, Tamiyoi and Lederero that are closer to Maralal town meaning commercialization of forest resources is a factor in deforestation. Proximity to urban centers was observed to have influence in cedar tree cutting down. This is clearly illustrated by fig 4.4 which identified higher cedar population densities in settlements far away from Maralal town and the vice versa of the same in the number of standing stumps where the settlements around the urban centers recorded higher number of stumps per plot. Lederero, Milimani, and Tamiyoi had 53, 43, and 36 numbers of cedar stumps per plot respectively which were the settlements with the highest. Nkorika had average number of 29 stumps per plot equally high but the researcher observed that, high numbers of cedar stumps in these plots were as result of forest fires incidences over 70% while cutting down accounts for the rest (*Field data 2009*). Deforestation rates were higher by 16% around the human settlement areas as compared to the control area. Mbaringon and Lodokejek had no cedar trees within the human settlement areas but households access the tree within the control area thus deforestation is higher in the control area.

**Figure 8: Average No. of standing cedar stumps in a quadrant plot of 100 x 100m**

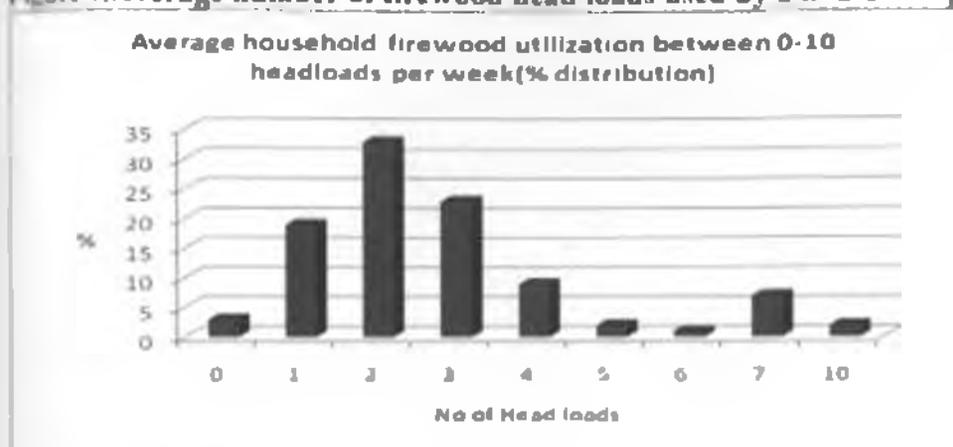


Source: Field data 2009

#### 4.4 Households energy consumption patterns.

Changes in lifestyle among the settling pastoral communities, translates to change in resources utilization patterns including household's energy requirements. Hundred percent of the interviewed households reported to depend on wood fuel for their domestic requirements. The research reflected increase of average number of firewood headloads per household to 2 per week. The tree species that is commonly used for fire wood is the olive which is known for its good calorific value. Cereals and legumes constitute over 75% of the households food profile and livestock products only accounts for 25% unlike the period before sedentarization where the diet was mainly livestock products for pastoralists(GoK 2009). Fig.9 explains that only 18% of the households interviewed utilize one head load per week, 35% utilize two headloads per week and 22 utilize three headloads per week. 6% reported to utilize seven headloads per week. During focus groups discussions(FGDs), the groups explained that the energy consumption at the household level has been exacerbated by upcoming petty trade in illicit brewing. Where on average the households engaged in illicit brewing use between seven and ten headloads per week.

**Figure 9: Average number of firewood head loads used by a household per week.**



Source: Field data 2009

#### 4.4.1 Utilization of olive

Charcoal burning especially in communities living around Maralal town is on increase every season reasons being livelihood drop outs always adopt this as an immediate means to diversify income sources for their households. Milimani, Tamiyoi and Ipartuk settlements are the leading in deforestation activities for the olive tree due to high charcoal burning incidences. In other settlements areas of Angata-Nanyokie, Poro, Nkorika, Lederu, Baawa, Mbaringon and Lodokejek firewood and cutting down of olive for livestock forage are the main reasons for olive deforestation. This is exhibited by the rate of deforestation of olive in the plots.

The number of standing stumps in Fig.10 identify Milimani to have registered 53, the highest average number of standing stumps per quadrant within the settled area. Tamiyoi 30, Lodokejek 30, and Ipartuk 19. While in the control area, same areas of Ipartuk, Milimani and Tamiyoi recorded the highest numbers of standing stumps of 35, 23, and 18 respectively. The proximity to Maralal town where charcoal demand is high, remains a factor behind these trends. The researcher observed that cutting down of olive for livestock feeds was the main reason noted in Lodokejek, unlike in the other three settlements where charcoal burning is main reason

#### Hypothesis testing

$H_0$

There is no significance difference in diameters at breast height (DBH) of olives in settled and control area.

Student's t test

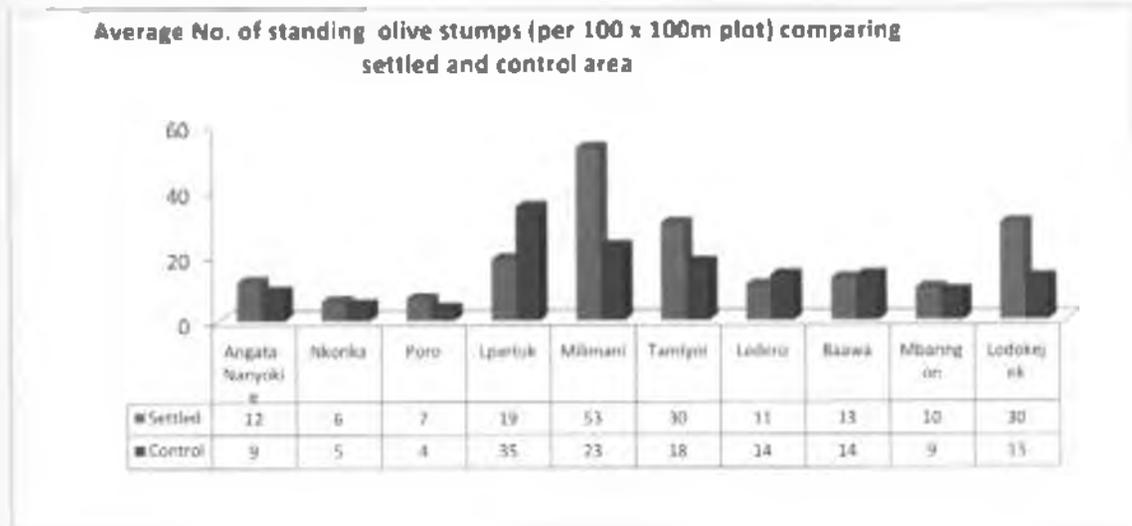
Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Settled and Control	35.500	34.1180	6.2291	48.240	22.760	5.699	29	.000

Since t calculated 5.699 is greater than t- tabulated 1.699 at significance level of 0.05 or 5% and 29 degrees of freedom, we reject the hypothesis. Implying there is significant difference in means DBHs of olive in settled and control areas.

The research highlights the difference in the type of regeneration available within settled area and control area. This signifies that higher population densities of olive in the control area have attained optimum girth growth unlike the trees around the human settlements where human activities are destabilizing the growth, including high rate of deforestation. Growing demand for wood fuel especially charcoal, is attributed to the significance differences in diameters in olive trees within the human settlement areas and the control area.

Figure 10: Average No. of standing Olive stumps in a quadrant plot of 100 x 100m

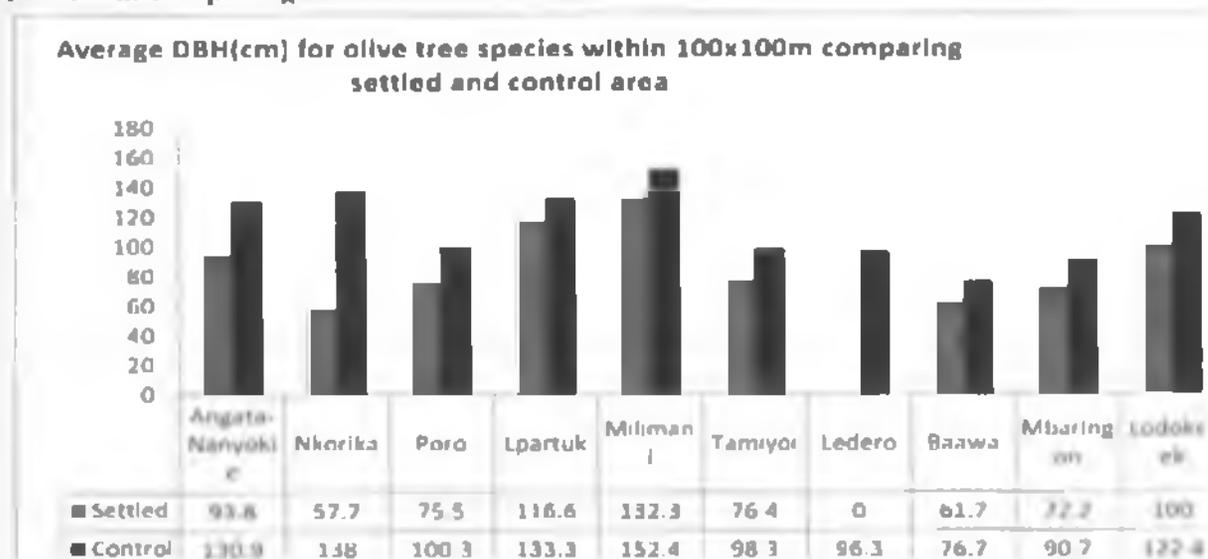


Source: Field data, 2009

Mean diameters of 78.6 cm in settled areas were recorded compared to mean diameters of 113.9cm registered in control area. Fig 11 depicts the maturity levels attained by the olive tree species in the forest reserve as compared to the low girth growth achieved around the human settlement area. High demand for wood fuel coupled with income sources diversification by

households, is attributed to increased rate of deforestation rate around the human settlements. Ledero settlements were disadvantaged as they recorded no standing olive stems for diameter measurements. This is due to low populations density per sample plot and high deforestation activities. Milimani and Lpartuk had the highest mean diameters in cm of 132.3 and 116.6 cm respectively. The same settlements have low average olive population densities but characterized by higher mean diameters as compared to the rest of the settlement areas.

Figure 11: Average diameter at breast height (DBH in cm) for olive tree species within 100x100m comparing settled and forest reserve.

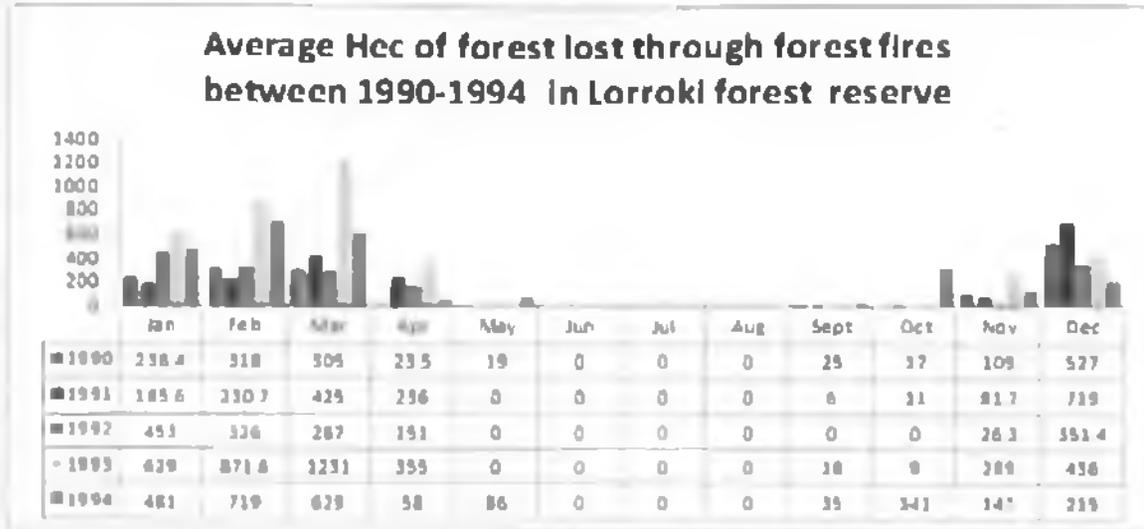


Source: Field data 2009

#### 4.4.2 Vegetation Fires

Forest fires occurrence is blamed for losses of biodiversity in Lomoki plateau especially within the forest reserve. Fires incidences have been common during the dry season when vegetation flammability rate is high. It was difficult for the researcher to access historical data on fires occurrence, however managed to get between 1990 and 1994. Fig 12 reflects seasonal vegetation fires occurrence where the pattern is in line with the rainfall pattern which is spread between March and August in a normal year. The concentration was therefore designated on the first quarter (Jan-March) and the last quarter (Oct-Dec) of the years. 1993 was the year which experienced extensive fire incidences total haeterage lost was 12311hec. On average, 193.7 hect of forest cover was lost between 1990 and 1994.

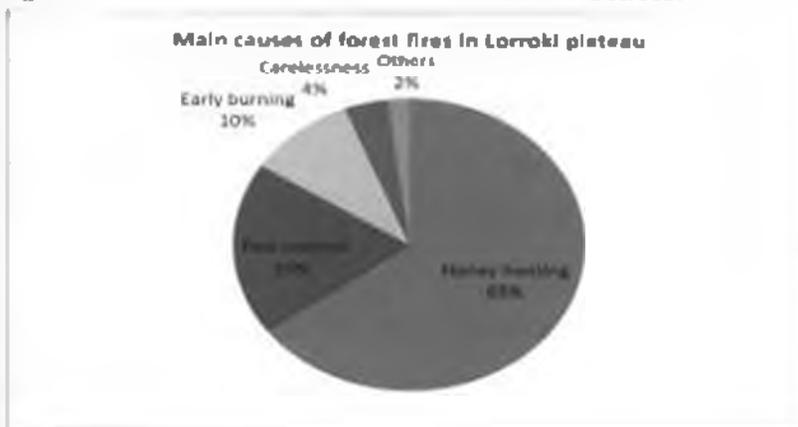
Figure 12: Forest fire occurrence and average losses in Hect in Lorroki forest reserve



Source: District forest office-Samburu (2007)

In Fig 13, honey hunting in the forest is the main cause of vegetation fires in Lorroki forest reserve causing 65% of the incidences reported. Quite often pastoralists set the vegetation on fire as measure to control pests e.g ticks this was reported to account for 19% of the causes. Early burning is common just before the onset of the wet season where pastoralists set on fires for lush and fresh vegetation regeneration during the onset of the rains in favour of livestock pastures. Carelessness and fires mishandling cause 4% and other reasons cause 2%. Lorroki forest reserve and communally own forests ecosystems, have been destabilized by wild fires incidences that has often led to losses of biodiversity.

Figure 12: The main causes of forest fires incidences.



Source: Field data 2009

#### 4.5 Impacts of human settlement on soil conditions

Soils samples were collected from the developed quadrants in the center of the plots. The center was determined by taking the diagonal measurements of the plot to the core. 500grams soil sample from half inch depth was collected, packed and delivered to Kenya Agricultural Research institute (KARI) national soils laboratory for complete soils analysis. The analysis took an average of ten working days then the results were made available. Soils fertility is dependent on the level of land degradation, where humus and soils organic matter, macro-nutrients and cation exchange capacity (CEC) determine fertility levels. While carrying out the soil analysis, there are other factors the research assumed that they remain constant that include livestock waste disposal mechanisms, the diversity of plants species especially those with nitrogen fixing qualities among others.

#### Hypothesis testing

H<sub>0</sub>

There is no significant difference in means of soil organic matter around human settlements of Lorroki plateau, compared to the means of soil organic matter in control area.

#### Student's t-test

##### Paired Samples Test

	Paired Differences					t-c	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Settled and Control	- .20013	.253271	.046241	-.29471	-.10556	4.328	29	0

t- Calculated stands at 4.328 and t-tabulated is 1.699 at 0.05 or 5% significance level and 29 degrees of freedom. We therefore reject the hypothesis, meaning there is a significance difference in means of soil organic matter in the settled and control areas.

The test signifies that there is a significant difference in means of soils organic matter in the settled and control areas. This clearly illustrates that soils cover around the human settlement are affected by human activities. Though there are many other factors that may be in play in determining the soil organic matter levels, microbiology is a pertinent part which is greatly affected by human activities as well. Biodiversity is an important component of soil organic matter levels and directly affected by human activities.

Though soil humus conditions are generally low in both settled and control areas, as per standard value of 1.5ppm (KARI 2009), mean rates in settled areas are generally lower as compared to the control area. This situation explains soils degradation level induced by human activities through increased settlement leading to declining soil humus conditions. This assumes that other factors like the soils micro-biology, plant species composition among others are inhibited by human activities.

$H_0$

Cedar trees mean DBH have strong relationship with mean soils humus level

Hypothesis testing to determine if the cedar DBH has relationship with soil humus levels was carried out. Simple linear regression was used to determine the relationship.

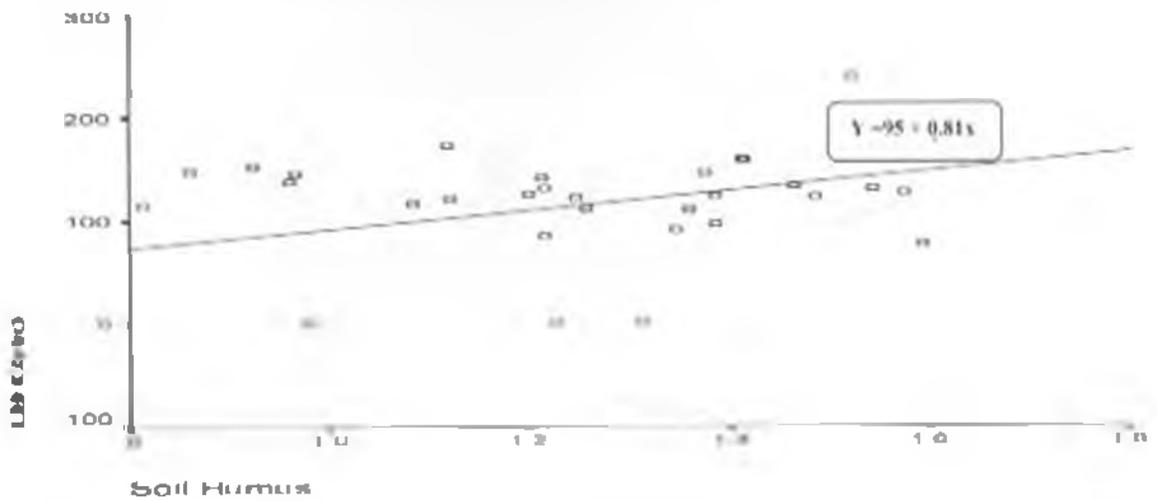
Table 2 gives the results of regression and Pearson correlation where ( $r$ ) was 0.81 and adjusted ( $r^2$ ) was 0.656. The  $r$  is a measure of the strength of the association. The computed  $r$  is 0.81 which means a strong positive linear correlation between the DBH in control area and soil organic matter level in control area. The computed  $t$ , with  $df$  of 29 at 0.05 significant level was 0.427 while the tabulated  $t$  was 1.699 in one tailed test and 2.02 in the two tailed tests. Testing the hypothesis at 0.05 significant level and 29 degrees of freedom, since  $t$ -calculated is less than the  $t$ -tabulated, we reject the hypothesis. This means that in the control area, the soil organic matter strong correlation with mean DBH was a chance event and the regression of DBH on soil organic matter level is not significant.

**Table 2: Regression and Correlation analysis**

Regression and Correlation analysis	Pearson correlation( $r$ )	Adjusted ( $r^2$ )	$t$ ( at 0.05 level of significance and 29df)		
			Calculated values	df	Tabulated value
DBH of cedar in Control and Soil humus level in Control area	0.81	0.656	0.427	29	1.699

Fig 14. Explains the regression equation derived from the simple linear regression.

Figure 14: Scatter Graph with line of best fit (Regression equation)



The regression equation is  $Y = B_0 + B_1X$

Where

$Y$  - the mean DBH of cedar

$B_0$  - the y intercept

$B_1$  - the slope

$X_1$  - mean soil humus

The line of best fit  $Y = 95 + 0.81x$

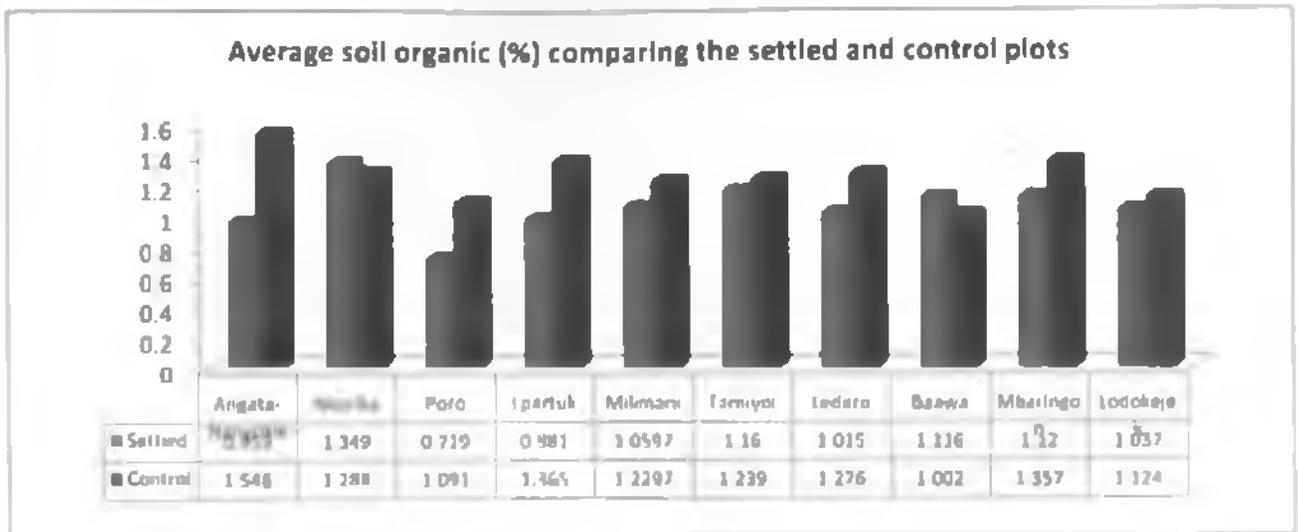
In the regression model, however, the  $r^2$  of 0.656 indicates that changes in soil organic matter level accounts for 65.6% of the total variation in DBH. Meaning the variation in DBH in the control area is explained by other variables not included in the simple linear regression model implying the association is non-linear.

#### 4.5.1 Impacts of human settlements on soils macro-nutrients

##### 4.5.1.1 Soils organic matter

Fig 15 reflects the soils organic matter levels both in the settled and control areas. With exception of Nkorika and Baawa, the rest of the settlements recorded lower humus levels as compared to that in the control area. This signifies that human activities are playing a role in humus levels of the soils around the settlements unlike in the control area. The soil microbiology is greatly affected by human activities which ultimately affects the soils properties.

Figure 15: Average soil organic matter levels settled verses control



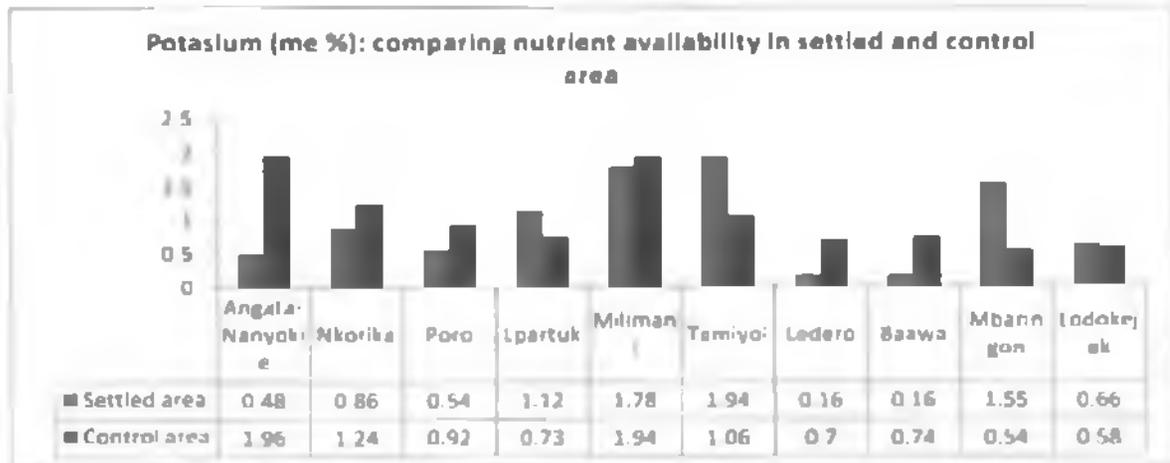
#### 4.5.1.2 Potassium

Fig 16 illustrates the imbalances of soils Macro nutrients availability particularly potassium in the settled area as compared to control area which is less destabilized by human activities. Milimani, Lamiyoi, Mbaringo and Lodokeje registered higher levels of potassium in human settled areas as compared to the control area. The standard measures soil potassium (me %) the categories commonly used are less than ( $\leq 0.4\%$ ) is regarded as low, 0.5-1.5% adequate and above ( $>1.5\%$ ) is regarded as high. Lederu, Ipartuk, and Baawa settled areas were under low category. While plots in the control area fall either under adequate or high categories. Good potassium nutrition is linked to improved drought tolerance, improved winter hardiness, better resistance to certain fungal diseases, and greater tolerance to insect pests. Potassium deficiency is relatively easy to detect compared to deficiencies in phosphorous. The tips and edges of the oldest leaves begin to yellow (chlorosis) and die (necrosis), so that the leaves appear to have been burned on the edges (Brady and Weil, 1999).

The original sources of potassium are the primary minerals, such as micas (biotite and muscovite) and potassium feldspar (orthoclase and microcline). As these minerals weather, the potassium becomes more available as readily exchangeable and soluble potassium which can be absorbed by plants roots. At any one time, most soil potassium is in primary minerals and non-exchangeable forms. In relatively fertile soils, the release of potassium from these forms to the exchangeable and soil solution forms that plants can use directly may be sufficiently rapid to keep plants supplied with enough potassium for optimum growth. (Brady and Weil, 1999).

Vegetation cover in degraded soils is therefore susceptible to potassium deficiencies. Settled areas of Ledero, Lpartuk, and Baawa are the most vulnerable to elements deficiency and farmers need to be advised to supplement the element in their crop land.

Figure 16: Potassium nutrient; comparing the nutrient's availability within settled and control area



Source: Field data 2009

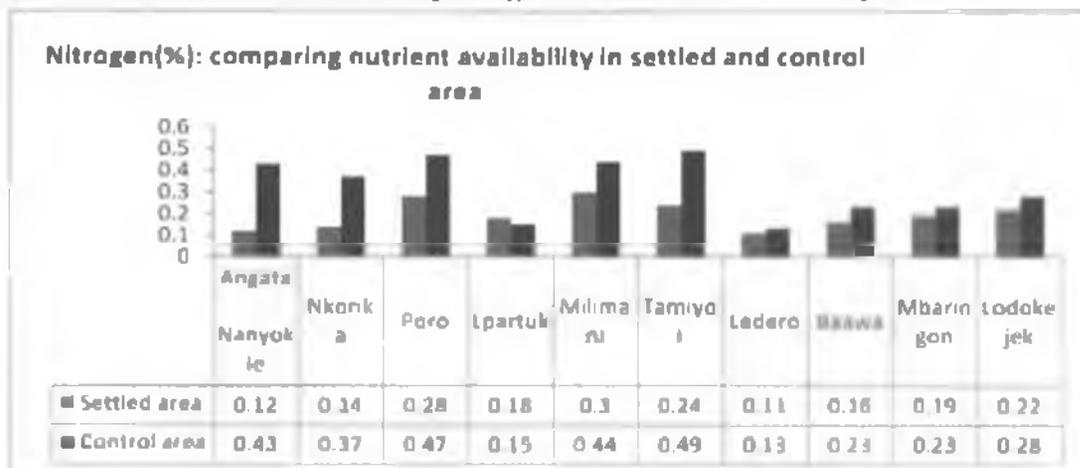
#### 4.5.1.3 Nitrogen

Fig. 17 compares nitrogen soil conditions within the settled and control areas. Lpartuk settlement was the only settled area that recorded slightly higher nitrogen levels by 5.5% as compared to the control area. The difference is quite insignificant in settled and control area in Lpartuk. Nitrogen availability is however higher in control area in the rest of the plots. Human settlements are attributed to the observed low trend in nitrogen nutrient around the human settlement areas. Lpartuk and Ledero control areas registered the lowest nitrogen levels of 0.15% and 0.13%.

Concentration of humus in topsoil horizon allows for relatively rapid conversion of organic nitrogen to soluble nitrate ( $\text{NO}_3^-$ ) and is subject to leaching or conversion to nitrogen gas (*denitrification*) which volatilizes out of solution into the atmosphere. Thus, when stored topsoil is spread on a disturbed landscape, nitrogen reserves may be depleted or altered by several chemical and biological phenomena and the healthy cycling of nitrogen through the ecosystem inhibited or prevented (Munshower, 1994). Nitrogen in soils can be in various different forms. Nitrogen is very dynamic and is constantly changing chemical species and concentrations. In most soils, nitrate is the common ionic form of plant-available nitrogen, but this element may also exist as ammonium ( $\text{NH}_4^+$ ) or nitrite ( $\text{NO}_2^-$ ) as well as other ions. Nitrogen is also incorporated in organic matter and microbes. When organic matter decomposes by microbial

processes or when the microbes themselves die and decompose, nitrogen is released in various forms into the soil solution (*Brady and Well, 1999*).

**Figure 17: Nitrogen nutrient; comparing the nutrient's availability within settled and control**

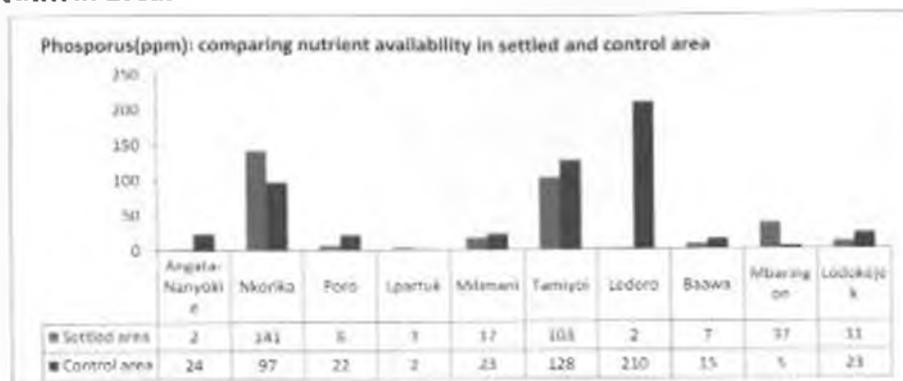


Source: Field data 2009

#### 4.5.1.4 Phosphorus

Like the other two nutrients, the trend is the same where most of the control areas reflected higher phosphorus levels as compared to settled areas. This is with exception of Nkonika which was higher by 5.9% and Mbarin gon was higher by 92%, which exhibited higher nutrient levels as compared to control areas Fig 18. Like nitrogen, phosphorus (P) is an essential part of the process of photosynthesis. The nutrient is critical in formation of all oils, sugars, starches among others. Helps with the transformation of solar energy into chemical energy; proper plant maturation; withstanding stress. Effects rapid growth encourages blooming and root growth. Deficiencies therefore affect vegetation development where regeneration is hindered by high levels of deficiencies in the soils.

**Figure 18: Phosphorus nutrient; comparing the nutrient's availability within settled and control area.**



Source: Field data 2009

#### 4.5.2.1 Conservation measures

Despite the evident environmental degradation activities due to human settlement in the plateau, minimal efforts are currently engaged to reverse the degraded soils conditions around both settled and the forest reserve areas. Tables 3 expound on the conservation measures adopted by interviewed households where 32% of the interviewed households reported practicing soil conservation measures in their farm land. The other 68% do not practice soil conservation measures

**Table 3: Percentage of households practicing soil conservation measures**

Households practicing soil conservation measures	Frequency	Percentage
Yes	32	32
No	68	68
Total	100	100

Source: Field data 2009

## 4.6 Impacts of environmental degradation on local livelihoods.

### 4.6.11. Land uses patterns

Pastoralists are further displaced because of expansions in Agriculture, urbanization, and other social amenities infrastructure including protected reserves. Sedentarization in Lorraki plateau is largely blamed for vegetation change. The same experience was shared in Wajir district, where the creation of many administrative locations with many chiefs caused severe land degradation with each chief wanting to develop the location. Water development became the common priority for each location then sedentarization of pastoralists take place and the end result is land degradation (UNEP 2000). Table 4 indicates that average land placed under utilization for domestic uses increased to an average of 7 acres for household settlement, crop cultivation, and livestock holding among other uses. Over 50% of the interviewed households reported to occupy 1 acre and less. While less than 10% have a land holding of more than 10 acres and less than 25 acres. The trend clearly reflects that the land available for grazing continues to shrink day by day as new land uses emerge.

Table 4: Average land holding and utilization per household

Acres	Frequency	Percentage (%)
0.25	1	1
0.5	13	13
0.75	2	2
1	36	36
1.5	11	11
2	9	9
3	6	6
4	3	3
5	4	4
7	3	3
8	3	3
10	2	2
15	3	3
24	2	2
25	2	2
<b>Average = 7.13</b>	<b>100</b>	<b>100</b>

Source: Field data 2009

#### 4.6.2 Changes in income sources

Sale of crops and livestock were reported to control only 6 and 14 percent respectively of the income sources as reflected in table 5. This means other income sources are coming into play dominating livestock sales that has been the main income source for pastoralists. Charcoal burning stands at 12 percent and casual labour remains the main source of income at 29 percent. This clearly illustrates that natural resource based livelihoods are threatened by ongoing environmental degradation activities in the plateau leading to livelihoods drop out who at the end depend other sources of living which degrade the environment. The main casual labour available is land cultivation which is commonly characterized by opening up of land for crop production. Opening up of new fields for crop production, entails vegetation clearing thus destabilizing the ecology.

**Table 5: Income sources at the household level**

Income source	Frequency	Percentage
Sale of crops	6	6
Sale of livestock	14	14
Casual labour	29	29
Sale of charcoal	12	12
Sale of wood products	3	3
Remittances	7	7
Gifts	3	3
Employment Salary	18	18
Petty trade	8	8
Total	100	100

*Source: Field data 2009*

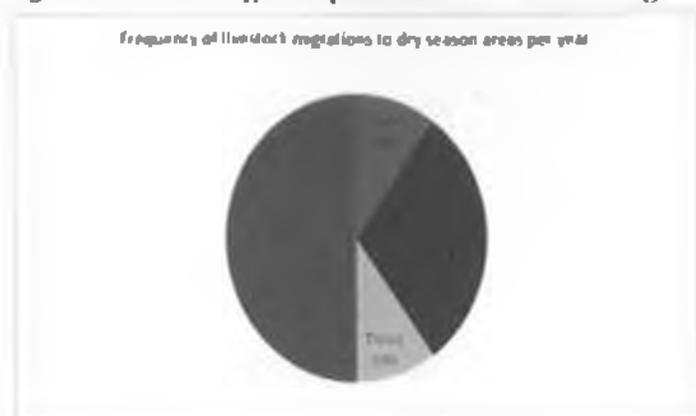
#### 4.6.3 Impacts of environmental degradation on livestock production

Frequency of livestock migration to dry season grazing areas within and outside the district's dry season grazing areas has not only increased but force cattle herds to remain away the whole year. Increased distances to dry season grazing areas coupled with frequent livestock migrations have led to high livestock mortality rates across all species. Failure of the soils to support vegetation regeneration as a result of sustained degradation is attributed to increased frequency of livestock migrations. Fig.18 depict that fifty percent of households interviewed reported their cattle to have migrated the whole year. Meaning a half of the settlement areas was unable to sustain livestock for a whole year thus migrating to other areas.

Most of these dry season grazing areas are commonly characterized by insecurity, and cattle rustling hotspots. This situation has subsequently led to losses of cattle by pastoralist to the

rustlers, impoverishing the livestock keepers. The initially designated areas for wet and dry season areas are no longer available as human settlement and agricultural activities currently take first priority in planning for land uses.

**Figure 19: Percentage frequencies of livestock migrations**



Source: Field data 2009

#### 4.6.4 Impacts of environmental degradation on crops

Table.5 indicates high variability in maize and beans production between 2003 and 2008 in Lorroki and Kirisia divisions/plateau. Other factors however have been in play, like insecurity, and high rainfall variability among others but soil infertility attributed to land degradation is the main factor behind varied crop yields for the last five years. The population that practices crop production stands at 29.2 percent with an average of 0.8 acre land size holding in Lorroki plateau (GioK, 2006). Poor crop performance due to environmental degradation is already affecting food security situation among these households. While average cattle herd size owned per households is 5.4 dropping from an average of fifteen in early 1980s a situation attributed to unfavorable livestock production in the plateau.

**Table 6: Crop production in Lorroki and Kirisia Divisions for the last 5 years (90 kg bags per ha.)**

Crop production in the last 5 years (90 kg bags per ha.)													
Lorroki Division													
Crop	Year	2003		2004		2005		2006		2007		2008	
		L/R	S/R	L/R	S/R	L/R	S/R	L/R	S/R	L/R	S/R	L/R	S/R
Maize	Planted ha.	780	10	800	15	730	10	150	116	650	12	600	10
	Total Prod.	12480	200	3000	75	12750	100	900	116	7800	126	1000	80
Beans	Planted ha.	150	15	150	10	130	15	5	18	412	6	300	10
	Total Prod.	900	75	300	30	1806	60	20	72	4120	8	600	50

Crop production in the last 5 years (90 kg bags per ha.)													
Kirisia Division													
Crop	Year	2003		2004		2005		2006		2007		2008	
		L/R	S/R	L/R	S/R	L/R	S/R	L/R	S/R	L/R	S/R	L/R	S/R
Maize	Planted ha.	1340	5	1420	5	1500	0	600	5	1600	10	480	280
	Total Prod.	21440	100	7100	25	28500	0	4800	50	12800	80	2000	1200
Beans	Planted ha.	295	10	350	15	400	0	150	3	400	100	330	80
	Total Prod.	1770	50	700	60	1600	0	300	12	1600	500	1342	320

\*L/R - Long runs \*S/R-Short Runs

Source: District Agricultural office Samburu Central (2009)

## CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

### 5.1 CONCLUSIONS

From the research findings it's evident that human settlement in Lorroki plateau continues to bear negative impacts on the environment. The two main livelihoods of pastoral and Agro-pastoral are threatened as they are natural resource base. Despite the appreciated development in most parts of the plateau, it's sad to note that this has happened at the expense of the environment. Deteriorating soils fertility conditions, depletion of cedar and olive trees are sufficient evidence that human settlement continues to impact negatively in Lorroki plateau ecology. As pastoralists settle, natural resources diminish very fast.

The research confirms the Malthusian theory on human population and land degradation. Lorroki plateau has suffered the same trend where population growth induced exogenous pressure on land and other natural resources bringing about ecological imbalances. Contrary to the study in Machakos by Tiffen where technological innovations were reported to have impacted positively on the ecology (Tiffen 1994), Lorroki's ecosystem is threatened.

The research revealed significant differences in means of diameters at breast height of both tree species in the settled area and control area. This clearly depicts the levels of deforestation of the older regenerations of both the olive and cedar tree species around the human settlement areas. Variation in diameters in control and settled areas indicates that it's only within the control area where ideal rotation age and optimum growth is achieved. In the settled area, maturing trees are utilized for construction and wood fuel. This does not mean that deforestation is restricted on the settled area only but it's practiced more around the human settlements. It is observed that environmental relationships are much more complex and it is highly interactive-that is Holocoenoitic. Vegetation is regarded as the most important living organism; vegetation supports the food chain pyramid by converting energy from the sun to all other living organism.

The dead vegetative matter is the basis on which humans depends. This is the source of soil fertility which promotes growth. Vegetation is the foundation of the hydrological cycle. Any nation and community that destroys vegetation cover chokes itself to death, intergenerational destitution will thus be inevitable. The differences in the means of soils organic matter within the human settlements areas and the control area were also observed as significant. Human activities

around the settled area are attributed to declining soil organic matter levels which in turn impacts negatively on the soils properties including the nutrients levels. Soils macro-nutrients deficiencies were generally common around the human settlement a situation that is attributed to low organic matter levels in the soils as depicted by the study.

This trend is not the best, taking into account that the available livelihoods have their foundation being natural resources. A new thinking therefore needs to be in place to facilitate a paradigm shift in development process cycles, where environmental concerns should form basic part of developmental agenda in the plateau. There is need to have environmental responsive society with a new vision of caring capacity in planning (Savory 1999). This should help a society to achieve an enhanced quality of life through several strategies such as promoting equality, promoting small family sized households and promoting sustainable use of resources. Equitable access and control by all community members will go a long way in ensuring concerted efforts in conservation of the available natural resources in the critical eco systems in Lorroki plateau. Sustainable development should be able to provide a balance between the development and ecology, ensuring intergenerational equity of natural resources (WEC'D 1987).

Zimmerman (1933) introduced a functional interpretation of resource which is still relevant. He argued that neither the environment as such nor part of the environment is "resources until they are, or are considered to be capable of satisfying mankind need". Resources are appraisal of resources and present an entirely subjective concept. This subjectivity is squarely determined by mankind because a resource becomes a resource when it is available for human use not merely by its physical presence. The transition process of the pastoralists to sedentary lifestyle in the plateau is a good example of the above interpretation by Zimmerman. Resources exploitation is taking place rapidly, accelerating the fragile ecosystems degradation in the plateau.

This ability to exploit resources is influenced by our art and sciences in other word our level technological development. This relationship has three important components: Resources are not, they become, and they are not static but expand and contract in response to human wants and actions (Zimmerman 1951). Lorroki plateau is experiencing such a situation where communities are rapidly identifying and exploiting resources unsustainably. A good example is the recent unselective clear felling of sandal wood (*Osyris lanceolata*) for commercial purposes in areas around Angata-Nanyokie. Other exploitation of natural resources that is not sustainable.

## **5.2 Recommendations**

### **5.2.1 Recommendations for policy makers and development actors**

#### **5.2.1.1 Strengthening traditional institutions**

There is need to integrate the formal institutions with the traditional ones in order to build participatory natural resource management.

#### **5.2.1.2 Promotion of energy saving and alternative energy techniques**

Local communities need to be supported with energy saving techniques in order to reduce fire wood demand. This should target both rural and urban areas in order to reduce daily household fire wood demand. Promotion of energy saving jikos which utilize minimal quantities of fuel wood among other techniques need to be promoted in urban areas. Energy saving liners and proper cooking techniques are but a few techniques that need to be promoted in rural areas. For settled rural households, biogas and solar cooker promotion would be the best alternative energy at the household level.

#### **5.2.1.3 Adoption of modern bee-keeping**

Over 65 percent of forest fires were reported to have been caused by honey hunting activities in the forest (GoK 1999). Modern bee-keeping techniques would salvage the forest fires hazards situation. Various development partners' efforts in promoting apiculture among the local communities have had positive impact in minimizing forest fire incidences, however a lot more need to be done in order to arrest such menace. Besides being a measure to control forest fires, promotion of apiculture would also diversify household's income sources. An established honey refinery around Muralal town, need to be supported to realise its full potential by being accessible to larger catchment area.

#### **5.2.1.4 Decentralized service delivery**

One of the main causes of human settlement in Lortoki plateau was found to be access to services by local communities around the district headquarters. There is need to decentralize basic services e.g. health, education through establishment of service centres at the local levels. Local service support funds should be directed to achieve this objective, in order to control movements of pastoralists into the plateau and urban centres.

#### **5.2.1.5 Sustainable agriculture**

Agro-pastoralists need to be enlightened on sustainable agriculture techniques in order to minimize soil erosion and soil degrading cultivation practices. Promotion of mixed farming would enhance optimal production. Use organic fertilizers and integrated pest management (IPM) approaches need to be promoted.

#### **5.2.1.6 Promoting integrated land use planning**

Land uses are increasing along with human settlements experienced in the plateau for the last twenty years. Advance plans to plan and accommodate emerging land uses should be a priority to all stakeholders in order to create harmony.

#### **5.2.1.7 Promotion of alternative construction techniques/materials**

Elastic demand for natural resources for construction characterizes the human settlements in the plateau. There is need therefore to promote sustainable use of natural resources, by reducing the quantities of natural resources used by growing populations for construction. This can only be achieved through promotion of alternative construction materials like, stabilized soil blocks, metallic roofing materials, interlocking soil blocks, among other techniques that minimize the use of posts and timber. Awareness creation on the need for communities to adopt live fencing materials instead of currently used cedar posts fencing materials.

#### **5.2.1.8 Promotion of non consumptive uses of natural resources**

In order to minimise human wildlife conflicts, communities should be facilitated to tap the existing tourism potentials in particular parts of the plateau through eco-tourism. Baawa settlement is already a head in eco-tourism activities which should be replicated elsewhere.

#### **5.2.1.9. Supporting rehabilitation activities**

Degraded sites should be reclaimed through concerted efforts in afforestation and reseedling activities. Conservation of catchment areas should be an immediate priority in order to control surface run-offs.

### **5.2.2 Recommendations for researchers**

#### **5.2.2.1 Causes of cedar die bark**

There is need for research institution (KIFRI) to disseminate the research findings on cedar dieback in the plateau.

#### **5.2.2.2 Soil fertility**

Complete soil fertility analysis need to be carried out especially in the upper parts of the plateau where large scale wheat production has been taking place, in order to advice the farmers on deficiencies correction measures.

#### **5.2.2.3 Alternative construction materials**

Continuous research should be sustained in order to provide alternative materials and appropriate and cheaper construction technologies

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# ANNEXES

## 1.0 Olive DBH (CM)

Settled	Control
93.8	100.9
147.2	126.4
82.7	138.0
64.6	142.0
75.5	100.1
82.3	112.4
119.6	135.3
85.0	124.0
132.3	132.4
69.0	146.0
76.0	98.1
52.0	121.8
0	96.1
0	112.0
61.7	76.7
48.0	117.0
18.0	90.7
42.0	132.0
100.0	122.1
12.0	85.6
76.0	78.0
142.0	136.0
92.0	84.8
68.0	100.1
70.0	72.0
56.0	98.0
81.0	91.0
124.0	128.0
86.0	98.0
121.0	111.0

## 1.1 Cedar DBH (CM)

Settled	Control
112.5	109.0
76.4	259.4
80.1	126.4
96.1	148.2
83.0	76.7
104	159.1
132.2	118
98.5	117
81.7	116.8
92.1	121.3
77	122.8
58	124
102	0
118.1	137.4
60.6	0
76.2	85.6
56.8	96.3
0	174
0	112
0	142.7
76.6	111.1
121.6	157.8
98.4	122
122	146
96	157.8
76	90.7
65	114

## 1.2 Soils organic matter levels(%)

Settled	Unsettled
0.860	1.542
1.063	1.923
0.954	1.574
1.302	0.861
1.461	1.592
1.284	1.411
0.631	0.813
0.423	1.004
1.103	1.375
0.954	1.464
0.845	1.246
1.144	1.386
0.961	1.226
1.342	1.485
0.876	0.978
1.118	1.214
1.415	1.384
0.948	1.318
1.054	1.256
0.865	1.213
1.125	1.359
0.987	0.923
1.312	1.319
1.040	0.965
0.980	1.415
1.146	1.345
1.234	1.311
0.891	1.214
0.945	0.960
1.275	1.198

# HOUSEHOLD BASED QUESTIONNAIRE (A)

1 District Name \_\_\_\_\_ 2 Division \_\_\_\_\_  
 3 Sub location \_\_\_\_\_ 4 Location \_\_\_\_\_  
 5 Name of Household \_\_\_\_\_ 6 Livelihood \_\_\_\_\_  
 7 Date \_\_\_\_\_  
 GPS Readings \_\_\_\_\_

## 1. DEMOGRAPHIC CHARACTERISTICS

1.1	Average household members in you household?	_____
1.2	How long have you lived in this community?	_____
1.3	Which sub-location did you come from before migrating into this community?	_____
1.4	Reasons for your movement into this community?	1. Insecurity 2. Access to social services 3. Access to natural resources 4. Others

## 2. Livestock

2.1	Does your household keep any livestock? 1. Yes 2. No (if No Skip to sec3)	_____
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Animals	Total Herd Size Today	Number Born during last 3 months	Number died during last 3 months	Main reason of death 1. disease 2. drought 3. conflict 4. predation 5. other	Average daily milk production in last 3 months (in 750ml bottles)
Total cattle					
Total Camels					
Total goats					
Total sheep					
Total Milk					

2.2	Who has been drinking milk in your household? (in the last 3 months)	1. Everybody 2. Only children 3. No one   _____
2.3	How has seasonal milk production situation been compared to the last 10yrs?	1. High 2. Fair 3. Low   _____
2.4	If milk production is low what factors are attributed to this?	1. Lack of pastures and water 2. Frequent livestock diseases out break 3. Insecurity 4. Others   _____

## 3. INCOME SOURCES

*List of the Main Income sources five for questions 3.1 to 3.3*

1 Sale of crops 2. Sale of Livestock 3. Sale of livestock products 4 Casual labour 5. Sale of charcoal 6. Sale of wood products 7 Remittances 8 Gifts 9 Sale of livestock feeds 10. Employment Salary 11 Petty trade

3.1	From the table above what was your MAIN source of income	_____
3.2	Is this source of income your normal income source?	1. Yes 2 No.   _____

3.3	If not, what is the normal main source for this time of the year? (choose from the above list)	[ _____ ]
<b>4.1 FORAGE</b>		
4.1.1	What was the average grazing distance in the last 10yrs	[ _____ ]
4.1.2	What is the average grazing distance currently?	[ _____ ]
4.1.3	How many months do you estimate forage to last before migrations commence? (estimate)	[ _____ ]
4.1.4	How is the quality and quantity of forage compared to the last 10yrs.	1. Good 2. Fair 3. Poor
4.1.5	What are the main constraints in accessing forage?	1. Security 2. Disease 3. Lack of water 4. Wildlife 5. None 6. Other specify [ _____ ]
<b>4.2 SOURCE OF ENERGY</b>		
4.2.1	What is the main source of energy in your household?	1. Wood fuel 2. Kerosine 3. LPG 4. Biogas 5. Others [ _____ ]
4.2.2	How many head loads of fire wood does your household use in a week?	[ _____ ]
4.2.3	Do you practice energy conservation techniques in your household?	1. Yes [ _____ ] 2. No [ _____ ]
<b>4.3 CONSTRUCTION MATERIALS</b>		
4.3.1	What was the construction materials used in 10yrs ago?	
4.3.2	What construction materials are currently used for construction?	1. Cedar posts 2. Cedar barks 3. Rafters withies 4. All of the above [ _____ ]
4.3.3	What average quantities of the same materials do you use for construction?	
4.3.4	Do you buy the materials or access them within your community land?	1. Buy 2. Access within [ _____ ]
<b>4.4 LAND TENURE AND UTILIZATION</b>		
4.4.1	What is the land ownership tenure?	1. Individual parcel. 2. Communal parcel. 3. Trust land [ _____ ]
4.4.2	What is the average land size a household own or utilizes?	[ _____ ] Acres
4.4.3	What are the proportions of land parcels utilized under 1. Crop production 2. Settlements	[ _____ ] Acres [ _____ ] Acres

## FOCUS GROUP DISCUSSION QUESTIONNAIRE (FGD) (B)

(This questionnaire is administered to at least 10 men and 10 women)

Community Name \_\_\_\_\_ Division \_\_\_\_\_  
 Sub Location \_\_\_\_\_ Location \_\_\_\_\_  
 Livelihood Zone \_\_\_\_\_ Date \_\_\_\_\_  
 GPS Readings \_\_\_\_\_

4.5. MIGRATION		
<i>(Out Migration (Outward))</i>		
4.5.1	Do your livestock herds migrate outside your community's grazing zones?	1. Yes      2. No
4.5.1	What are the main reasons for livestock out-migration in your community?	A). Insecurity          b). Search of pasture and water          b). Pest and disease          d). Other
4.5.2	Where do your livestock commonly concentrate during the dry season?	1. Neighboring districts 2 Neighboring divisions. 3 National parks 4 Neighboring country.
	How often do your cattle migrate in search of pasture in a year?	1. Once 2. Twice 3. Half year 4. Whole year
5.1 NATURAL RESOURCE ACCESS AND UTILIZATION		
5.1.1	What is the main source of water in your community currently?	1. Traditional _____ 2. Catchments pools/plans  3. Constructed shallow wells (functioning) 4. Boreholes _____ 5. Other (Specify) _____
5.1.2	What was the main source of water in your community in the past 10yrs (choose from 1-5 options)	
5.1.3	What is the return distance to the main source of water currently in Km?	
5.1.4	Is the actual main source of water the normal source for this month of years?	1. Yes          2. No.
6. PERFORMANCE OF TRADITIONAL INSTITUTIONS		
6.1	Which were the functional institutions that ensured natural resources management?	1. Council of elders 2. Cultural believes 3. Functional committees 4. Others
6.3	What led to collapse of these institutions?	1. Government policies 2. Weak cultural values 3. Insecurity 4. Others
7. STAKEHOLDERS		
7.1	Who are your development partners?	
7.2	What are their specific roles in development process?	
7.3	Are there conservation strategies/activities implemented with stakeholders?	1 Yes      2 No.

7.4	If yes what activities?	<ol style="list-style-type: none"><li>1. Soils conservation</li><li>2. Energy conservation</li><li>3. Afforestation</li><li>4. Other specify (            )           </li></ol>
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**Pictorial evidence on human settlement verses the environment.**



*Image 1: Demand for housing and construction materials for homesteads*



*Image 2: Opening up of virgin land for settlement and Agricultural production*



*Image 3: Unsustainable use of forest produce*

*Image: Debarking of cedar tree for roofing*



*Image 5: Whats the future of this ecosystem if the same trends of human settlements continues?*