ASSESSING THE DIFFERENT FORMS OF ENVIRONMENTAL REPAIR APPROACHES AND THEIR EFFECTIVENESS IN AMBOSELI ECOSYSTEM, KAJIADO COUNTY - KENYA

BY

ISAIAH SARUNI MWATO JACKSON

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DECLARATION

This research project report is my original work and has not been presented for examination at any other institution

Signed: …….. Date: ……

Isaiah Saruni Mwato Jackson

C50/76061/2012

This research project report has been submitted for examination with my approval as the University Supervisor.

Signed: …….. Date: ……

Dr. T. Thenya

Lecturer, Department of Geography and Environmental Studies

University of Nairobi

DEDICATION

This research project report is dedicated to my lovely wife Catherine Nkaayiai Saruni, our son Jason and daughter baby Joan.

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABBREVIATION AND ACRONYMS

ACC	African Conservation Centre
ACP	Amboseli Conservation Program
AEMP	Amboseli Ecosystem Management Plan
ANP	Amboseli National Park
ANR	Amboseli National Reserve
ASAL	Arid and semi-Arid Lands
AWF	African Wildlife Foundation
BL	Big Life
DPSIR	Driving forces, Pressure, States, Impacts, Responses
FGDs	Focus Groups Discussions
HWC	Human Wildlife Conflict
IFAW	International Fund for Animal Welfare
KWS	Kenya Wildlife Service
KWT	Kenya Wildlife Trust
MWCT	Maasai Wilderness Conservation Trust
NGOs	Non-Governmental Organizations
SPSS	Statistical Program for Social Science
UN	United Nations
UNEP	United Nations Environmental Program

ABSTRACT

An ever increasing human, livestock and wildlife populations in the rangelands have led to the reduction and disappearance of woody vegetation, grass species and animals in some areas of the Amboseli ecosystem, which has adversely affected the land resource factors such as flora and fauna, soils, and water, thus having a profound impact on its functions which consist of productive, cultural, and physiological utilities. In the effort to restore the degraded rangelands of Amboseli ecosystem, stakeholders have put in place different environmental repair approaches (scientific and traditional) aimed at aiding the degraded ecosystem's recovery The study aimed at examining the different forms of environmental repair approaches, effectiveness of these approaches, and the rationale for the choice of approach being used by different stakeholders in the ecosystem. A structured questionnaire was administered, a simple random sample of 386 of group ranchers of whom 64% were from Olgulului/ololorrashi group ranch, 31.1% were from Imbirikani group and 4.9% were from other areas including Amboseli national park. Respondents were randomly selected for an interview and subjected to both closed and open ended questionnaire. Moreover, focus group discussions within the area of study were conducted and key informants interviewed. Data analysis was carried out the use of frequency tables and visualization charts. Hypothetical data was tested by using chi-square goodness of fit statistical tests.

On the different forms of repair approaches; the results found that 74.6% of respondents said that they were aware of environmental degradation, while 78% were familiar with environmental repair approaches. The study found that 91% of respondents confirmed that the Maasai traditions practiced various approaches that maintaining rangelands. About 94% of respondents gave their opinion that the state of rangelands vegetation in 70s and 80s was very good. On repair approaches effectiveness, 80.6% of respondents cited different environmental repair approaches being used and the traditional repair approaches top the list of effectiveness at 24.9%, reforestation at 14%, fences and enclosures at 10.4%, among others. On the rationale for the choice of a repair approach, 50.3% of respondents interviewed indicated that their rationale for the choice of environmental repair approach. The hypothesis testing results on rationale further shows that $\chi 2$ (1) = 0.439, p = .439 (p > .0005). This tells us that there is no statistically significant association between Forms of environmental repair approaches and rational for the choice of environmental repair. The study concludes that environmental repair is an expensive process, and the focus of good

environmental repair is to avoid ruin by doing away with existing but unnecessary demands. This study therefore recommends that the policies that favours and strengthen traditional repair approach should be developed so to maintain or improved further the best practices.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Land degradation is the state in which the capacity of land to produce declines temporarily or permanently. The productive purposes, ecological, cultural, and physical functions of land as a resource become affected to adverse levels. The impact is the same as a long protracted loss ecosystem function as a result of disturbance from which without help, the ecosystem cannot restore itself. Humans derive essential environmental services such as water, food, and energy, from the ecosystem. It therefore places land at the centre of trade-offs between human necessities and environmental sustenance, since land use boosts the value of primary production for human consumption at the expense of ecosystem functions.

It is a widely held perception that land degradation is among the most severe environmental related problems in Sub-Saharan Africa (Beinart, 1996; Hoffman *et al.*, 1999; SADC–ELMS, 1999 Hoffman & Todd, 2000) and globally (Dregne *et al.*, 1991; UNCED, 1992; Reynolds & Stafford Smith, 2002). Land degradation mainly occurs when the soil's capacity to retain and store water deteriorates; soil loses essential nutrients; and toxic substances accumulate in the soil (Smith 1989, Friedel 1991, National Research Council 1994). Loss of soil water and ability to store water may be caused by soil compaction, loss of organic matter, and decline of soil depth.

Blackburn (1984) raised through his summary, the worries that grazing bring about soil compaction which may enhance soil bulk density, decrease soil porosity and water infiltration, thus leading to surface runoff, soil erosion, and transport of non-point source pollutants. In addition, increase in salinity reduces water availability for plants. Use of heavy machinery in farming (Brady and Weil 2002) and trampling of land by livestock causes soil compaction which in turn leads to undesired alterations in the soil hydrological processes (Manzano and Navar 2000 Yates *et al.*, 2000) such as water infiltration (Hartge 1988). Loss of organic matter in turn is associated with soil compaction, decline in fertility and a general deterioration of soil quality through destabilization of aggregates and reduction of cationic exchange capacity (Bohn *et al.*, 1993, Fassbender 1993). Salinity reduces the ability of plants to extract water from the soil; it has been recognized as a source of land degradation due to irrigation practices (Thomas and Middleton 1993) and as one of the factors leading to the fall of the Mesopotamian culture 6,000 years ago (Jacobsen and Adams 1958).

Various attempts have tried to estimate the extent to which land has been degraded and desertification caused. "A synthesis of the most recent global assessments of human-induced land degradation estimated that 69.5% of the world's drylands are affected by various forms of land degradation" (Dregne, *et al.*, 1991 in Diouf *et al.*, 2001). Basing on Adams' assertion, it is estimated that people close to 2.6 billion or more feel the effect of desertification and land dereliction in over 100 countries spread the world over, thus 33% of the earth surface influenced by the impact. The in-depth knowledge possessed by pastoral communities all over the world, is an ancient knowledge of conducting rangeland assessments, which then determine how land is to be used (Mills *et al.*, 2002). This is an attribute of the various factors such as improper practices of land-use, human over-population, overstocking, environmental degradation, and drought conditions that are persistent. Kenya is majorly dominated by rangelands in which pastoralism is the main activity. The rangeland is vast with low human population density but high livestock and wildlife population density. However, attempts have been made in the recent past, to shift from purely pastoral system to farming (Katampoi *et al*. 1990, Berger 1993).

Marginal pastoral areas experience acute land pressure as a consequence of livestock husbandry which adversely affects the environment. Estimation indicates a rate of 35% land degradation worldwide caused by overgrazing and 49% in Africa (Haen, 1993; Pinstrup-Anderson and Pandya-Lorch, 1994). Land pressure and overgrazing are orchestrated by the ever increasing human population, overstocking, altered grazing patterns as a result of land privatization, loss of grazing lands, political instability causing limited mobility, and other forms of land pressure (Fratkin, 1991; Ensminger, 1992). Herders in such circumstances adopt diverse responses in order to have minimal risks on the environment and reduce on uncertainty (Western and Nightingale, 2002). They also ensure their livelihoods are diversified in such aspects as; crop cultivation, wage employment, land partitioning, livestock trading, tourism among others (Okello, 2005; Ntiati, 2002).

The increase in human, livestock and wildlife populations in Amboseli rangelands has led to the reduction and disappearance of woody vegetation (such as the *A. Tortilis* and fever tree), grass species and animals in some areas of the ecosystem. In the effort to restore the vegetation within and outside Amboseli national park, ranging from scientific to traditional, stakeholders have managed to put up approaches to repair the degraded ecosystem. The

approaches range from electric fence enclosures, Inkaron (traditional grass banks), Olopololi (area set aside for calves and goats kids), reforestation, and grass seed bank and community conservation areas.

1.2 Statement of a Research Problem

Sub-Saharan Africa and especially Kenya is faced with serious environmental and social problems due to land dereliction and desertification. The capacity of land to produce is reduced to larger extents as a result of land degradation. It therefore mirrors the long protracted loss of functions of the ecosystem as a consequence of eco-disturbance from which without help, the system cannot self-restore. The larger portion of Kenya is rangeland under which the dominant activity is pastoralism. Rangelands have low human population density but support a high population density of both livestock and wildlife. Moreover, 80% of Kenyan land is either of arid or semi-arid conditions, with an estimation of 8-10 million people feeling the adverse effects of dwindling resources, drought, floods, food insecurity, and poverty.

Soil destruction at Amboseli environment is pecularised by the changing composition of plant breeds, depletion of woodland vegetation because of charcoal burning and waste of timberlands a vast elephant population around Amboseli National park, soil abrasion, soil compaction, surface duck out, water retention and holding capacity worsened, deprivation of nutrients or build up of salts and other polluted materials in the soil, and overgrazing. Loss of organic matter in later characterised by soil compaction, reduced productivity with broad reduction in soil quality through diminishing of aggregates and therefore undermining acationic exchange capacity (Bohn *et al.,* 1993, Fassbender 1993). Different forms of land degradation discussed above is an attribution to the improper practices of land utility and in particular; agricultural growth and expansion; population increase of humans and animals; land privatization; environmental dereliction; mining; drought among others.

Land destruction challenges mentioned above are crystal clear in Amboseli ecosystem. Currently, in Amboseli different stakeholders are using different methods and approaches ranging from ancient to science based and all are geared to aiding the degraded ecosystem recovery. The study used structured questionnaire survey, observations, and interviews of different stakeholders, community FGDs and key informant on existing electric fence enclosures, the traditional Maasai; Inkaron (traditional grass banks), Olopololi (area set aside for calves and goats kids), reforestation, and grass seed bank and community conservation areas, communities practices on range management and rangeland repair methods that all are geared to aid the ecosystem in restoring woodlands vegetation and grasses for the health of the ecosystem.

The information generated by the study will help the ecosystem managers to make informed decisions on land use plan, the most effective approach of ecosystem repair and utilization of natural resources. The study has made critical recommendations essential to the development of action plans purposely for the restoration, rehabilitation, and repair of the already destroyed ecosystem and direct proper and sustainable actions of land-use in the Amboseli ecosystem. In particular, the study examined and revealed some of the approaches towards environmental repair, their efficiency, and the rationale behind the choice of a given approach in use by some stakeholders in a bid to restore ecosystem functions of Amboseli back into order. The findings on the most effective approach for repairing the degraded ecosystem will be made available to Amboseli community and stakeholders at Amboseli Noonkotiak community resource/information centre.

1.3 The Goal and Objectives of the Study

Broad Objective

To examine environmental repair approaches used to aid recovery in the Ambseli ecosystem, Kajiado County, Kenya.

The specific objectives of the study were to;

1. To identify the different forms of environmental repair approaches being used in Amboseli ecosystem
2. To assess the effectiveness of environmental repair approaches being used in the Amboseli ecosystem
3. To determine the rationale for the choice of environmental repair approaches being used by stakeholders in Amboseli ecosystem

Research Questions

1. What are the different forms of environmental repair approaches used by stakeholders in Amboseli ecosystem?
2. Which of the different forms of environmental repair approaches are effective and why?

What is the rationale for the choice of environmental repair approaches being used by stakeholders in Amboseli ecosystem?

Research Hypothesis

H_o: There is no significant difference in the effectiveness of different forms of environmental repair approaches

H_o: There is no significant rationale for the choice of environmental repair approach by stakeholders in Amboseli ecosystem

1.4 Justification of the study

Land degradation in Amboseli ecosystem is characterized by the changing composition of plant species, loss of woodland vegetation due to charcoal burning and destruction of woodlands by huge population of elephant especially around Amboseli National park, soil erosion, soil compaction, surface runoff, worsening soil capacity to hold and retain water, loss of nutrients or build up of salts or other contaminated materials in the soil, and overgrazing. In most parts of Kenya, rangeland livestock production is a form of extensive grazing system practised by the nomads of the arid regions. Amboseli rangelands not being exceptional, the 2009 drought left bare ground, top soil was washed away and lack of grass seeds for continued germination leaving the rangeland environs very unproductive. The increase in human, livestock and wildlife populations in Amboseli rangelands has led to the decline and loss of forested vegetation (*A. Tortilis* and fever tree), grass species and animals in some areas of the ecosystem. In the effort to restore the woody vegetation within and outside Amboseli national park, stakeholders have managed to put up several electric fence enclosures that exclude elephant and giraffe to restore woody vegetation and grass in the ecosystem.

Traditionally the Maasai communities practice the concept of *Olopololi* (meaning setting aside a grazing areas for young calves and shoats kids). These traditional practices gave the rangeland time to regenerate and recover by their own. On the other hand, grazing management was critical. The *Inkaron* (grass banks) for dry season grassing areas were set aside by the entire community in agreement and the rules and penalties governing the grass banks. The grass banks are only used by livestock during dry season thus enabling rangelands grasses to mature and release seeds banks into the soil. Upon massive losses of both livestock and wildlife in the drought of 2009, a section of the Amboseli Maasai pastoralists participated in a horizontal learning trip to Baringo. One very important lesson learned from the trip was that rangelands in Baringo were reseeded with a number of indigenous perennial grass species. The Amboseli pastoralists bought the idea and now though on small scale they are practising rangeland reseeding and rehabilitation.

The study examined the different forms of land degradation in Amboseli ecosystem, determined the rationale for the choice of ecosystem repair approaches by stakeholders in Amboseli ecosystem and to assess Amboseli ecosystem repair approaches and their effectiveness. The information generated by the study will benefit the Amboseli ecosystem

managers to make informed decisions on land use plan, the most effective approach of ecosystem repair and utilization of natural resources. The study has made critical recommendations essential to the development of action plans purposely for the restoration, rehabilitation, and repair of the already destroyed ecosystem and direct proper and sustainable actions of land-use in the Amboseli ecosystem.

1.5 Scope and Limitations

The research objectives examined the different forms of environmental repair approaches, effectiveness of the approaches and the rationale for the choice of approach being used by different stakeholders in the Ambseli ecosystem in restoring back the ecosystem functions. The area of study is Amboseli ecosystem (Amboseli national park and the two community owned group ranches). The study used structured questionnaire survey, observations, and interviews that were administered to the local community, different stakeholders, the FDGs and the key informant on different existing electric fence enclosures, the traditional Maasai communities practice on range management and rangeland repair methods that are all geared to aid the degraded rangelands ecosystem in restoring woodlands vegetation and grasses for the health of the ecosystem.

A key limitation that the researcher encountered was respondents‟ truthfulness. During the research, I encountered respondents who were unwilling to give out full and true information. Instead, they revealed what they thought the researcher wanted to hear and not the facts on the ground. To overcome the challenge, I assured the respondents of their confidentiality, anonymity, and a reassurance that their feedback was only a necessity of the study. Moreover, I was also faced with a problem of accessing senior officials of the institutions engaged in rehabilitation of Amboseli ecosystem, owing to their busy timelines. As a result, I had to use electronic means of communication such as email to access them, for instance emails to get their reply. Time and financial constraints was another major challenge in data collection across the whole Amboseli ecosystem. I had to engage research assistants to drop and pick questionnaire in the whole of Amboseli ecosystem.

1.6 Definition of Terms

Environmental Repair: This is the process through which the ecosystem is aided out to recover, following degradation, destruction, and damage (Keenleyside *at el.*, 2012).

Land degradation: It is the state at which the capacity of land to produce remains permanently or temporarily destroyed.

Ecological Restoration: It is the process through which damage orchestrated by human influence to the diversity and indigenous ecosystem dynamics is repaired.

Amboseli: it means "Salty Dust" in the Maasai language.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter presents literature review on the subject under study with respect to the research objectives on the rangelands environments, degradation, documentation of the different forms of environmental repair approaches, the effectiveness of the approaches and the rational for the choice of approach being used by different stakeholders in the ecosystem.

2.2 Rangelands

25% of Kenya's human population lives under arid and semi-arid lands (ASAL), and the same lands support about 60% of livestock population and substantial portion of wildlife (GoK, 1994). Kenya is dominated by rangeland under which pastoralism is mainly practiced. Moreover, 80% of Kenyan land is either of arid or semi-arid conditions, with an estimation of 8-10 million people feeling the adverse effects of dwindling resources, drought, floods, food insecurity, and poverty. The Amboseli ecosystem falls under the Chyulu/Kilimanjaro volcanic natural region which is an acacia dominated dry woodland savannah.

2.3 Rangelands Productivity

This vegetation type supports the pastoralist lifestyle of the local Maasai and a wide array of savannah wildlife species, the cornerstone of tourism in the ecosystem (AEMP 2008 – 2018). The bigger part of the Amboseli ecosystem is semi-arid but despite its relative aridity, it has a high productivity with regard to livestock and livestock products. Some the useful products from the ASAL include; timber, firewood, charcoal, fruits, gums, resins, honey, and herbal medicine (Ngugi and Nyariki 2003). Mt. Kilimanjaro gives rise to water springs emanating from the basin of Amboseli ecosystem, which leads to formation of several swamps essential for the maintenance and sustenance of livestock and wildlife within the ecosystem.

2.4 Land degradation

There are global concerns regarding land use owing to the fact that land surface processes influence the climate. Therefore, alteration of these processes has adverse effect on the ecosystem functions upon which life depends. Human land-use finds itself at the centre of intricate and pressing issues encountered by land administrators, users, and policy makers globally (De Fries *et al.*, 2004, platt and Rutherford 2004). Land degradation, defined as the reduction of land's capacity to produce temporarily or permanently, (Blaikie and Brookfield,

1987), is regarded as by the world as a major problem (UNEP, 1992). Through the definition of (Dumsday 1986), the economic dimension of land degradation is well captured as those adverse effects that land use may cause on the land functions. Rangelands occupy 47% of the earth surface (Heitschmidt and Stuth 1991). Low and erratic precipitations, poor drainage, rough landscape and topography, and often poor soil fertility, are some of the features that identify with rangelands. The composition, distribution, and productivity of plant species are influenced by fire, rainfall, wind, soil type, and grazing animals.

Although degradation of the ecosystem does alter species composition to certain extents, such areas retain control over some important resources. Gravity of degradation increases when a particular area loses control over the important resources of the land. It is complex to make general conclusions about what changes range conditions as a result of the interactions between land-use and ecological features (IPAL 1984, Sinclair and Fryxell, 1985; Homewood and Rogers, 1987). Recently, controversy has arisen focusing on whether the vegetation dynamics witnessed in ASAL are caused by either climatic factors or consumers (Ellis and Swift, 1988; Behnke and Scoones, 1993).

Although Kenya's tourism backbone being the Amboseli ecosystem, its biodiversity faces a threat of habitat dereliction, waning ecological integrity, fuelling human-wildlife conflict, population pressure, and loss of migration (AEMP 2008 - 2018). Significant changes of land-use have been witnessed in the Amboseli ecosystem, thus increasing the amount of land for human settlement and cultivation. Landscape satellite images analysis during late-twentieth century to early 21st century indicate an increase of 24.4% of land under cultivation and settlement, a reduction of 15% of forested and grassland vegetation, while wetlands registered a 12.3% decline. Currently, animal movement around Amboseli National Park has been limited as a consequence of land subdivision in the area (ACP and GEF pro-doc 2012).

2.5 Forms of Land Degradation

Soil erosion as a result of wind and water effect are the two major forms of degradation. Other types of degradation are vegetation damage and loss, and soil salination (Woods 1983 Chartres 1987). Alteration of the landscape and the change in composition of flora are majorly anthropogenically influenced (Wittig, *et al.*, 2007). Human overpopulation has led to the huge environmental degradation being observed (science.jrank.org.2011). Waugh (1999)

made an attribution of 70% of the desertification problem towards the ever increasing human population, among other factors. Acute pressure is exerted on the natural resources available by overpopulation and especially in drylands. The pressure comes due to the increased food demands pushing for subdivision and parcelling of land for food production (Waugh, 1999).

Land degradation appears in many forms such as soil erosion, salinization, soil acidification, soil contamination and toxification, and loss of soil structure. Currently one sixth of the world's population is affected and a quarter of the earth surface is lost annually due to the adverse effects of desertification, soil erosion, and salinization (World Resources Institute, 1992). Economic development is much sabotaged and undermined by this degradation and to some extents irreversible.

2.5.1 Soil erosion

Soil erosion can be defined as the process through which a variety of agents carry, move, and transport soil from one place to the other. The agents may include; water, wind, and mass human and animal movement causing soil loss. Since the U.S Dust Bowl during the 1930s, soil erosion has earned recognition as a major problem from various stakeholders including governments and scientists (Jacks and Whyte, 1939).

Soil erosion is mainly influenced by rainfall (amount, frequency, duration, and intensity), wind-speed (direction, strength, and frequency of high intensity events), land-use and management, topography, and soil properties (Morgan, 1986; Hallsworth, 1987). According to (Barber 1984), the immediate causes of soil erosion are; topography, rainfall, wind, vegetation cover absence, and soil practices. Additionally, there are underlying and distant factors of soil erosion which may include; population pressure, poverty, high cost and inaccessibility of inputs, insecure land tenure, lack of appropriate production and conservation technologies and many of these are further influenced by various government policies or lack of them.

Factors affecting nature of Soil erosion

Topography

The rough, uneven, or rough landscape and sharp undulations and slopes influence the rate of soil erosion through their morphological features. Among them, gradient and slope length,

are critical components in the quantitative relationships of soil loss estimation (Wischmeier and Smith 1978). Sloping lands encourage rapid movement and carriage of dislodged soil particles downhill, during rainfall. The inclined angle enhances flow of water which with it carries soil particles thus causing dramatic increase in soil erosion. It is generally conceded that increased slope gradient and length facilitates erosion owing to the increase in overland flow volume and velocity.

Rainfall and wind

Rainfall and wind are the major climatic components that cause soil erosion. Energy transmitted from rainfall or wind processes or a combination of both forces does set in motion the process of soil erosion. Although it is not easy to notice, witness, or observe the impact erosion on daily basis, water and wind have a quick capability of occasioning soil damage. So far, sheet and drill erosion are the most rampant and prevalent types of accelerated erosion, and their impact on agricultural production is beyond other kinds of erosion. Rainfall and wind orchestrated erosion is a sequential process which first dislodges soil particles from the general soil mass and then carry away the detached particles (Young and Wiersma 1973).

Gullies ranging from 1m to 100m in depth may be formed from the erosion as a result of intense rainfall and rapid runoff (Pimentel *et al.,* 1998). A relative of the ability of rainfall to cause erosion is the rainfall intensity, distribution, and amount. The intensity of rainfall is highly effective in causing soil erosion as compared to rainfall amount. In the tropical regions, erosion may reduce the rate of infiltration up to 23% which in turn enhances surface runoff (Lal 1976, cited in Pimentel *et al.,* 1998).

Soil properties

Soils exhibit variations in their resistance to erosion due to their difference in such properties as texture, and level of organic matter. The resistance may also depend on the soil condition and depth. Soils with high amount of silt are highly subject to erosion as compared to clay or sandy soils (Nill *et al.,* 1996). Silty soils possess weak structural stability, which explains their high rate of erodibility. Upon impact of rain drops, silty soils quickly form surface seals. Better aggregation exhibited by clay soils makes it difficult to be eroded, and also sandy soils are less likely to be eroded due to their non-sealing surface.

Inadequate soil depth negatively affects to critical levels, the soil's capacity to hold and retain water, and flora rooting anchorage. A decrease in soil depth reverts vegetation from croplands to weedy and thorny grasslands, which may end up degrading to bare rock. Soil organic matter enhances and improves soil structure, water infiltration, and root penetration, therefore reducing the rate of soil erosion with increasing organic matter (Wischmeier and Smith 1978). As a consequence of deteriorating soil structures, soils have been made fragile and susceptible to being eroded easily. Soil erosion is also influenced by such soil conditions as antecedent moisture content, vegetation cover, slope and tillage system, which eventually leads to degradation. On moist soils, when rainfall starts there will be a higher runoff as compared to dry soils.

Vegetation and land cover

All over the world, areas covered with vegetation or undisturbed forests experience lowest rates of soil erosion approximately a range of between 0.004 to 0.5 t/ha per year (Pimentel *et al.*, 1998). However, as a result of converting forest land to agricultural land for cultivation, the vegetation cover is removed thus causing an increase in surface erosion. Vegetation cover, and living and dead biomass reduce the rate of soil erosion through the interception and dissipation of raindrops and wind energy. Foliage above the ground slows down the velocity of running water over the soil which in turn lowers the volume of water and soil lost in surface runoff. Moreover, soil particles are physically bound by the plant roots thus causing soil stability and increasing its resistance to erosion. Pores created in the soil by plant roots enable water to sip easily into the soil matrix thus enhancing water conservation. Water uptake by plants also causes depletion of soil water content thus increasing the rate of water infiltration.

Land use and management

Erosion mainly affects croplands and pastures but due to repeated tilling makes croplands more vulnerable to erosion than pastures, since the soil is left without protective vegetation cover. Socio-economic factors and especially in rural areas highly influence inappropriate utilization of land which sparks off land degradation. Land-use practices affect soil protective cover in any area and which in turn influence the rate of soil erosion or level of erodibility. Deforestation, burning of crop residues or removal of them for fuel and animal feed, causes a

decline in the soil's content of organic matter, making it less productive and highly susceptible to erosion.

2.5.2 Biological degradation of soil

Biological degradation is occurs when the soil's humus content reduces as a result of mineralization (Solomon 1994). Organic matter decays due to the actions of microbial activity. Organic matter which is usually in the form of decaying leaves and stems, is majorly concentrated near the soil surface. Therefore, erosion of topsoil leads to the reduction of the levels of soil's organic content and thus losing food for micro-organisms. Once the depletion of the organic layer, the soil's capacity to produce declines, and so does the crop yields because of the degraded soil structure and depletion of nutrients.

2.5.3 Chemical degradation (nutrient depletion) of soil

Generally, surface runoff causes the loss of nutrients through erosion. Finer soil particles are highly vulnerable to erosion. Owing to the fact that nutrients are found in abundance in finer soil fractions, they are carried along during erosion and thus lost in the process. However, nutrients are not only lost during erosion but through chemical degradation as well. Soil properties deteriorate through such processes as acidification, and salination or sodification. Sodification or salination is a common process in ASAL where rainfall is extremely at low levels, causing soil leaching of excess soils down through the profile. Soil acidity may be accelerated through the burning and clearance of vegetation, consistent application of acidified fertilizers, and excessive irrigation (Thomas 1997). However, more underlying causes of chemical degradation may exist.

Generally, Ethiopia has given utmost attention to soil erosion, as it perceives erosion as the main form of degradation and loss of nutrients. Therefore, there is little knowledge of the existence of other processes of nutrient loss. For instance, Pol (1992) reported 17% rate of nitrogen loss through erosion, based on a research conducted in southern Mali. With respect to the situation in Ethiopia, there is little understanding of the link between soil erosion and nutrient depletion (Stoorvogel *et al.,* 1993).

2.5.4 Physical degradation of soil

Physical degradation may be brought about through such processes as sealing, compaction, and reduction in aeration and permeability. Absence of organic content in the soil and presence of fine sand particles and silt highly contributes to surface sealing. Overstocking and overgrazing causes heavy soil trampling which in turn leads to soil compaction. The profound grazing of livestock has been found to have adverse effects on the soil, since it impacts other components of the ecosystem as well. Nearly every aspect of soil structure and function, e.g soil porosity, chemistry, microbiology, nutrients cycle, erosion rates, and productivity, have been found to be subjects of alteration by livestock activities. Watering points and routes plied by cattle are in particular vulnerable to soil compaction thus reducing water infiltration and causing excessive runoff. Consequences are that, revegetation is impeded and the uninterrupted water down slope creates rills and gullies.

2.6 Effects of land degradation to Pastoral economics

Activities that damage or remove vegetation or soil at unsustainable rate damage ecosystem functions. Biomass removal and physical disturbances degrade wildlands. Several human activities like; abusive grazing, deforestation, fodder removal, fuel wood collection, vehicles mining and cultivation do damage vegetation. In East Africa, the most cited reasons of rangeland deterioration have been constant overgrazing, drought, and inappropriate cultivation (Coppock, 1994; Mäkel, 1994; Herlocker *et al.*, 1995a; Herlocker, 1999). Through degradation, a quite a number of desired plant and animals' species are lost or reduced, plant biomass is declined, primary production is decreased, and sustainable energy flow along the food chain is reduced (Whisenant S.G, 1999).

Adverse and enduring alterations in the composition of the vegetation of rangeland areas and their productivity carry with them far-reaching consequences for the pastoral economies in East Africa. The Maasai of East Africa set out specific grazing lands during wet seasons and dry periods as a way of adapting to the life in arid lands (Berger, 1993). Rangeland utility for the Maasai community was premised upon mobility, splitting and dispersion of livestock over the landscape during both wet and dry seasons (Oba *et al*., 2000), to guarantee restricted dry strenuous constant grazing. Both in Kenya and Tanzania, there are dramatic shifts in the Maasai areas with respect to land tenure and land-use, imposing wide consequences on the rangeland dynamics.

Competition from other practices of land-use such as crop farming have led to the progressive loss of grazing lands for the Maasai community (Campbell *et al*., 2000), and also through the establishment of wildlife protection areas (Western and Wright, 1994). The intense pressure from group ranch members pushing for land privatization has led to further subdivision of group ranches. The consequence is that the trend has shifted from extensive seasonal grazing to continuous and intensive livestock grazing (Burnsilver and Mwangi, 2007). A hypothetical prediction indicates negative effects on the rangeland as a result of the collapse of traditional Maasai grazing system (Kioko *et al.*, 2012).

The effectiveness of native pastoral systems including best exploitation of the existing natural resources, efficient risk management means by dodging drought conditions, prevents natural resources from being over-exploited, through the reduction of concentration of livestock in one area (Homewood *et al.*, 1991; Benhke *et al.*, 1993). There have been interactions between pastoralists and sedentary farmers, however increase in human population and commodity production have expanded agricultural activities to formerly common grazing lands (Fratkin 1997). The basic pastoral forage and forage resources destroyed through over-exploitation had already taken serious dimensions even before the recent drought experienced in Sahel. The results have been catastrophic for years with rainfall declining below the average levels (Nicholson 1978, Rain 1999, Mertz, 2010).

Livestock influence on environmental degradation is clear and evident. Animals trample and uproot young germinations, The influence of livestock is apparent at trampling and uprooting of young germinations, crashing of spikelet and the release of seeds, which works against the protection provided by the envelopes, distribution of certain diasporas and consecutive occurrence of defoliation (Pierre, 2011). Cattle grazing can also cause slow growth of the roots, declined capacity to hold water, and loss of flora vigour in entirety, making forage a subject of disease and replacement by intrusive or invading species (ehow.2011). However, it is widely accepted that if pastoralist can practice their activities on a large spatial area by migrating to areas where they can exploit key rich resources, negative effects of grazing on plants biodiversity do not arise (Sinclair and fryxell 1985, Ellis and Swift 1998, Behnnke and Abel 1996).

2.7 Rangeland degradation Irreversibility

The effects of rangeland degradation can be irreversible sometimes. They may include physical and chemical damage to the soil, and in some extreme cases loss of plants and animals. It should therefore be considered that today's actions in the rangeland may lead to regrets of the future generations (Krutilla and Fisher 1975; Chisholm 1981b). Preserving land whose utility renders it technically or economically irreversible, may be more beneficial than its immediate use.

2.8 Environmental Repair Approaches and their Effectiveness

The existence of land degradation is not in itself an economic argument for those who own land privately or government, to put to a stop further degradation or work on restoring wasted land (Maclead N.D. *et al.,* 1990). Several options of reclaiming pastures severely invaded by woody weeds exist and as well reclaiming the scalded surfaces. The options include; use of prescribed fire; herbicide control; goats; sowing pasture; chain clearing; blade plough; and water ponding.

Rangelands upon which, livestock and wildlife graze are affected by a variety of practices. Implementation of the practices will significantly reduce the impacts of land degradation. Different rangelands and social systems will demand different combination of practices to be applied upon them, in a bid to reduce land degradation. Despite having the evaluation and critical analysis of ecological, social, and economic costs, biodiversity issues and the genetic conservation of plants and animals for future use are addressed to a small extent. The evaluation of diverse mitigation methods brings up a number of issues as indicated in the following classes of approaches:

2.8.1 Rangeland rehabilitation

Through rehabilitating rangelands, a perfect opportunity for the sequestration of carbon is presented. Such practices of rangeland rehabilitation include; afforestation, reforestation, grass and shrub establishment on saline soils, among others (Glenn *et al.,* 1992). UNEP having assessed the costs to be involved in rehabilitating degraded rangelands the all over the world by combining the practices mentioned above, it gave an estimation of close to US$5 billion to US$8.8 billion or more annually and over a period of two decades.

Collection of seedling by the seed bank is an essential process in maintaining the richness of plant species and also restoring species richness in rangelands having poor species (Edwards and Crawley 1999). Regeneration of seedling depends on the soil seed bank, seed immigration from surrounding areas, and seed generated by the resident plant species (Hulbert 1988, Maret and Wilson 2000). Distribution of adult plants is primarily determined by factors controlling germination and early seedling growth (De Jong and Klinkhamer 1988, Mustart and Cowling1993). With respect to environmental factors, soil moisture is the main impediment of seedling establishment in semi-arid rangelands (Skoglund 1992, Snyman 1998, Schellenberg1999). Possession of the knowledge of various responses concerning seedling in different environments is of prime importance in understanding the dynamics of different communities (Tyler 1995, De Villiers *et al*. 2001, Jutilaand Grace 2002).

2.8.2 Reduction of Livestock numbers

The value of livestock as a social resource to the locals and national economies will determine the practicability of reducing the number of livestock. For instance, in Australia where there are sheep grazing systems, Howden (1991) discovered some links between the emission of methane and nitrous oxides and the stocking rate. Howden exhibited that a change in the time of lambing, reducing stock in overgrazed areas, and management of fire frequency did reduce the emissions of GHG without necessarily affecting the net income.

2.8.3 Changing the patterns of mixing animals

Varying the blend of animals depends upon the type of rangeland and proposed mix of animals. A consideration of rearing only cattle and a small stock of sheep or goats may not be ecologically effective; since it may lead to a version of economic risks especially in bad times where the cattle perish and goats survive. Such kind of a grazing mix may lead to the deterioration of the ecosystem. A composition of both cattle and wildlife may be efficient both ecologically and economically.

2.8.4 Animals' distribution patterns

Carbon sequestration is expected to increase through changing animal distribution pattern. Changing the distribution pattern increases plant cover which eventually improves the health root system by the lighter intensity of grazing. Such patterns can be changed through salt

placement, establishment of water sources, and fencing. However, methane production is expected not to be influenced by a change in the distribution patterns.

2.8.5 Increasing Plants diversity

It is advised to improve diet quality fed to the animals, in order to reduce the emission of methane from domestic animals and wild ruminants. Provision of protein supplements is an alternative. However, local communities and economies will derive additional benefits from the planting of adapted and productive species e.g halophytes where appropriate and as well native grass.

2.8.6 Use of Chemical and Mechanical means

Other practices like application of herbicides, use of mechanical methods to rehabilitate unhealthy rangeland, and watershed scale developments involve greater ecological, social, and economic costs. Specific values are not given because they vary depending on specific goals, rangeland health, and country. Economic costs can be derived from Heady (1988), Valentine (1990), and Child *et al.*, (1987).

2.8.7 Water Use and Management

Annual distribution of precipitation is a major determinant of water availability in the ecosystem. Also, water availability in the soil is usually influenced by the landscape, topography, geomorphology, and the soil nature of any given land system. Survey indicates that water content in contiguous soils may vary by a factor of one to ten or more (Le Houérou, 1962; Floret and Pontainier, 1982, 1984). Tillage and mulching processes may modify water distribution in the soils, it can also be influenced by soil and water conservation techniques, runoff farming, water harvesting, and wadi diversion.

2.8.8 Land-Use Systems

For many years, pastoralists, ranchers, and farmers have faced the challenge of adapting to the effects of drought and desertification. However, pastoralists and ranchers have drought evading strategies and farmers have drought enduring techniques which include adoption of a small stocking rate that preserves ecosystem dynamics and its capacity to recover from drought effects. They also employ agroforestry techniques where they plant fodder shrubs

and trees that can store large amounts of food over long periods of time, so as to have them provide extra source of feed whenever drought occurs.

2.8.9 Conservation and Biodiversity

The world's ASAL contain a large number of species flora and fauna essential to survival of humankind as a whole. Many species face the threat of being endangered or soon will be endangered as a consequence of the recent desertification witnessed across several regions in the world. Establishing conservation projects such the *in situ* is the only way preserving this biological capital for the better life of humankind. However, conservation becomes an expensive affair especially in those areas experiencing acute demand of land and land resources due to high population density. It also includes creation of conservation areas.

2.8.10 Agroforestry

In the struggle to fight desertification and improve arid and semi-arid lands, agroforestry plays an instrumental role (Le Houérou, 1980; Baumer, 1987; Le Houérou and Pontainier, 1987). Other than losing control over resources, a seriously damaged ecosystem loses capacity for self-restoration or repair and the ability to stop further degradation. Such ecosystems become less resilient to further stress or destruction and are of less service to the environment (Whisenant S.G, 1999).

For long, land managers have found the need to have practical and efficient structure for attainment of restoration goals (Cairns 1993; Clewell and Rieger 1997). In that accord, much of the study and research regarding ecological restoration has placed much emphasis and focus on coming up with frameworks and conceptual models that link ecological theory to a variety of approaches of restoring a degraded system (Aronson and LeFloch 1996; King and Hobbs 2006; Westoby et al. 1989; Whisenant 1999). Additionally, there has been a wide recognition of the need to develop conceptual frameworks for restoration premised on ecological principles (Hastings *et al.,* 2005; Young *et al.,* 2005).

2.8.11 Governance

Restoration of rangelands is now a major objective of the Government. The enactment of the rangeland law in 1985 was a major attempt to improve the rangelands and their management. The enactment imposed prohibitions on activities aimed at damaging the rangelands, and the

provincial administration was empowered to prevent unauthorized cropping, impose fines for serious violations of the law, and order restoration of damaged land (Han J.G *et al.*, 2008). Within the Animal Husbandry Bureau, the government created such departments as rangeland monitoring and management departments mandated to oversee land-use practices across the rangelands. A series of policies and regulations have been enacted by the stakeholders such as the government and other related sectors since 1990, in order to protect the environment and rangeland resources.

Contribution of the Study

The above land degradation challenges are clearly evident in Amboseli ecosystem. Currently, in Amboseli ecosystem different stakeholders are using different methods and approaches ranging from traditional to science based and all are geared to aiding the degraded ecosystem recovery.

The information generated by the study will help the ecosystem managers to make informed decisions on land use plan, the most effective approach of ecosystem repair and utilization of natural resources. Recommendations made by the study are critical in developing action plans that will restore, rehabilitate, repair the degraded ecosystem and inform sustainable utilisation of plant resources in the Amboseli ecosystem.

2.9 THEORETICAL FRAMEWORK

Ecological Theory and Restoration

Ecological Restoration is the process of repairing a damage caused by human to the diversity and dynamics of indigenous ecosystem. Example of restoration include removal of harmful non-native species and repair of residual damage left by these species, conservation or reintroduction of native species crucial to healthy ecosystem functions or returning natural patterns of disturbance and succession to a landscape (e.g. through fire management). Since the success of these intervention is frequently limited by financial, environmental and time constraints, a body of theory has been developed to optimize the efficiency and effectiveness of restoration strategies.

Since the establishment of restoration ecology as a recognized sub discipline of ecology there have been urgent calls for the development of a theoretical frame work to guide practitioners. A growing body of literature has acknowledge the importance of general ecological theory in

restoration; for example, knowledge of habitat succession, movement of species across boundaries of the restored area, and the existence of alternate stable state of communities is necessary for defining realistic end-points for restoration. This article focuses on the quantitative approaches used to formalize restoration problem, starting with the mathematical formulation of the problem in terms of an objective function and constraints, illustrated with some simple examples and a review of some solution methods along with a brief discussion of their relative merits and drawbacks.

Defining an Optimal Restoration Problem

In order to efficiently deploy limited resources to repair a damaged ecosystem, it is vital to frame a restoration problem in terms of measurable quantities relating to the underlying biology and proposed restoration actions and to devise mathematical relations describing their interaction. It is first necessary to quantify the state variables, the set of management units to be worked with, the set of possible restoration actions and their costs and the range of values these variables can take. These will then be used to define the objective function, a quantity to be maximized or minimized whose value reflect the success of the restoration activity, and the constraints, a set of biological or financial restrictions limiting the scale of restoration. Depending on the form of the objective function and constraints, an appropriate solution technique is chosen and used to compute the optimal set of restoration actions. This process is summarized as follows;

State Variables

Let $s(t) = s_1(1), \ldots, s_n(t)$ be the set of n state variables of interest at time t. These may represent a set of candidate sites, ecosystems services or species for restoration, or different life stages of a single focal species. The s_1 may take binary values (e.g. 0 = unoccupied, 1 = occupied by the target species), a distance set of integer values (e.g. scores of 1-5 for habitat quality ranging from degraded to pristine, species richness) or vary continuously (e.g. species density, area occupied by a given species).

1. **Select state variable.**

. Patch state – e.g. occupied/unoccupied, degraded/restored
. Area – e.g. reserve size, species range
. Species – e.g. density, richness

2. **Define restoration actions and associated costs**

. Increase patch quality/connectivity
. Increase size of protected/managed area.
. Reintroduce/Remove species

3. **Define objective**

. Minimize cost/maximize area of restoration
. Maximize ecosystem services/species richness
. Minimize invader damage/density, native extinction risk

4. **Define constraints**

. Anthropogenic (e.g. budget, effort, timeframe of restoration)
. Biological (e.g. population dynamics, habitat succession, nutrient flow)

5. **Choose solution method**

Objective and constraint functions are
. simple/additive/deterministic: exact solution by analytical methods (e.g. linear/integer programming)
. Nonlinear/stochastic: approximate solution by numerical methods

Optimal Restoration Strategy

Figure 1: schematic depicting a five-step process for defining an ecological restoration problem in a form amenable to mathematical or computational solution.

Restoration Actions

Let $r(t) = r_1(t), \ldots, r_n(t)$ be the set actions affecting each of the n state variables above, and undertaken at time t. These actions must be measured in (or transformed to) the same units as the state variables. For the sake of illustration, assume that restoration will take place at discrete time units $t = 1, \ldots, t_{max}$, where t_{max} is the time horizon. At each time step the relationship between the dynamics of the ith state variable pre- and post- restoration and the restoration action undertaken is described by a function fi, such that

$$s_i(t+1) = f_i(s_i(t), r_i(t)) \qquad (1)$$

If the outcome of the restoration activity is uncertain, the dynamics are instead described by a set of conditional probabilities that state variable s_i takes on the value $s_i new$ at the next time step, given its value at the previous time step and the action taken.

$$P(s_i(t+1) = s_i new \,) \, s_i(t), r_i(t)) \qquad (2)$$

Objective Functions

The objective function can take a variety of forms, depending on specific problem. In many cases it is expressed as a weighted sum of the state variables or restoration actions at the final time steps. Two illustrative examples of objective functions are given below.

Example 1: Maximize Biodiversity in a Managed Habitat

Suppose the state variables s_i represent the presence or absence of indigenous species i, but that some species are of higher conservation concern than others as measured by a weighting index w_i. The objective of optimization may be to maximize biodiversity, as measured by a weighted sum of the total number of species present following restoration:

$$\sum_{i=1}^{n} w_i s_i(t_{max} + 1) \qquad (3)$$

Example 2: Eradicate Invader at Minimum Cost

Suppose instead that the s_i represent the area occupied by the ith life stage (e.g. seedling, juvenile, adult) of an invasive species, that the corresponding restoration activities r_i denote that area of stage I removed and that the aim of restoration is to minimize the total cost of

eradication. If the cost of removing one stage of i of the invader is e_i and the economic discount is d, the objective function to be minimized is

$$\sum_{t-1}^{max}{}_{c} \quad - dt\left[\sum_{i=1}^{n} c_i r_i(t)\right] \qquad (4)$$

Example 1 is a simple illustration of a more general class of objective functions that seek to maximize the total utility from a set of biodiversity *assets* (e.g. species, habitat types, ecosystem processes). Example 2 typifies a class if objective functions aiming to minimize the restoration *effort* (e.g. total restoration cost, total number of sites restored) needed to meet a given restoration goal (e.g. invader eradication, all changes to the physical or chemical environment that slow or prevent natural recovery of the invaded community, and they may recolonize restored areas if eradication is impossible during the time frame of restoration. In this case, an appropriate objective may be to minimize the sum of residual damage (a function of the cumulative amount of the invader removed) and future colonization risk (a function of the density of the invader remaining at the end of the restoration period). If uncertainty is incorporated explicitly into the model formulation, the aim of the restoration will be to optimize the expected value of the objective function.

Constraints

Many restoration problems are subject to budget constraints. If c_i is the per unit cost of restoration activity r_i, and $C(t)$ is the total budget available at time step t, then at each time step the budget constraint can be expressed

$$\sum_{i=1}^{n} c_i r_i(\mathrm{t}) \leq (t) \qquad (5)$$

Frequently, the units of the state variables and the restoration actions (e.g. area, population density) are constrained to be positive, yielding the biological constraints

$$S_i,\ r_i \geq 0 \text{ for all } i. \qquad (6)$$

Finally if the objective is to minimize the cost or effort required achieve a given outcome, this outcome appears as a constraint. In the case of the invader eradication at minimum cost

(example ii), the invader density at all n life stages must be exactly zero after the final round of restoration i.e.

$$S_i(t_{max} + 1) = 0 \text{ for all } i. \qquad (7)$$

Solution methods

There are many potential solution methods for optimization problems, each with advantages and disadvantages. Computational limitations dictate that simplifications are necessary, either in describing the underlying biology of the system, the functional form of the objective and constraints, the time horizon of restoration, or the number of specie, patches, or states considered; where these simplifications are made depends on the actual system being considered for restoration and the judgment of the user. A brief survey of solution methods, and their relative strengths and weaknesses, follows.

If the inherent variability in the biology, environmental conditions, and success of a planned restoration action is relatively low, a deterministic modeling frame-work maybe appropriate, whereby the dynamics of the system can be described by systems of (continuous-time) differential or (discrete-time) different equations. If, in addition, the expressions describing the dynamics, the objective function, and constraints are sufficiently simple, these systems can be solved exactly and rapidly for the optimal restoration strategy. Consider the example of a colonizing invasive species whose population dynamics are effectively density independent, where the objective is to minimize population size at the end of restoration period, and removal costs are directly proportional to the number of individuals removed. If removal occurs at discrete time steps the system can be solved using linear programming, or if removal occurs continuously the calculus of variations may be the appropriate solution method. While real-life restoration problems are rarely this simple, the fast, efficient, and exact solution of the simplified system may yield key insights by allowing longer time frames and exhaustive sensitivity analyses to be conducted that may not be possible using more computationally intensive solution methods.

Unfortunately many restoration problems cannot be described in such simple terms, and in particular, accounting for uncertain outcomes explicitly in the formulation of the optimization problem is desirable. In this case, a suite of approximate numerical solutions can be determined by computational methods including stochastic dynamic programming, stimulated annealing, and genetic algorithms. The chief disadvantage of these methods is the

exponentially rapid increase in computation of restoration or the number of states considered (e.g., patches, species, and population sizes). Additionally, it is difficult to be sure that the algorithm employed is converging on the "true" optimal restoration strategy without undertaking time-consuming sensitivity analyses.

Optimal Strategy

When the optimal strategy has been computed, the results will be output as the set of restoration actions $r_{opt} = r_{opt}(1) \ldots r_{opt}(t_{max})$ yielding the optimal value of the objective function. In many cases, the optimal strategy at any given time step is to prioritize restoration activity on a single state variable. However, unlike ad hoc methods where the sequence of restoration events is arbitrarily predefined, the optimal strategy often switches which state variable is the target of restoration. The timing of this switch is dictated by how much future damage is valued relative to immediate outcomes by the restoration planner as the end of the restoration period approached. In spite of the challenges involved in defining a parsimonious model of a restoration problem and choosing an appropriate solution method, optimal restoration strategies are usually more efficient and effective than ad hoc or fixed management strategies, and they also provide a valuable baseline analysis for the feasibility of a proposed restoration effort before costly field trials are conducted.

2.10 CONCEPTUAL FRAMEWORK

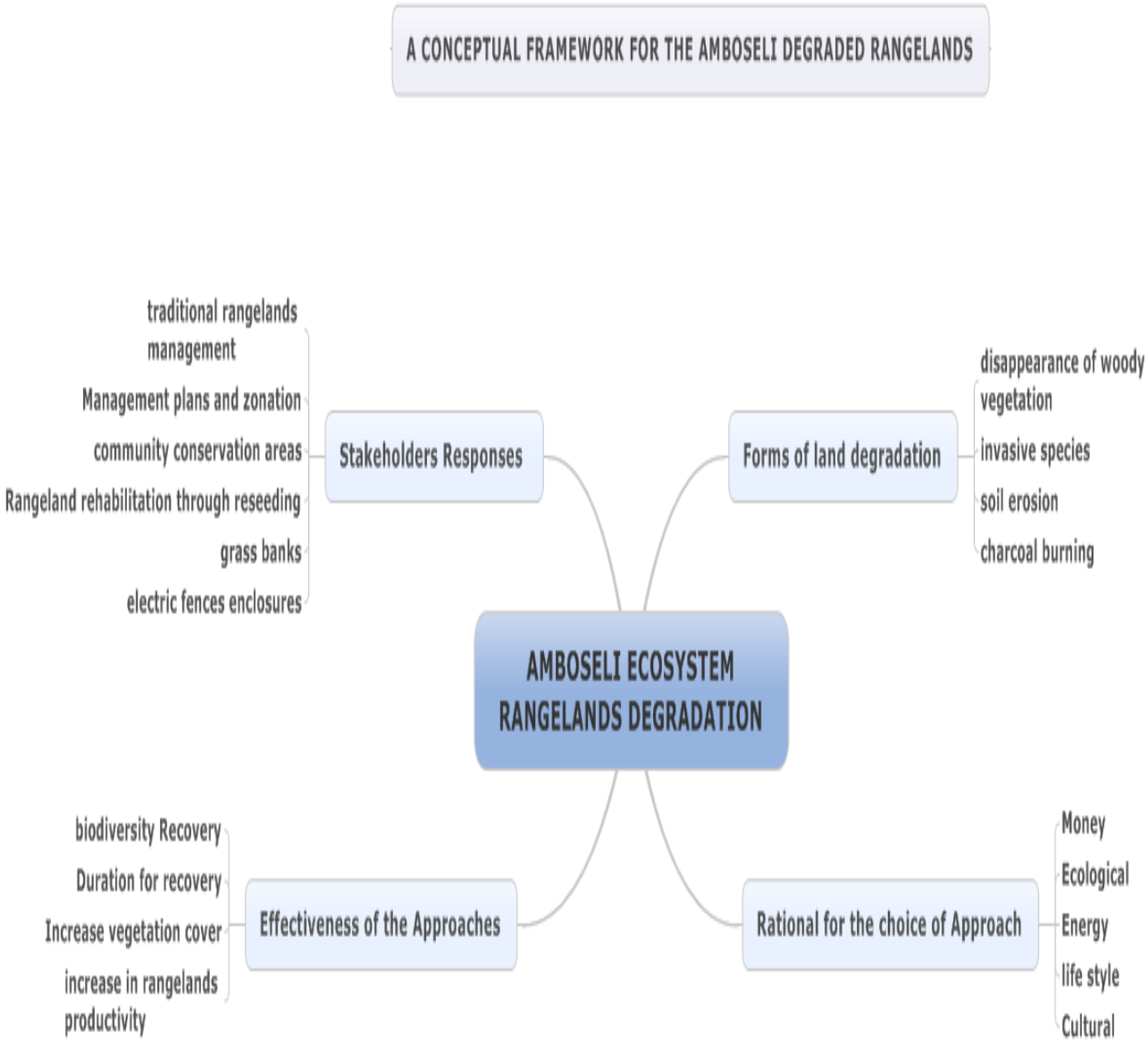
The Amboseli degraded rangelands do exactly take the clear example of the theoretical framework of the DPSIR which is an important tool in putting development into check through an integrated environmental assessment. Based on the DPSIR framework, a chain of causal links exists consisting of *'driving forces'* (economic sectors and human activities), *'pressures'* (emissions, waste) to *'states'* (physical, chemical, and biological), and *'impacts'* on ecosystem ecosystems, human health and functions, in turn causing political *'responses'* (prioritisation, target setting, and indicators). A description of the causal chain remains a complex phenomenon and especially from the driving forces to impacts and responses. Therefore, while describing it should be broken down into sub-tasks, e.g taking into accounts the relationship between pressure-state and impact response.

A '*driving force'* is a need. For instance, human needs such as shelter, food, and water, are the primary driving forces, while the secondary driving forces may include such needs less necessary as entertainment, mobility, culture, e.t.c. For industries, their driving force could be the need for maximization of profits at the lowest cost possible. Human activities such as transportation or food production are motivated by driving forces to meet certain needs. The human activities eventually exert *'pressures'* on the environment as a consequence of processes of consumption and production. Amboseli ecosystem exhibits such activities in two different ways; excessive use of environmental resources; and changes in land-use.

Therefore, effects of the *'pressures'* consequentially affect the *'state'* of the environment under impact; the quality of various compartments of the environment (air, water, soil, etc.) with regard to the purpose they fulfil. Therefore, a combination of physical, chemical, and biological conditions makes up the 'state of the environment.' Any alteration of the physical, chemical, or biological state of the environment weighs consequences on the ecosystem, determining its quality and influencing the welfare of human beings therein. In a nutshell, changes of the state of environment carries environmental or economic *'impacts'* on the functioning of the ecosystem, its capacity and ability to sustain life, and ultimately affecting human health and as well economic and social functioning of the society. A *'response'* is the reaction from the society, stakeholders, or policy makers, as a result of undesired impact on the ecosystem. The *'response'* can influence any part of the chain between driving forces and impacts. The steps being adopted by stakeholders in Amboseli ecosystem points to response to address the impact of degradation by using various methods of ecosystem repair.

Therefore, with the help of the DPSIR conceptual framework, this study intends to carry out a socio-economic and environmental degradation assessment of Amboseli ecosystem rangelands. The objectives of the study is to assess the different forms of environmental repair approaches and their effectiveness, and to determine the rationale being use by stakeholders to choose the methods for repairing the degraded ecosystem.

Figure 1: **Conceptual framework**



Adopted and modified from DPSIR

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter, reviews of the literature related to the area under study, presented by a number of authors, researchers, analysts, and scholars. The literature review considers the research objective on the area description, history, climate, location, topography, geology, flora, and fauna in the Amboseli ecosystem. The chapter also presents the research methodology. They include the various procedures, schemes, and algorithms used in research. The methods are well planned, scientific, and value-neutral. They include; theoretical procedures, experimental studies, numerical schemes, statistical approaches among others. The research methods aid to gather samples, collect data, and solve a problem. For instance, scientific research methods demand design, the sample size determination, sample size calculation, sampling procedures, data collection methods, data analysis techniques, and methods of data presentation based on the gathered facts. Scientific research accepts only those conclusions based on explained and verified experiments and not just reasoning.

3.2 The Amboseli ecosystem

3.2.1 Location

The Amboseli ecosystem lies immediately northwest of Mt. Kilimanjaro near the Tanzania border. It is in Kajiado County, Loitokitok District in southern Kenya and covers about 5700km^2. It is between longititude37 E and 37 – 30’ E and latitude of 2^0 – 30 and 2^0 – 45 S.

3.2.2 Area Description

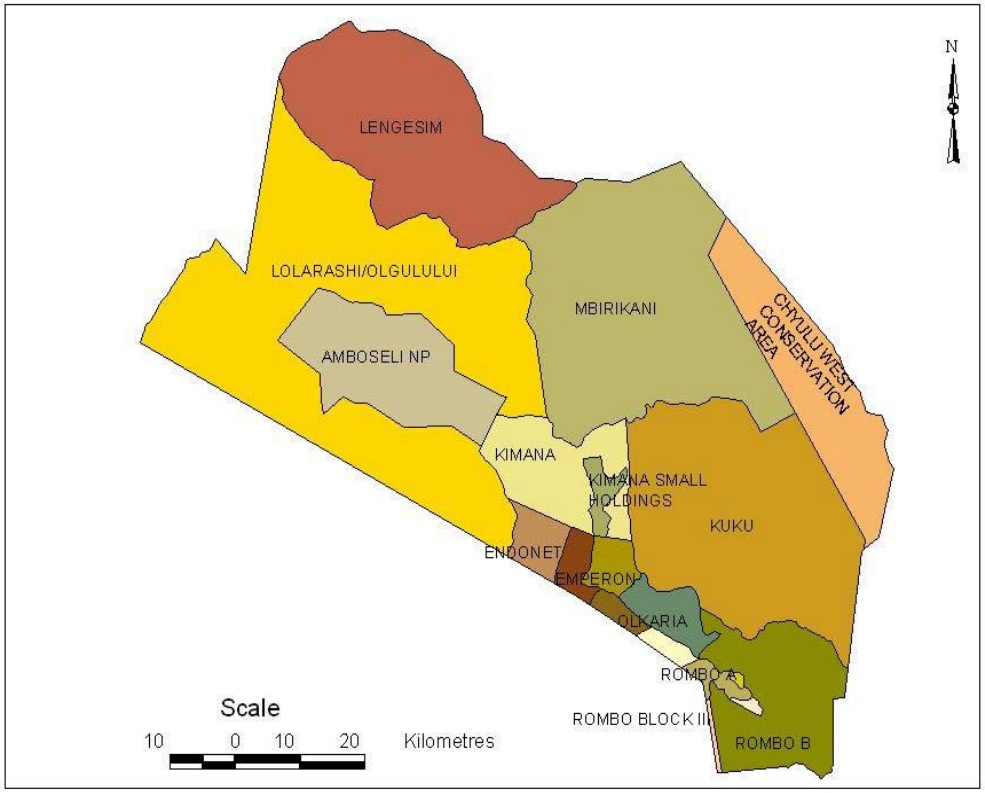
The Amboseli ecosystem is approximated to cover an area of around 5,700 square kilometres, being a stretch of between Mt. Kilimanjaro, Chyulu Hills, Tsavo West National Park and the Kenya/Tanzania border. Amboseli is generally arid and semi-arid, with slight variations in tis agro-ecological zones. Amboseli is well suited for pastoral activities rather than cultivation, being highly potential to conserve wildlife and support tourism industry.

Administratively, the Amboseli ecosystem is made up of Amboseli National Park and surrounded by the six group ranches. The ranches are identified as; Kimana/Tikondo, Olgulului/Olararashi, Selengei, Mbirikani, Kuku, and Rombo and they are approximated to be around 506,329 hectares in total size of the area they cover, in Loitokitok District (AEMP

2008- 2018). In addition, Amboseli ecosystem also includes the former 48 individual ranches found at the foot slope of Kilimanjaro and now they are being cultivated to grow crops.

The main causes of the continuing deterioration of the ecosystem's integrity have been attributed to increase in human population and settlements, failure in local governance, overstocking, marginal farming that is destroying the only permanent wetlands, fencing of vital wildlife corridors, sub-division of the group ranches and increasing game meat poaching. This scenario has generated competition and conflict among the people, livestock and wildlife and threatens their future (AEMP 2008- 2018).

Figure 2: **Amboseli Ecosystem Components (Source AEMP 2008 - 20018)**



3.2.3 Area History

In the Maasai language, the name Amboseli translates to "Salty Dust." The volcanic ash that erupted from Mount Kilimanjaro a thousand years ago is what led to the 'salty dust.' The present Amboseli National Park is a remnant of the Southern game reserve that covered 27,700 square kilometres established in 1906. It was later reduced to 3,260 square kilometres in 1948 and named Amboseli National Reserve, under the control and administration of

National Park Trustee. The year 1961 saw ANR being placed and county council. However, the discovery of the uniqueness of Amboseli and the need to be placed under intensive care and management led to the 1972 presidential decree to have 390 square kilometres portion set aside exclusively as a national park. In the same year, the park's new boundaries were demarcated and gazetted as government land. Amboseli National Park was finally instituted and placed under the control of Kenya National Parks Trustees in October 1974. From the 1990s up to date Amboseli was taken over by the KWS.

From colonial times to present day, the central government, wildlife conservationists and the Maasai have had separate but interacting interests in the Amboseli and its environs. This interaction was influenced by the changing political, social, and economical circumstances in the country throughout this period. The local community view the park as enclosing Enkongu Narok and Longinyei swamps, two among the seven main wetlands that constitute the most important dry season grazing areas in the Amboseli ecosystem while the conservation; colonial and post-colonial governments value the park as an important refuge for wildlife during dry season.

The system's inefficiency reflects a system beyond just corrupt bureaucracy: the park's management has never made just retribution a priority, in addition to the affected Maasais remaining uncompensated and park revenue getting lost. In 1981, the Maasais having lost grazing rights, simultaneously unpaid for damages against them, and unmaintenance of the Amboseli water pipe, left them without an option but to unlawfully retake grazing and watering rights lost to the park.

3.2.4 Climate

The Amboseli ecosystems fall under arid climate zone V and VI by (Pratf and Glosyme 1977), with and variable rainfall, (receives rainfall between 200-400mm per annum). The low rainfall is attributed by the park being on the leeward side of Mt. Kilimanjaro. Rainfall is distributed in two seasons of the year i.e. April – May and Nov – Dec, recurrent droughts and potential evaporation of 2200mm per annum typifies the region (KWS 1991). The temperatures of the Amboseli ecosystem fluctuate between 14 – 30^{o}c. The minimum temperature ranges from 14 – 18^{o}c in July – August while maximum ranges from 26 – 30^{o}c in February – March.

3.2.5 Topography

Amboseli ecosystem is generally flat and on a very low relief at the base of Mt. Kilimanjaro. A portion of the park on western part is dominated by a seasonal lake, The lake Amboseli, that is 76 km wide in the Northern part but 32 km in the south west side near the Tanzanian border. Elevation in the basin increases gradually towards the eastern side of the park. It rises to Chyulu hills and to the west it rises to Ol Donyo Orok, to the south the ground rises to the foothills of Mt. Kilimanjaro. Within the Amboseli ecosystem are a number of hills such as Lemomo, kitirua hills, Observation hill and Ilmerishari hills. Within the park, the lowest area is the lake Amboseli basin and the highest being Kitirua hills.

3.2.6 Geology and Hydrology

The Amboseli region underwent a period of metamorphosis during Pliocene times. This resulted in intense folding into a series of hills northward of the park. In the Pliocene, Kilimanjaro is said to have erupted and the lava flows blocked off the Pangani River, creating lake in what is now the Amboseli basin (Thorsell et al 1981).

3.2.7 Fauna

Amboseli elephants

Amboseli ecosystem has an elephant population of about 1400 individuals. These elephants have been a major driving force in the ecology of the Amboseli Ecosystem and are closely associated with habitat changes in the Amboseli National Park. The elephants have been the subject of one of the longest elephant studies in Africa and as a result of the long and close interaction with researchers, the elephants are approachable giving visitors excellent opportunities for watching them at close range. They further attract a lot of interest from wildlife researchers.

Array of ungulates

It supports a wide variety of wildlife which are readily visible. The park is a home to 56 species of large mammals. Though Amboseli ecosystem is a semi-arid environment, it supports a wide range of ungulates, which in turn support carnivores such as lion, leopard, cheetah, hyena, jackals, civets, and serval cats. This agglomeration of ungulates makes Amboseli an important wildlife conservation area in Kenya. The ungulates habitat utilization pattern is similar to that of the Maasai livestock and thus, Amboseli Ecosystem is a test case of how wildlife conservation and pastoralism can coexist.

Rich birdlife

Amboseli National Park is one of the 60 Important Bird Areas (IBAs) in Kenya and thus it is recognized as globally significant for bird conservation. The ecosystem has a rich birdlife, with over 400 species recorded, of which 40 are birds of prey. It has globally threatened bird species (e.g. Lesser Kestrel), restricted-range birds that are found only in a very small area such as the Taveta golden weaver, bird species that live only in a particular vegetation type such as the Grosbeak weaver, and regionally threatened bird species such as Martial eagles. The bird life in Amboseli is diverse due to the varying habitats. In October-December when the rains are on or about, the local birds are joined by migrants such as European storks from the Northern hemisphere, sometimes in fairly large numbers, and bird watching around the swamps and seasonal lakes can be a very rewarding venture.

Diverse carnivores

Most of the carnivore species, including leopard, lion, cheetah, and caracal, hyena, and serval cat can be seen easily in the Amboseli Ecosystem. These carnivores rank high as a tourist attraction in the Park and adjacent areas. They also play a significant role in controlling the herbivore populations.

Vegetation

The Amboseli ecosystem falls under the Chyulu/Kilimanjaro volcanic natural region which is an Acacia dominated dry woodland savannah. This vegetation type supports the pastoralist lifestyle of the local Maasai and a wide array of savannah wildlife species, the cornerstone of tourism in the ecosystem. The bigger part of the Amboseli ecosystem is semi-arid. Nevertheless, water springs associated with Mt. Kilimanjaro emanate at the basin of the ecosystem and give rise to several swamps which are critical to maintaining wildlife in the ecosystem. The high primary productivity of the swamps is able to sustain a vast array of wildlife species in a semi-arid environment and contributes to the high biodiversity and tourism value of the ecosystem.

The Amboseli ecosystem embodies five main types of habitats, which includes; open plains, acacia woodland, rocky thorn bushes, swamps and marshes. The park embodies several types of semi-arid vegetation, swamps and marsh lands. In general there is a gradient of vegetation from the bare lake bed, through grasslands to acacia woodlands. The basin is surrounded by *Commifora africana* bush land while grasslands are dominated by *Sporobolus consimilis*,

Cynadon dactylon, *Suaeda monica.* The plants species in the woodland includes; *Acacia nubica*, *Acacia melifera, Acacia draipanalobium* and Salvadora species.

3.2.8 Land use zones

The ecosystem has been divided into three broad zones i.e. arable agriculture, livestock production, and wildlife tourism, based on environmental and socio-economic considerations (see table below). (AEMP 2008- 2018).

Table: 1

Land use zone	**Land use objective**	**Zone description**
Wildlife tourism	Wildlife conservation and tourism	Includes Amboseli National Park and the existing and proposed community wildlife concession areas
Livestock production	Livestock production through pastoralism	Includes all the area in the ecosystem that is neither under agriculture or conservation land uses
Arable agriculture	Agricultural production through rain fed and irrigated agriculture	Includes all the irrigation schemes and the arable strip of land at the foot slope of Kilimanjaro

3.2.9 Society and cultural

What makes the Maasai culture famous is the fact that the culture has remained largely unchanged in the midst of western influence. The traditionally semi – nomadic Maasai tribe has held on to their culture. Their largely livestock grazing lifestyle has been important in conserving wildlife resources in the Amboseli Ecosystem. Although many of the cultural and sacred sites are not well documented in the Amboseli Ecosystem, there is rich history that needs to be well understood and protected. These include areas used by the Maasai for various cultural ceremonies such as circumcision. Other cultural sites include the Maasai Moran Manyattas, and the Chyulu caves.

3.2.10 Economic Activities

Amboseli ecosystem is one which has seen its land being subjected to pastoral land-use practices as the main economic activity for the past century. Emerging activities with respect to land-use in the Amboseli ecosystem be it agriculture or wildlife, they will have to effectively compete with pastoralism not only on economic grounds but as well spiritual and cultural basis.

3.3 Research Methodology

3.3.1 Research Approach to the study Area

The research study involves reporting of characteristic of the phenomenon under investigation carried out to described situation or events. Thus is a descriptive type of research. The Amboseli ecosystem comprises of community owned group ranches which includes; Imbirikani, Rombo, Olgulului, Kuku, Eselenkei and Kimana plus the Amboseli National park which is general study area as shown in Table 1 below;

Table 2: **Amboseli National park and Group Ranches, Group ranch Size (hectares, No. of members**

Group Ranch (GR)	**Year of Est**	**Ranch Size Ha**	**Reg members**	**If they have Mgt Plan**	**Type of leadership**	**GR Stakeholders**
Olgulului	1973	147,050 16	11,482	Yes	Elected	ACC, BL AWF,KWS, IFAW, KWT, BABOON RESEARCH
Kimana	1974	25,120 12	843	Yes	Elected	BL, AWF, KWS
Selengei	1975	74,794 16	3,604	No	Elected	LION GARDIAN, PORINI CAMP, KWS
Imbirikani	1976	125,893 62	4,627	On	Elected	BL, ACC, LION GARDIAN, AWF, KWS
Kuku	1977	96,000 57	12,469	No	Elected	MWCT,AWF,KWS

Rombo	1978	38,000 10	3,665	Yes	Elected	BL, ACC, KWS
Amboseli NP	1976	39,200	200	Yes	Warden as manager	All the above partners
Total		**506,857 173**				

The whole ecosystem is very important in this research study but due to an extensive versed-ness of the landscape, I had to come up with a selecting criteria form two (as showed by the highlight) community owned group ranches and the national park that is at the heart of the ecosystem. The criteria took into accounts the following aspect;

- -The size of the group ranch
- -Their strategic location within the ecosystem
- -Number of registered members
- -Availability of management plan
- -Sample Representation
- -Their relevance to the topic of study

Thus through stratified sampling based on the above different characteristic of the strata in reference to table 1, the researcher selected two group ranches namely; Olgululuin and Imbirkani and the Amboseli national park as the study area for the research study. The selected areas of study offer the most contrasting situations in terms of land tenure/land use types and intensities, ecological conditions and provision of benefits from wildlife-based tourism to the local communities.

The environmental degradation and repair approaches are different depending on part of the ecosystem you are and strategies appropriate for different dry-land eco-zones used by communities and the stakeholders. The environmental degradation repair approaches/methods some rely solely on natural process, rainfall for the regeneration and restoration while others need human aid. Community participation and involvement in the environmental repair process is critical and cut across all stages. The grass production, productivity, survivability, germination and propagation trails on indigenous grass species, trees and shrubs are equally important.

Table 1: **The strategy for mapping different forms of environmental repair approaches**

• **Forms of environmental repair approaches**	**Item to map**
• Reduction of Livestock numbers	-improved breeds, holdings, paddocks
• Rangeland rehabilitation -	-Reseeding the degraded land
• Changing the patterns of Mixing animals	-Rotation and herd composition
• Animals' distribution patterns	-Grazing plan and committee
• Increasing Plants diversity	
• Use of Chemical and Mechanical means	
• Water Use and Management	-Location of water pans and borehole
• Land-Use Systems-	-napier stripes, mgt plans with zonation
• Conservation and Biodiversity	-Conservancies Management plans
• Agroforestry	-Shamba system especially in forest
• Governance	-Policies, LUP, management plans
• Enclosures	-Electric Fences, other fences
• Traditional	-Grass banks(inkaron), Olopololi
• Re-afforestation	-Tree Planting
• Terracing and gabions	-Terracing and gabions
• Trenches	-water holding trenches

Independent and dependent variables

Five different groups of factors are identified to induce degradation of grassland to significant extents. The first group consists of the reflectors of global climatic changes; biophysical variables. Botanic or biotic variables make up the second group. They include plant cover and plant productivity. The impact brought on the ecosystem as a result of livestock and wildlife activities falls in the third group. High intensity of grazing is a major driving force of grassland degradation. The effects of human activities or interference and socioeconomic development are variables described in the fourth group. High levels of poverty as a consequence of unsustainable development and declined biomass productivity is the express manifestation of land degradation in the dry-lands. The last group of variables consist of such factors as water accessibility, elevation, and gradient, and slope aspect, influence degradation of the grasslands (J. Dodson and B. Tóthmérész, 2011)

3.3.2 Research methods

They include the various procedures, schemes, and algorithms used in research. The methods are well planned, scientific, and value-neutral. They include; theoretical procedures, experimental studies, numerical schemes, statistical approaches among others. The research methods aid to gather samples, collect data, and solve a problem. For instance, scientific research methods demand design, the sample size determination, sample size calculation, sampling procedures, data collection methods, data analysis techniques, and methods of data presentation based on the gathered facts. Scientific research accepts only those conclusions based on explained and verified experiments and not just reasoning.

3.3.3 Population and sample

The whole ecosystem is very important in this research study but due to its' extensiveness, versed-ness of the landscape, cost of carrying out the research and the huge population of the membership (about 36,690), The researcher selected two group ranches namely; Olgulului and Imbirkani and the Amboseli national park as the study area for the research study. Therefore, a sample from the two group ranches and park was determined as follows.

3.3.3.1 Determining Sample Size

When formulating or structuring a survey, it is essential to put into regard the selection and size of sample collected. Sample size offers the estimate precision, and increasing the chances of the estimate value being the true value in the population. To determine sample size, the following factors have to be considered; population size, frequency of the outcome of interest, desired confidence level, and the resources available (time, personnel, testing capacity, etc). Calculation of the sample size can be based on a single outcome variable of interest or on a number of variables. The procedures and formulae used for categorical data to come up with sample size have similarity but with some variations.

Assuming the alpha level is set a priori at .05 by the researcher planning to use a proportional variable, and allowing a percentage of 5% as the acceptable error, and has employed Cochran's sample size formula as an estimate of the scale's standard deviation for categorical data. Below is the how the formula was used, accompanied with explanations as to how certain decisions were arrived at; (Cochran 1977).

$$n_o = \frac{(t)^2 * (p)(q)}{(d)^2}$$

$$n_o = \frac{(1.96)2\ (.5)(.5)}{(.05)2} = 384$$

Here, t represents the value for selected alpha level of .025 in each tail = 1.96. (Considering that the true margin of error is likely to go beyond the acceptable margin of error, the alpha level of .05 is an indication of the risk undertaken willingly by the researcher as a result of the error variations). Where (p)(q) represents the estimate of variance which equals .25. (Maximum possible proportion (.5) * 1- maximum possible proportion (.5) produces maximum possible sample size). Where d = acceptable margin of error for proportion being estimated = .05 (error researcher is willing to except).

Therefore, for a population of 16,109, the required sample size is 384. However, since this sample size exceeds 5% of the population (16,109*.05=805), Cochran's (1977) correction formula should be used to calculate the final sample size. These calculations are as follows:

$$n_1 = \frac{n_o}{(1 + n_o / \text{Population})}$$

$$n_1 = \frac{(384)}{(1 + 384/16{,}109)} = 375$$

Where population size = 16,109 where n_o = required return sample size according to Cochran's formula= 384 where n_1 = 375 required return sample size because sample > 5% of population

3.3.3.2 Stratified random sampling

The commonly used technique in coming up with a household survey is the stratification of the population to be made a subject of survey, before sample selection. With this technique, the survey population is classified into sub-populations-strata-based on the back-up information known concerning the full population; (UN New York, 2005). From each stratum, sample elements are then selected out with consistency to the survey objectives.

Example

The sample design of a survey consist of two strata – group ranches and Amboseli national park. Information from the population registered members is available to classify all the geographic administrative units into either Imbirikani, Olgululi group ranches or Amboseli national park, thus allowing the population to be stratified by this criterion. In reference to *table 1*, on the highlighted areas of study, the calculation formula for the sample distribution is as follow;

$$\text{Strata a} = \frac{\text{Strata a population}}{\text{Total population}} * \text{Sample size}$$

Thus for example the calculation for the three areas are as follow;

$$\text{Imbirikani} = \frac{4{,}627}{16{,}309} * 375 = 98 \text{ respondent}$$

$$\text{Orgulului} = \frac{11{,}482}{16{,}309} * 375 = 264 \text{ respondent}$$

$$\text{Amboseli NP} = \frac{200}{16{,}309} * 375 = 5 \text{ respondent}$$

It is decided to select a proportionate sample in each stratum (as opposed to disproportionate) because the population is distributed 27% Imbirikani, 71% Orgulului and 2%- Amboseli NP. Upon stratification of the sample, in each strata, the sample of the respondent was selected through simple random sampling.

3.3.4 Methods of data collection

Data collection was through mapping of all possible different forms of environmental repair approaches observation, secondary data, interviews and survey questionnaires. The data was primarily collected using questionnaires, designed and distributed randomly to respondents across the study area. The respective respondents included the local communities who are practicing different lands use activities i.e. agriculture and pastorals, the conservation stakeholders who have stake in community conservancies and government line ministry. Interviews and survey questionnaires was administered to FGDs and Key informants. The research study aimed at collecting data (n=375 questionnaires) as shown by the sample size calculation formula below. The social science research and especially of this kind require different approaches and I therefore prefer to use the following sampling approaches.

3.3.4.1 Questionnaire design

Relevant questionnaire were developed on the determination of survey objectives and tabulation plan. The questionnaire was instrumental during the survey process, since they transferred information from the respondents to the users. The sample survey questionnaire was in the form of both open-ended and closed questions. Open-ended questionnaire allowed the respondents to answer according to their thoughts with regard to the question. Closed-ended questionnaire on the other hand provides the respondents with answers to choose from, thus restricting the application of their thoughts to the question (UN New York, 2005). The administration of study questionnaire across the study area was done through random selection across the population.

3.3.4.2 Semi Structured Interviews

Interview is just but another method of data collection. Those selected to conduct field interviews should be thoroughly trained before embarking on the research objectives. The training programme of interviewers is purposefully to bring uniformity in the interviewing procedures adopted during the survey. Moreover, it is necessary since it does avoid diverse interpretations, definitions, concepts and objectives of the survey by interviewers, which in turn minimizes interviewer bias. During the training process, the interviewers being trained should actively participate by taking turns in explaining to each other various items in the questionnaire. The interviewers should learn both theoretically and practically by having both class and actual field settings during the learning process.

Interviews involved the collection of the data through talking to the respondents. Thus due to low literacy levels and avoiding taxing patience of individuals' verbal interviews were also very necessary. Two focus group discussion (FDGs) were contacted in the two group ranches namely; Olgulului and Imbirikani one for each group ranch and the FGDS comprised of groups of ten to fifteen people. The FDGs discussion were expected to take about two hours each depending on the responses speed of answering questions. Key informants were drawn across the study area from the community, KWS, Conservation NGOs among others was selected by the researcher based on their experience, knowledge of the ecosystem and the leadership role they play. A total of ten (10) key informant will be selected across the study area.

The sample of data collected was from 375 respondents from the study areas and selection was be stratified and then randomized through simple random sampling, observations, interviews, questionnaire and mapping of the different forms of environmental repair approaches, Secondary data collection was also to be used in this study. Data collection period is as shown by the time schedule in the appendices of this document.

3.3.5 Methods of data Analysis

3.3.5.1 Statistical Package for the Social Sciences" (SPSS)

The "Statistical Package for the Social Sciences" (SPSS) is a package of programs for manipulating, analysing, and presenting data; the package is widely used in the social and behavioural sciences; Sabine L. and Everitt B., (2003). Data analysis employed the Statistical Program for Social Sciences (SPSS) method. The Statistical Package for the Social Sciences (SPSS) is a software package used in statistical analysis of data.

3.3.5.2 Chi-square goodness of fit ($\chi 2$)

The first type of chi square test is the goodness of fit test. Any statement or claim with respect to the distribution of the whole population of a given ecosystem is based on the test. The consistency of the hypothetical population distribution with the distribution in this survey is observed through examining the data in the sample.

The chi square goodness of fit test was used to test the level of significance of the rationale for the choice of environmental repair approaches being practices by stakeholders and the effectiveness of the different repair approaches in Amboseli ecosystem. The $\chi 2$ distribution is used for testing the goodness of fit of a set of data to a specific probability distribution;

Gupta C. B., Gupta V. (2004). In a test of goodness of fit, the actual frequencies in a category are compared to the frequencies that theoretically would be expected to occur if the data followed the specific probability distribution of interest. The results finding have been presentation through tables, graphs, and charts.

CHAPTER FOUR: RESULTS AND DISCUSSION

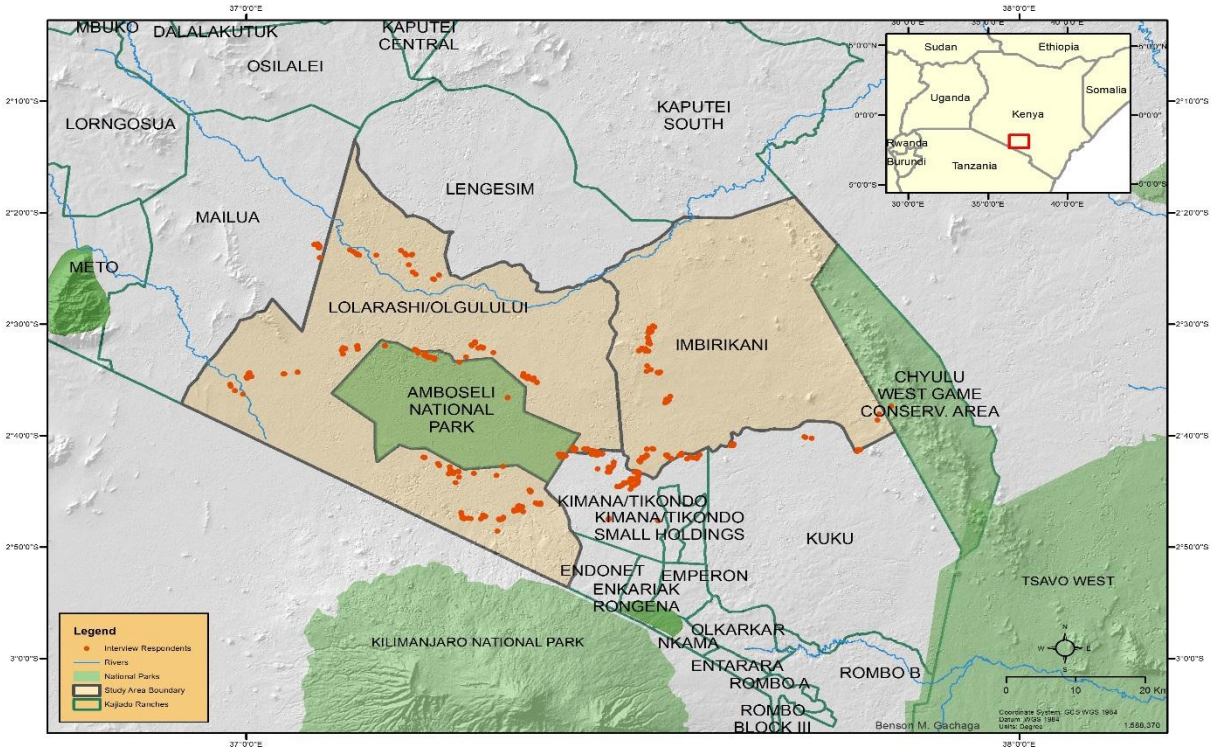
4.1 Introduction

This chapter covers the data analysis results, interpretation and the presentation of the research findings and detailed discussions of the Key results findings.

4.2 Demographic Characteristics of Respondents

About 95.3% of the general respondents interviewed in the study area were Maasai and of whom 64% are from Olgulului/ololorrashi group ranch, while 31.1% of the respondents are from Imbirikani group and 4.9% are from other areas including Amboseli national park as shown by Figure 3;

Figure 3: **Study area Map showing Respondents distribution**



On the aspect of gender, 59.8% of the general respondents represented men while 40.2% female. There was a higher percentage of both young adult 21 - 30 years at 33.9% and middle age people 31 years – 40 years at 26.7% among general respondents, young respondent below 20 years accounted for 2.6%, compared to 17.4% elderly respondents. The overall level of literacy was lower among the sampling unit; 64.2% of the respondents had no education, while only 6.2% of the general community had tertiary education as shown in table 3,

Table 2: **Level of education of the general community respondents**

Level of Education	**Percentage**
No Education	64.2
Primary	19.7
Secondary	9.6
Collage/university	6.2
Total	**100**

Pastoralism was the main primary livelihood strategy of the mainstream of general community respondents at 49.2%, Nevertheless, 43.3% of the respondents practice agro-pastoralism as their primary livelihood strategy (table 4). A small percentage 7.5% of the respondents pointed out other livelihood strategy aside from the Pastoralism and agro-pastoralism.

Table 3: **Primary livelihood strategy within the general community respondents**

Livelihood Strategy	**Percentage**
Agro-pastoralism	43.3
Agriculture	4.9
Pastoralism	49.2
Business	1.3
Beadwork	0.3
Self employed	0.3
Employment	0.5
Total	**100**

4.3 Objective One: The different forms of environmental repair approaches being used in Amboseli ecosystem

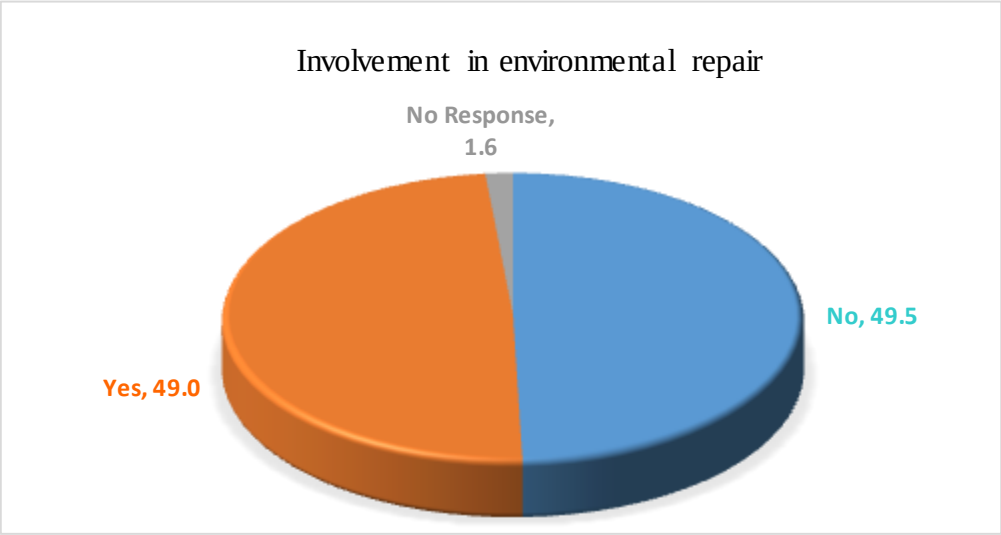
4.3.1 Environmental Repair Approaches

On environmental repair approaches, 78% of general respondents were familiar with the idea of environmental repair and aware of environmental repair approaches. About, 70.6% of the

male respondents were aware of seven forms of environmental repair; namely enclosures at 49.4%, terracing at 5.2%, reforestation and gabions each at 4.3%, creation of community conservancies at 3.9%, trenches at 3% and rangelands rehabilitation at 0.4%. On the female respondents; 67.7% were aware of seven forms of environmental repair; namely enclosures at 54.8%, reforestation at 7.7%, terracing at 2.6%, gabions each at 1.3%, trenches at 0.6%, creation of community conservancies at 0.6%, and rangelands rehabilitation at 0.0%. On the general respondents in all the study area villages, about 72.5% of community respondents were familiar with traditional approach of environmental repair approach. In terms of specific locations in the study area, in Amboseli park the Environmental protection was cited higher at 2.2% but in Imbirirkani group ranch reforestation was cited higher by 8.3%, while Olgulului - Meshenani the most popular among respondents was reforestation at 33.3% followed by traditional practices and enclosure each at 16.7%, settlement control at 10.5% and last but not least at tree cutting protection at 9.1%

Almost half 49% of the general community respondents of the 78% that are familiar and are aware of environmental repair approaches have in one way or another been involved in environmental repair, of the 70.6% of the male respondents who were aware of seven forms of environmental repair, only 49.2% of male have been involved in the different forms of environmental repair. Top on the list of involvement for male; community education and awareness creation at 6.9%, followed by Reforestation at 6.5% and environmental protection at 5.2% among others. On the female respondents; of 67.7% who were aware of seven forms of environmental repair, only 34.8% of female have been involved in the different forms of environmental repair. Top on the list of involvement for female; stop cutting of trees and bushes around homestay at 8.4%, followed by community education and awareness creation at 6.5%, and environmental protection at 3.9% among others. Nearly 49.5 of the respondents who were interviewed said that they have not been involved in any environmental repair approach as showed by the Figure 4.

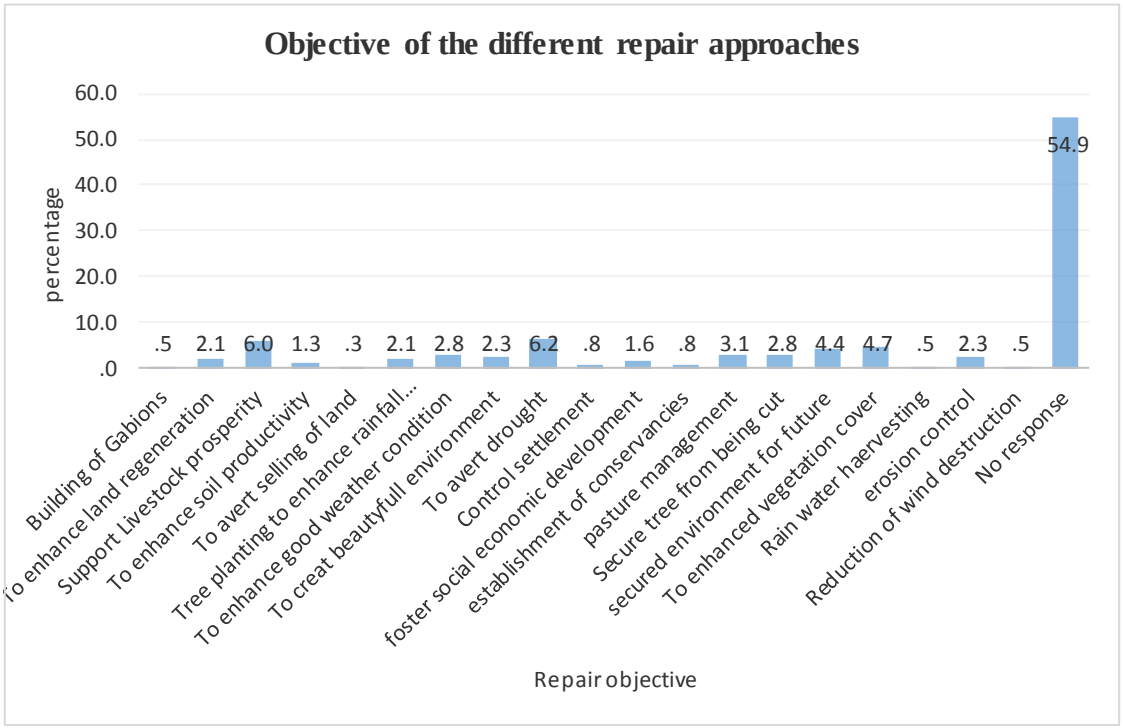
Figure 4: **Opinion on involvement in environmental repair**



The 49% of the general community respondents that were familiar and aware of environmental repair approaches indicated that they have been involved in restoring the degraded environments in the following ways; top on the list is community education and awareness creation at 6.7%, traditional grazing committee at 6.2%, reforestation at 6%, stop cutting of trees and bushes around homestay at 5.2%, Environmental Protection 4.9%, Pasture management at 4.7% and 3.4% settlement and grazing patterns control. The other repair approaches involvements includes; rehabilitation, environmental club, enclosures, pruning of trees and bushes, community resource assessor, holistic management, construction of water pans, seasonal livestock migration calendar, Establishment of conservancies, building of gabions and terraces, building of trenches and control charcoal burning.

On involvement in environmental repair, 49% of the respondents whom in one way or another were involved in the environmental repair approaches confirmed that they had different objectives which they were trying to achieve in the process of restoring the environment. The objective with the highest proportion coming up from the respondents is to avert drought at 6.2%, followed by support Livestock prosperity at 6%, to enhanced vegetation cover at 4.7%, secured environment for future at 4.4% and last but not least pasture management at 3.1%. The other objectives given by the respondents are showed by the Figure 5.

Figure 5: **objectives of environmental repair approaches**



4.3.2 Role of different stakeholders in Environmental repair

On the stakeholders' role in environmental repair, 83.2% of the general community respondents said that the community have played a very important role in environmental repair. The respondents indicated that their role in restoring the degraded environment has been through; Securing traditional grass bank accounting for 12.7%, followed by controlling cutting down of trees at 9.6%, setting up enclosures traditionally called Olopololi for calves and young once of goat and sheep kids at 8.3% and controlling settlement at 7.8% among many others.

On Non-Governmental organization, 45.9% of the general community respondents said that NGOs equally play an important role in environmental repair. Nearly 45.9% respondents believed that the main role of NGOs in restoring the degraded environment are as follows; capacity building for communities on environmental protection accounting the highest proportion at 9.6% followed by wildlife protection at 7.5%, advocating for stop cutting down of trees at 6.2% and last but not least creation of community conservancies at 3.9%.

Only 40.7% of the general community respondents interviewed believed that government has played a role in environmental repair, a lesser proportion (26.2%) of the respondents new no role played by government in environmental repair. The majority of the 40.7% respondents

believed that the main role that government played in environmental repair includes; Provision of water accounting for 13.7%, followed by environmental protection at 8.3%, control charcoal burning at 4.1% and last but not least wildlife securities 3.9%.

On individual farmers, only 27% of the respondents have participated in contributing to the restoration of the degraded environment. A substantial majority of the respondents cited that they role in restoring the degraded environment has been through; construction of terracing and gabion accounting at 8.0%, followed by tree planting at 4.1% sensitizing people on environment 2.8%, and uphold law and order at 2.6%. A reasonable proportion (34%) of the general community respondents interviewed said that they have not played any direct role by themselves in restoring the environment.

On other specified stakeholders, only 13.8% of the respondents pointed out that there other stakeholders contributing to the restoration of the degraded environment. A minor proportion of the respondents said that the other stakeholders role in restoring the degraded environment has been through; Establishment of conservancies along corridors accounting 4.1%, followed by community education and awareness at 3.1%. A reasonable proportion (34%) of the general community respondents interviewed said that there are no other stakeholders involved in restoring the environment.

4.3.3 Maasai Traditional approach in Maintaining Rangelands

The traditional ways of maintaining rangelands tents to flow with all the age brackets, 91% of the general respondents confirmed that the Maasai traditions practiced various approaches of maintaining rangelands, of the many approaches, 14.6% of the respondents said that Maasai maintain rangeland through; traditional grass bank, followed by no cutting down of trees at 8.4%, and last but not least setting up Olopololi enclosures 6.8%. The other ways and means in which the Maasai traditions maintained rangelands are as shown by table 6. For instance; on the age bracket 50 years and above, the main ways traditional rangelands were maintained was through; Traditional grass bank at 23.9%, followed by use of seasonal calendar at 9% and last but not least enclosures and traditional laws and customs each at 7.5%. On age bracket of 41 - 50 years the main ways traditional rangelands were maintained was through; No cutting down of trees accounting for 12.5%, followed by control livestock migration and traditional grass bank each at 10.8%. On age bracket of 31 - 40 years the main ways traditional rangelands were maintained was through; traditional grass bank at 14.6%, followed by enclosures and no cutting down of trees accounting each at 7.8%. On age bracket

of 21 - 30 years the main ways traditional rangelands were maintained was through; traditional grass bank at 13%, use of seasonal calendar and no cutting down of trees each at 9.9%. Those of age 20 years and below indicated enclosures and traditional grass bank each at 2%.

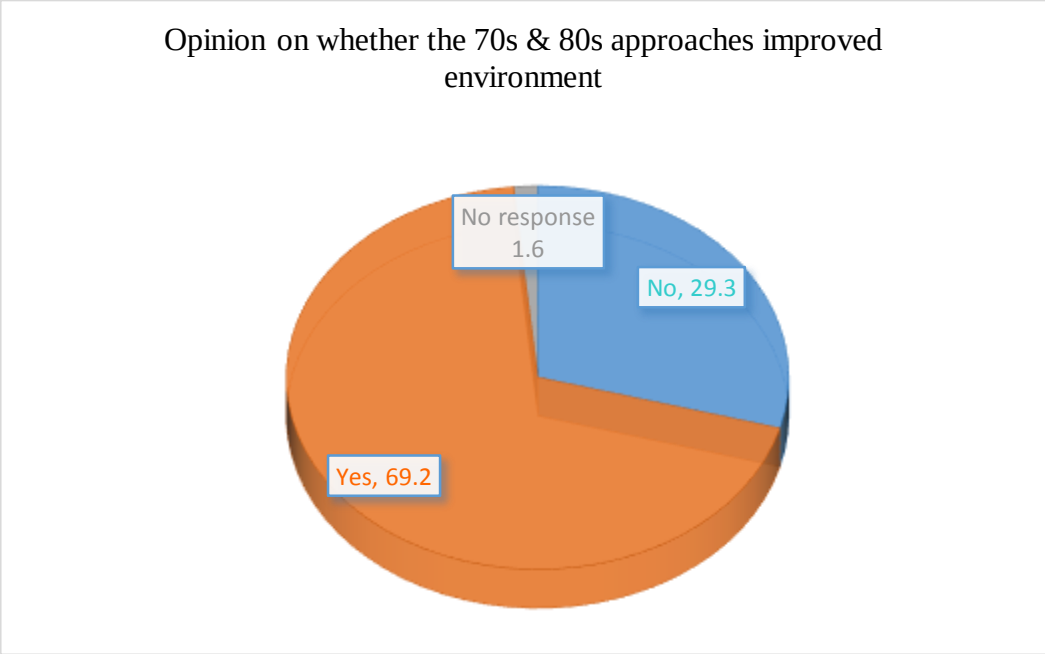
Table 4: **Ways in which the traditional Maasai community maintained range productivity**

stakeholders role in environmental repair	**Percent**
None	34.1
Scholarship on wildlife and environmental courses	0.3
Employment of community rangers to take care of environment	0.5
Provision of water	0.5
Predator consolation	0.3
Building of gabion	1.3
Environmental laws enforcement	0.3
Reseeding rangelands	0.3
Establishment of conservancies along corridors	4.1
Community education and awareness	3.1
Livelihood diversification	0.5
Provision of tree seedlings	0.3
Controlling invasive species	0.3
Enclosures	0.5
Controlled settlement	1.0
Trenches	0.3
No response	52.2
HWC - Lion proof bomas	0.3
Total	**100**

The 91% of respondents who confirmed that the Maasai traditions practiced various approaches of maintaining rangelands, 69.2% of them also believed that the approaches used in 70s and 80s s improved the environment (Figure 6*)*. The respondents interviewed gave the following as the most commonly cited approaches at that time; maintaining of traditional grass bank (Oloopololi/Inkaron-maa) accounting for 27.2%, followed by enclosures meant

for calves and goat/sheep young once at 10.9%, livestock migration at 10.1% and last but not least land preservation/conservation at 5.7% and last but not least controlled settlement at 5.2%.

Figure 6: **Opinion on whether the 70s and 80s approaches improved the environment**



On opinion whether the 70s and 80s approaches improved the environment, 71.6% of respondents who indicated that the approaches used in 70s and 80s improved the environment, 60% of them supported they opinion of the approaches improving the environment due to the following main reason; Availability of enough pasture at 13.7%reliable rainfall at 6.8%, increased tree cover at 6.2%, livestock survival rate was high due to less diseases at 5.7%.and last but not least soil productivity was high at 5.2%,

4.3.4 Environmental Degradation and its effects

On environmental degradation, 74.6% of the general respondents said that they were familiar with environmental degradation, 70.2% of the 74.6% general respondents who are familiar with environmental degradation; attribute degradation to the following factors desertification accounting 14.1%, prolong drought at 8.5%, soil erosion at 8%, less rainfall at 6.9% and increase in population at 5.9%. The general respondents in all the different locations in the study area had differing familiarities of the main factors causing degradation; for instance in Imbirikani – Inkoisuk, Esambu and Orgosua villages unplanned settlement was at 25%, less rainfall at 83% and increase in population at 57.1% respectively. While in Olgulului - Namelok osoit village unplanned settlement at 44.4% and less rainfall at 70%.

About 86.8% of the general respondents believed that the following are the main factors causing environmental degradation; prolong drought accounting 26.4%, Overpopulation please ensure good grammar and punctuation why capital letters for words that are not noun or first word in a sentence of human, livestock and wildlife at 17.1%, cutting down of trees at 7.5%, Overstocking at 10.5%, Land clearing and deforestation at 4.7% soil erosion and climate at 3.1% each among many others. The other many factors that the general respondents believed to also cause environmental degradation are as shown in table 7.

Table 5: **Causes of environmental degradation**

Causes of environmental degradation	**Percentage**
Prolong drought	26.4
Soil erosion	3.1
Overgrazing	2.6
Industrial Pollution	1.6
Charcoal burning	1.0
Poor waste disposal	1.0
Unplanned development	.8
Industrialization	.3
Mining	1.0
Land clearing	.3
Use of chemical pesticides	.3
Deforestation	4.4
Soil infertility due to use of fertilizer	1.6
Overstocking	3.4
Don't know	6.5
Disappearance of plant and animal species	1.6
Ozone layer depletion	.3
Increase in elephant population	.5
Lack of environmental education	2.3
Poor management of rangelands	.5
Cutting down of trees	7.5
Poverty	1.0

Causes of environmental degradation	Percentage
Poor Leadership	1.0
Lack of employment	.3
Overpopulation	17.1
Land subdivision	1.3
Climate change	3.1
Unplanned settlement	2.1
Demand for food	.3
Commercialization of land	.3
No Response	6.7
Total	**100.0**

The 86.8% of the general respondents who indicated that they were familiar with environmental degradation, also pointed out that environmental degradation has effects. These include livestock and wildlife death accounting for 19.5%, lack of pasture at 19%, drought at 13.9%, and reduction in grazing land 8.7% leads to long migrations at 3.8%, and reduction in population at 3.8% last but not least. Pastoralism and agro-pastoralism were the main primary livelihood strategy accounting for 92.5% of the general community respondents. On the two main primary livelihood, it's clearly evident that degradation has effects to the livelihoods; For instance; in Agro-pastoralism the main effects cited by majority respondents are as follows; Lack of pasture accounting for 25.7%, followed by livestock and wildlife death at 17.4% and last but not least reduction in grazing land at 16.2%. on pastoralism the main effects as indicated by majority respondents are as follows; Drought accounting for 31.6%, followed by lack of pasture at 21.1% and last but not least livestock and wildlife death at 15.8%.

4.3.5 Temporal and spatial change of Rangelands vegetation

The state of rangeland vegetation tendsto be affected by the factor of age; since among the strong reasons given by each respondents age bracket seem similar among the elderly and also the young respondents; For instance, on the age bracket of 50 years and above and that of 41 – 50 year which both accounts for 36.6% of the general respondents indicated the following as reasons for change in state of rangelands vegetation; Less rainfall accounting for 17.8% and 18.9% respectively, followed by lack of pasture at 8.1% and 13.4% respectively; and last but not least population increase at 7.5% and 6.8% respectively. The vegetation change images of 1986, 2000 and 2014 below clearly give evidence that there is vegetation change in Amboseli ecosystem.

On the age bracket of 31 – 40 year which both accounts for 26.7% of the general respondents indicated the following as reasons for change in state of rangelands vegetation; less rainfall accounting for 16.5%, followed by prolong drought and population increase each at 7.8%. The age bracket of 21 – 30 year which accounts for 33.9% of the general respondents indicated the following as reasons for change in state of rangelands vegetation; less rainfall accounting for 14.5%, followed by cutting down of trees and population increase each at 8.4%. Those of age bracket 20 year which is 2.6% of the general respondents low also indicated the following as reasons for change in state of rangelands vegetation; less rainfall accounting for 20%, followed by soil erosion and population increase each at 10%.

On the status of rangelands vegetation, 53.6% of the general respondents interviewed believed that there has been great changes on state of the vegetation in the Amboseli ecosystem. As shown by the three Amboseli ecosystem vegetation change images above, the respondents said the following are the top on list as the main drivers of the vegetation change; Disappearance of species 6.4%, Human settlement expansion due to population increasing accounting 5.6%, Less rainfall at 5.4%, Land subdivision and deforestation at 4.3% each, and last but not least land subdivision 3.8%.

About 94% of the respondents gave their opinion that the state of rangelands vegetation in 70s and 80s was either good or very good as shown in Figure 7, while 56.2% of the same respondents indicated that the current state of rangelands vegetation is very bad as shown in Table 8, bring the table here and take figures to where they are discussed check and adjust in the whole document 53.6% of the respondents said that the visible changes in vegetation is

the disappearance of plant species accounting 81% follow at a distance by soil erosion 5.7%, increase in extent of bare land and reduction of animal foliage at 2.6% each and coming in of new plant species at 2.3%.

Figure 7: **Opinion on the state of Rangelands vegetation in 70s and 80s**

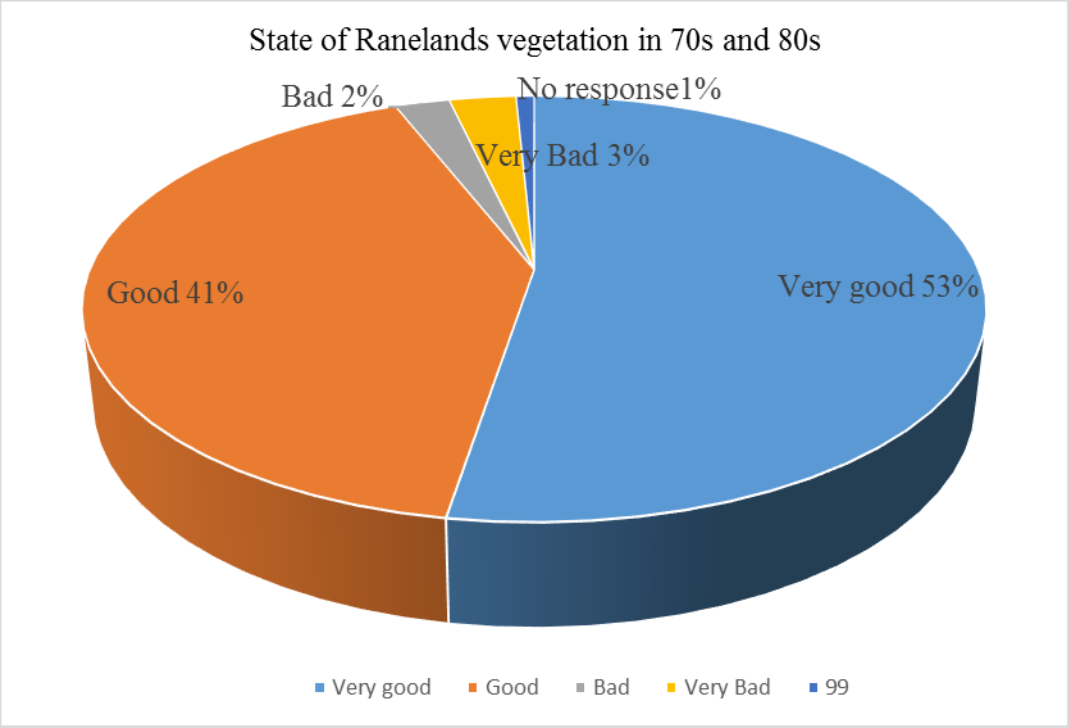


Table 6: **Opinion on the current state of Rangelands vegetation**

Current state of rangelands vegetation	Percentage
Very good	6.5
Good	36.5
Bad	39.4
Very Bad	16.8
99	.8
Total	100

4.3.6 Economic Implication of Rangelands degradation

On economic implication of rangelands degradation, 62% of the general respondents noted that environmental degradation has economic implications. The respondents interviewed said that the following are the main economic implications of degradation; Poverty accounting for 13.6%, followed by loose of livestock and economic crisis each at 6.7%, Loss of grazing land at 5.4%, High cost of living at 4.9%, increase in drought frequency and food shortage each 4.4% and last but not least low farm yields at 3.3%.

4.4 Objective Two: Assessment of effectiveness of environmental repair approaches being used in the Amboseli ecosystem

4.4.1 Assessment of the effectiveness of Repair approaches

On the assessment of the effectiveness of the Repair approaches, 80.6% of the general respondents point out that the different environmental repair approaches being used to restore the degraded environment in Amboseli ecosystem are effective. A majority of the respondents said that the traditional repair approaches top the list of effective approaches accounting for 24.9%, followed by reforestation at 14%, fences and enclosures at 10.4%, preserving trees and forest at 8.5%, creation of community conservancies at 4.1%, last but not least Rangelands rehabilitation and trenches at 3.6% and 2.6% respectively.

About 83.8% of the 80.6% who said that the different environmental repair being used to restore the Amboseli ecosystem degraded rangelands are effective supported their opinions with following reasons among many others; because of its' long term results and benefits accounting 9%, followed by the approaches being Simple to apply and maintain at 8.5%, it increases forage for animals and community cooperation in implementation each at 6%.

The overall level of education was lower among the general respondents; 64.2% of the respondents had no education, while only 6.2% of the general community had tertiary education. The effectiveness of the repair approach tents to show similarity in terms of role of repair approaches that are effective across the different level of education as strongly indicated by each respondents. Among those with no education; it provide long term results and benefit was top accounting for 9.3%, simplicity of the approach to be applied and maintained at 8.5% and last but not least increase in forage for animals at 6.5%. Those with primary education; top on the list was it provide long term results and benefit accounting for

9.2%, simplicity of the approach to be applied and maintained at 8.5%, it prevent soil erosion, no cutting of trees and it guarantee livestock survival each at 6.6%. Secondary education; increase in forage for animals, it enhances community cooperation in implementation and simplicity of the approach to be applied and maintained each at 10.8% and no cutting of trees at 8.1%. And for those in college and university; it increases vegetation and bushes, it prevent soil erosion and it enhances community cooperation in implementation accounting for 8.3%.

A half 50% of the general respondents indicated that the different environmental repair approaches being used to restore the degraded environment in Amboseli ecosystem are not effective. Among the ineffective repair approaches, a significant majority of the respondents said that the top on the list are as follows; reforestations accounting for 15.3%, Enclosures at 9.6%, gabions at 8% and last but not least terracing at 4%.

45.2% of the 50% who indicated that the different environmental repair being used to restore the Amboseli ecosystem degraded rangelands are not effective supported their answers with following reasons among many others; due to human population increase accounting for 6.4%, due to lack of awareness at 4.9%, some repair are not suitable for the environment at 4.1%, due to human settlement at 3.6%, due to high cost of maintenance at 2.8%, for example in the case of reforestation more trees should be planted at 2.8% and last but not least due to lack of proper management at 2.6%.

Table 7: **Hypothesis testing on significant difference in the effectiveness of different forms of environmental repair approaches**

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	393.739[a]	196	.000

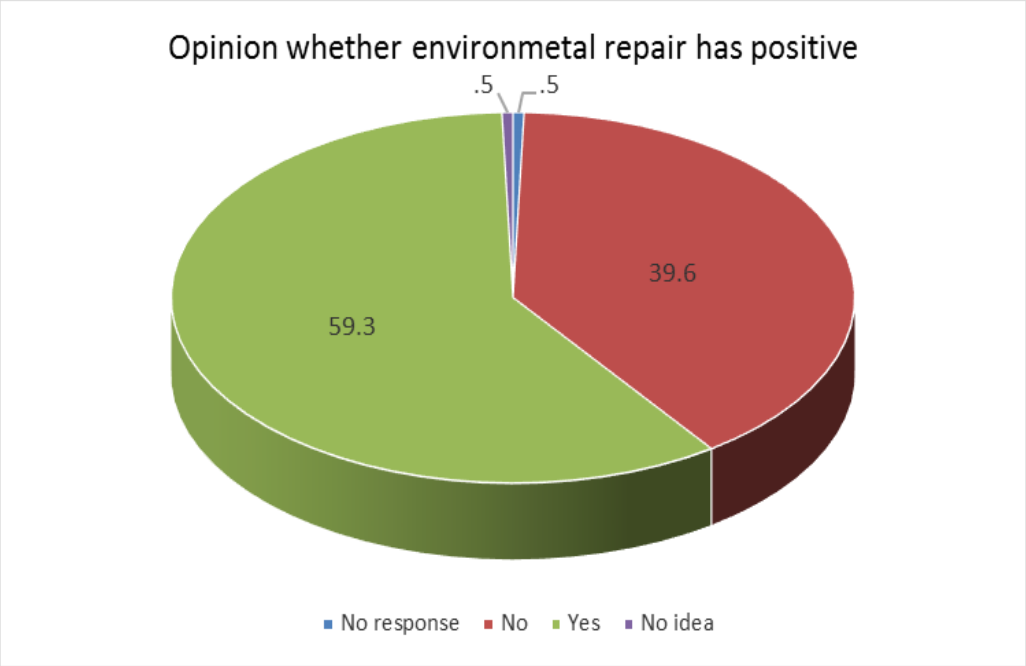
a. 215 cells (92.7%) have expected count less than 5. The minimum expected count is .00.
We can see here that $\chi 2$ (1) = 0.000, p = .000. This tells us that there is no statistically significant association between Forms of environmental repair approaches and effectiveness of the repair approach

4.4.2 Role played by environmental repair

On the role played by environmental repair, 87.6% of the general respondents said that environmental repair has played a very important role in restoring back the degraded environment. According to the majority respondents the top role of environmental repair

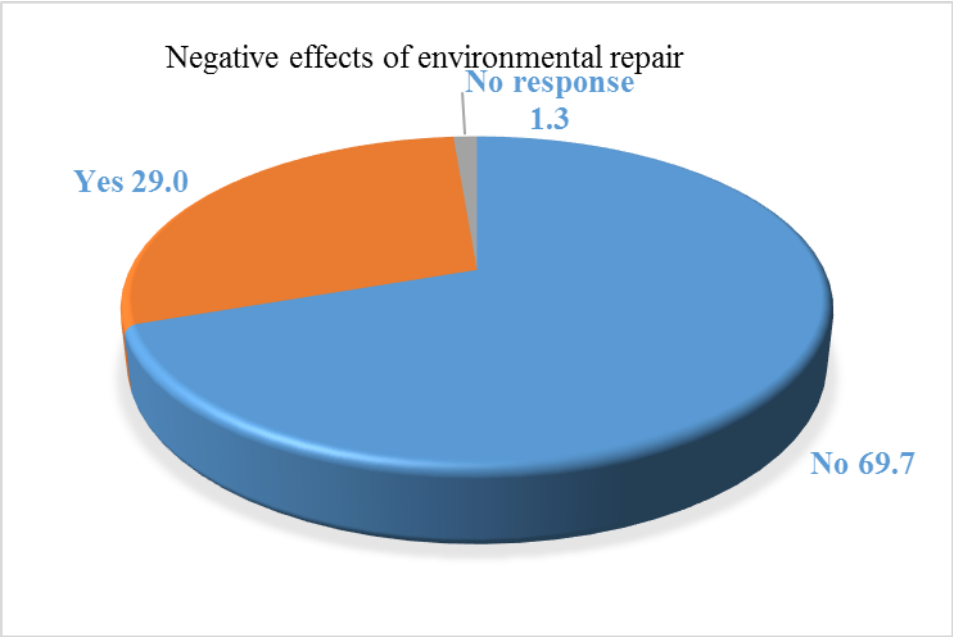
approaches includes among many; to enhance forage for livestock accounting 17.6%, followed by to reduce drought at 9.3%, to make environment conducive 9.1%, to enhance rain at 7.8%, and last but not least to reduce livestock death at 6.5%.

Figure 8: T**he respondents' opinion on positive effects of environmental repair**



On positive effects of environmental repair, 59.3% of the general respondents point out that environmental repair has following positive effects in the order of top in the list; it enhances grass availability accounting for 13%, it help in restricting settlement at 6%, good health for the animals at 3.9 % it help boosting social economic growth 3.1%, development and It enhance rain at 2.3% and last but not least production goes up each at 2.1%,

Figure 9: **The respondents' opinion on negative effects of environmental repair see my earlier comments on placement and discussion**



As shown by the figure 9 above, only small proportion of 29% of the general respondents indicated that environmental repair has the following negative effects in the order of the strongest effects; it results to land subdivision accounting for 4.9%, followed by less water availability for maintaining trees in the case of reforestation at 2.3%, Establishing of community conservancies reduce access of grazing land at 2.1%, fences also become barriers at 1.8% and last but not least It bring dangerous animals close to people at 1.3%.

4.5 Objective Three: Rationale for the choice of environmental repair approaches being used by stakeholders in Amboseli ecosystem

4.5.1 Rationale for the choice of Environmental Repair Approach

On the rationale for the choice of Environmental Repair Approach, 50.3% of the general respondents interviewed indicated that there reasons for the rational for the choice of environmental repair approach and this includes; the level of security required by the approach accounting for 5.7%, cost of the repair at 4.4%, the profitability and long term results at 3.4%, If it provide pasture 3.4%, past experience at 2.1% and last but not least the degree of repair in which that degraded environment require at 1.6%.

On the two main livelihood strategy, it's clearly evident that livelihoods affects the rational for the choice of the repair approach; For instance; profitability and long term results of the repair approach accounting for 5.4%, followed by cost of repair at 4.8%, and last but not least if it provide pasture and level of security required by the approach each at 4.2%., on pastoralism, the top on list is level of security required by the approach accounting for 5.3%, followed by cost of repair, if it provide pasture and if it improve the living standard of people each at 3.2%.

It's also clearly evident that education affects the rational for the choice of the repair approach; for instance, on no education group; security required by the repair approach accounting for 5.6% and the cost of the repair at 4.8%. Those with primary education; security required by the repair accounting for 6.6%, if its profitability and has long term results, cost of repair and past experience each at 3.9% For secondary education; for security, the degree of repair in which that environment require and the viability of the approach each accounting for 8.1%.

About 66.7% of the general respondents interviewed said that there are several factors that influence the rational for the choice of which environmental repair approach to use. In the list of order, the following is list of factors that influence rational; Leve of poverty accounting for 7.2%, followed by easy to managed at 6.4%, frequency of drought at 5.9%, level of education each accounting for 5.9%, cost of the repair approach at 5.9%, Availability of rain at 5.9%, labour intensity in terms of management at 6.5%, viability of the approach at 5.1%, the support of the community good will 4.9% and last but not least Population at size 4.1%. About 77.2% of the general respondents indicated that the rational for the repair approach can be improved through; educating the people accounting for 26.4%, by scaling up the repair approach at 10.3%, by planting more trees 9%, last but not least by doing more research at 7%.

Table 8: **Hypothesis testing on significant rationale for the choice of environmental repair approach by stakeholders in Amboseli ecosystem**

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	113.642a	112	0.439

a. 126 cells (92.6%) have expected count less than 5. The minimum expected count is .00. We can see here that $\chi 2$ (1) = 0.439, p = .439. This tells us that there is no statistically

significant association between Forms of environmental repair approaches and rationale for the choice of environmental repair.

4.6 Discussions

4.6.1 Environmental repair approaches in Amboseli ecosystem

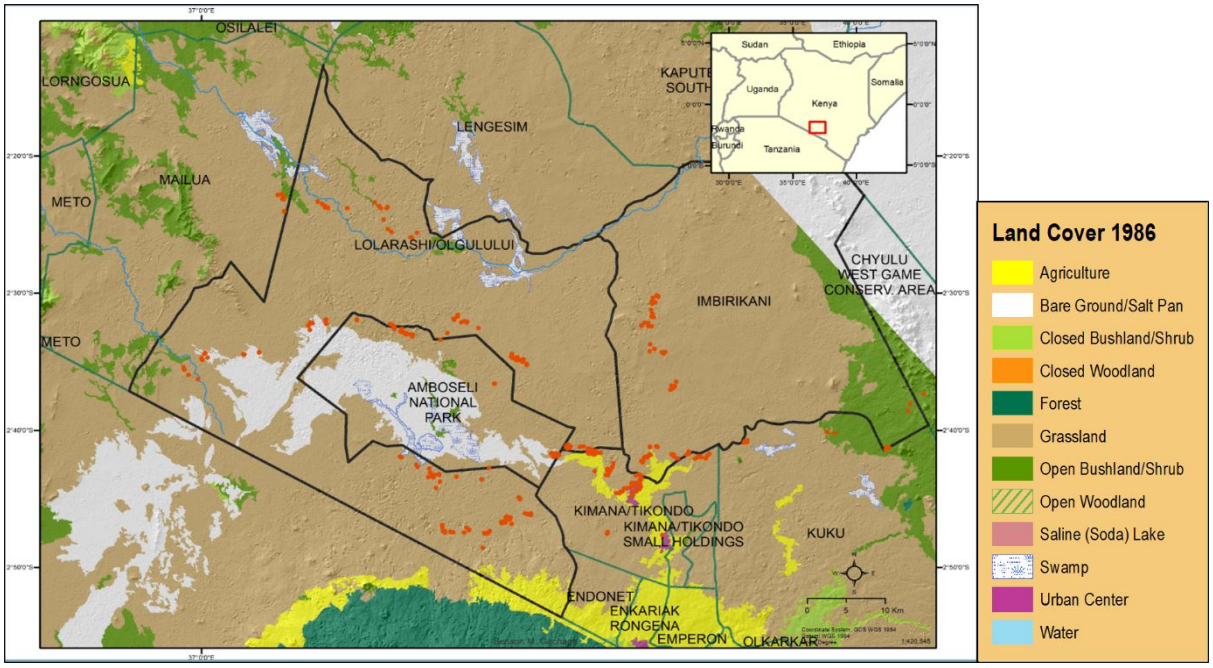
The study established that the general respondents confirmed that they were familiar with environmental degradation and the factors attributing to degradation. Water and wind erosion, vegetation loss and damage, and soil salination, were found to be the main forms of environmental degradation (Woods 1983 Chartres 1987). The most known causes of deterioration in East Africa were identified to be chronic overgrazing, drought, and inappropriate cultivation. The study through key informants and focus groups discussion also confirmed the following to be among the factors causing environmental degradation; Loss of trees (vegetation), gully erosion, loss of grass cover, high elephant population, habitat destruction, overstocking, high human population, uncontrolled settlement/sedentrization, extensive and expansion of agriculture. The study findings in all the different locations of the study area had differing familiarities on the main factors causing degradation; for instance in Imbirikani – Inkoisuk, Esambu and Orgosua villages it was unplanned settlement, less rainfall and increase in population. While in Olgulului - Namelok osoit village unplanned settlement and less rainfall were the main factors. The existence of land degradation is not in itself an economic argument for private landholders or government to prevent further degradation or invest in land restoration (Maclead. *et al.*, 1990). The study findings also established that environmental degradation has effects. These include livestock and wildlife death, lack of pasture, drought, and reduction in grazing land, long livestock migrations and reduction in population.

The study further reveals that the respondents are aware of environmental repair, but a considerable proportion of the respondents also were not familiar or aware of environmental repair approaches. A damaged ecosystem to grievous proportions not only loses control over its resources but also loses its ability and capacity to self-repair and resist further dereliction. As a result, it becomes less resilient to factors that add stress and damage to it (Whisenant, 1999). The study findings indicated that majority of the respondents were aware of forms of environmental repair; namely traditional practices, enclosures, terracing, reforestation, gabions, creation of community conservancies, trenches, and rangelands rehabilitation. Aforestation, reforestation, grass and shrub establishment, controlling grazing lands, halophyte establishment on saline soils, etc, seem to be the most appropriate approaches in

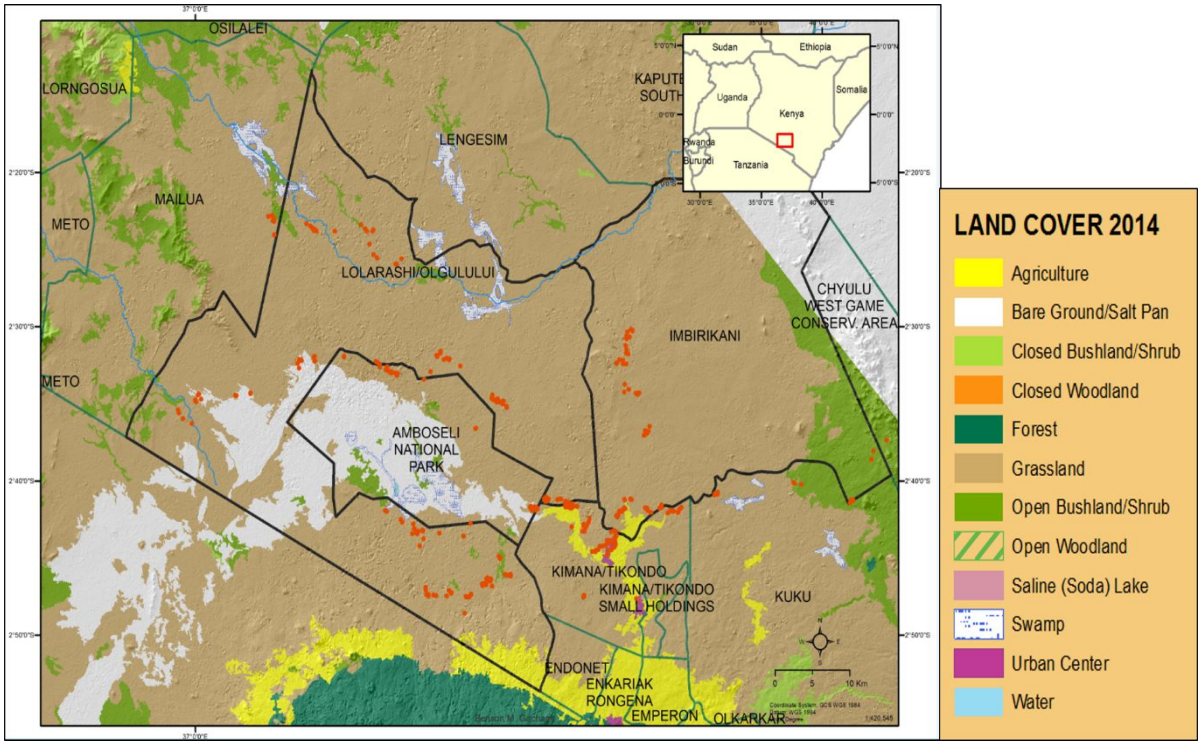
rehabilitating degraded ecosystems (Glenn *et al.,* 1992). The study findings further reveals that there are different stakeholders involved in environmental repair in Amboseli ecosystem, the different stakeholders play different roles in effort to restore the degraded rangelands. The support and collaboration exhibited by the various stakeholders establishes the foundation of success in the restoration goal (Egan *et al*., 2011), and especially when the degraded environment harbours the local and indigenous people or communities. Therefore, a constituency of support can only be created when all partners and stakeholders are involved and engaged in the whole process of rehabilitation; planning, implementation, and reciprocal learning, which builds a sense of identity, ownership, and trust (Hill *et al*., 2010).

The study findings also confirmed that the Maasai traditional practices helped in maintaining rangelands. The main ways in which the traditional practices maintained rangelands were through; traditional grass bank, use of seasonal grazing calendar, no cutting down of trees and last but not least setting up Olopololi enclosures and traditional laws and customs. Through using traditional knowledge of the ecology, stakeholders can derive some valuable information and practice (Berkes *et al*., 2000). The Maasai will expand their scope of grazing area and avoid taking their livestock to areas experiencing dry season, by using donkeys to transport water (Jacobs 1980). The strategy has seen Amboseli National Park increase its total carrying capacity by half (Western 1982). To maintain long-term productivity of the rangelands and ensure low-cost production that is sustainable to the ecosystem, herd diversity and splitting are techniques that can be used. For instance, the Maasai herd their flocks of goats in such a way to avoid encroaching into the bushes (Jacobs 1980). It is hypothesized that the fall of the traditional grazing system of the Maasai is likely to negatively affect the rangeland and lead to its degradation (Kioko *et al.*, 2012).

The Amboseli ecosystem has undergone significant changes in land use with an overall increase in the amount of land under cultivation and settlement. Analysis of satellite images of the landscape from 1975, 1990, 2000 and 2010 show a 24.4% increase in cultivation and settlement, a 15% decline in dense woodland/forest and wooded/shrub grassland vegetation while wetlands declined by 12.3%. Currently, the increased land subdivision around the Amboseli NP has constrained animal movement (ACP and GEF pro-doc 2013). The study also borrowed from land cover vegetation change images of 1986 and 2014 analysis that was done by African conservation centre (ACC) in 2015, which clearly give evidence that there is vegetation change in Amboseli ecosystem since the images shows increase in the extent of bare land.



The 1986 Amboseli ecosystem land cover map (ACC 2015)



The 2014 Amboseli ecosystem vegetation cover (ACC 2015)

Agroforestry may play an extremely important role in the development of semi-arid and arid lands and in the struggle against desertification (Le Houérou, 1980; Baumer, 1987; Le Houérou and Pontainier, 1987). The study through key informants and focus groups discussion defined environmental repair as the intervention to bring back the normal state of environment or process of trying to bring back vegetation cover through both artificial &

traditional method which includes; Traditional (grass bank), Controlled settlement, electric fences to allow regrowth in the park, reseeding of rangelands and Reforestation.

4.6.2 Effectiveness of environmental Repair approaches

Restoration ecology is a comparatively young discipline that intends to offer the technical underpinnings to the managing and restoration of damaged ecosystems. In humanity's struggle to manage, conserve, and repair or restore the world's ecosystem, they have found ecological restoration as a key instrument in the face of ballooning rates of environmental damage (Richard J. Hobbs *at el.,* 2008). The research indicated that the respondents were well aware of the various approaches that were in place to repair and restore the Amboseli ecosystem, and were effective. The process of restoring the environment and repair activities are a span of a spectrum of interventions, which range from virtual non-existence to the construction of novel ecosystems (Hobbs *at el.,* 2008). In order to attain the goals and objectives of restoring the ecosystem, land managers have found the need to develop and establish practical and efficient framework (Cairns 1993; Clewell and Rieger 1997).

The initial or primary step is to interrupt the cycle of land degradation by intervening into the existing system and break the circle. Much emphasis should be placed on the soil's water retention capacity and vegetation restoration. There are many water harvesting techniques that can be employed on diverse scales. They include; contour buns, terraces, trenches, and construction of water reservoirs such as dams. The techniques are to be chosen or employed based on the local conditions such as; slope, soil type, rainfall amount, etc., and culture (farmers or pastoralists) (Lucas *at el.,* 2015). The study findings indicated the following as the most effective forms of environmental repair approaches; traditional practises e.g. grass banks, seasonal grazing calendar, livestock migration etc. reforestation, fences and enclosures, preserving trees and forest, creation of community conservancies, Rangelands rehabilitation and trenches. The study findings also revealed that every repair approach targeted a certain objective; some of the objectives highlighted by majority of the respondents as the target of the various repair approaches includes; to avert drought, if the approach support livestock prosperity, if it enhanced vegetation cover, if it secured environment for future and last but not least if it enhances pasture management.

The use of other techniques such as chemical control, mechanical methods, or biological practices to rehabilitate unhealthy rangelands, sometimes weigh far much reaching consequences on the ecological, social, and economic costs. The study findings further

indicated reasons given by the respondents as to why the above approaches are effective; because of its' long term results and benefits, Simplicity of the approach to be apply and maintained, if the approach increases forage for animals and community cooperation in implementation of the approach. The results on hypothesis testing further shows that $\chi 2$ (1) = 0.439, p = .439 (p > .0005). This tells us that there is no statistically significant association between Forms of environmental repair approaches and rational for the choice of environmental repair. Therefore, we fail to reject the null hypothesis and conclude that there are statistically significant association between Forms of environmental repair approaches and rational for the choice of environmental repair. New pressures like climate change may cause the demands for natural resources and the nature of natural resources to change, thus exerting pressure on the already fragile ecosystems. Where there exist some conflict-for instance where the degradation of the ecosystem is being fuelled by the needs of subsistence livelihood for the dependent communities, getting down to understand the main causes of conflict will provide a resolution and eventually have effective restoration efforts to repair the ecosystem (Keenleyside *at el.,* 2012).

4.6.3 Rationale for the choice of environmental repair approaches in Amboseli ecosystem

A study has shown that land managers and land beneficiaries have five basic and essential principles of ecology. The principles are related to time, place, species, disturbance, and the landscape. During the research, many of the respondents interviewed confirmed that indeed there were several factors that influenced the rationale of adopting a given approach of environmental repair. Caution is necessary when deciding about whether, when, and how to repair a degraded ecosystem. The rate of failure for ecological restoration projects is high and therefore the best choices are not to intervene. Among the considerations to take into account include; whether active repair is necessary; feasibility of the project; and risks of harmful side effects. Poor perception about certain interventions can unintentionally carry far-reaching consequences indirectly and on a long-term basis (Suding *at el*., 2004). The research found some of the rationale that informed repair approaches adopted. They included; poverty levels; practicability and management of the approach; drought frequency; literacy levels; feasibility of the approach or its viability; rainfall availability; labour intensity in terms of project management; and both political and community goodwill.

Before embarking on ecological restoration of a particular ecosystem, there is a need to take into account, the cultural values and practices that influence the ecosystem. The values and practices are often intertwined. Traditional human activities that are ecologically sustainable have had profound influence on certain ecosystems to the extent of making a mutual reinforcement of cultural practice and ecological integrity. In such instances, it will demand the recovery of the traditional but ecologically sustainable cultural practices in order to have effective ecological restoration (Keenleyside *at el.*, 2012). UNEP estimated a cost of around US$5-8.8 billion annually for the next two decades that will be used to rehabilitate the degraded rangelands all over the world, by applying a combination of the set of practices. Ecological restoration is generally targeted at re-establishing or repairing an ecosystem that will be capable of continuing to function and support species diversity and interactions of various factors such as; geographic, geological, and climatic situation. The repaired ecosystem may end up being a reflection of the past conditions, or be a novel ecosystem evolving with the changing climate. The extent of intervention, timescale, and approach are dependent on the degree or level of degradation.

The study established that the general respondents indicated that there reasons for the rational for the choice of environmental repair approach which includes the following; the level of security required, cost of the repair, the profitability and long term results, If it provide pasture, past experience and the degree of repair in which that degraded environment require. The results on hypothesis testing shows that $\chi 2$ (1) = 0.000, p = .000. (p > .0005) This tells us that there is no statistically significant association between Forms of environmental repair approaches and effectiveness of the repair approach. Therefore, we fail to reject the null hypothesis and conclude that there are statistically significant association between Forms of environmental repair approaches and effectiveness of the repair approach.

Specific best practices have to apply the following key messages (Keenleyside *at el.*, 2012); whether it addresses major causes of degradation – embarking on repair process without tackling the main causes is likely to be a futile struggle, set clear restorative goals-it may be inappropriate to target for a 'pristine' state under rapid environmental changes, ensure an engaging and all inclusive process of all relevant stakeholders, among others. Moreover, the practice should assess the possible effect on climatic changes, among other substantive changes such as feasibility and durability of repair, and try to build on resilience. The research indicated that respondents' livelihood strategy influenced the rationale for the choice

of the repair approach. Restoring the environment is an expensive and equally time-consuming affair that it can bring damaging impact if not handled cautiously or managed properly. Environmental repair should first focus on preventing or avoiding degradation by removing existing pressures; in many instances that is the most important step, further interventions are unnecessary.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter covers the summary of key data findings, conclusion drawn from the findings highlighted and recommendations made there-to. The conclusions and recommendations were drawn in addressing the research question or achieving the research objectives which included the examination of the different forms of environmental repair approaches, assess the rational for the choice for the approaches and the effectiveness of the approaches being used by different stakeholders in the ecosystem. Kajiado County, Kenya.

5.2 Summary of Findings

The purpose of the study was to examination the different forms of environmental repair approaches, the effectiveness of the approaches and the rational for the choice of approach being used by different stakeholders in the ecosystem, Kajiado County, Kenya.

5.2.1 Forms of Environmental Repair Approaches

Forms of environmental repair approaches included all the traditional practices, restoration, reclamation and rehabilitation ways which the respondents gave as means being used to restored the degraded environments back to their original state. The study established that good percentage of the respondents were familiar with the idea of environmental repair and aware of forms of environmental repair approaches. Nearly half of the sampled (*n=193*) respondents indicated that they have been involved in repairing the degraded environments. However, in terms of specific locations in the study area, in Amboseli park the Environmental protection was cited higher as oppose to Imbirirkani group ranch where reforestation was cited higher and Olgulului - Meshenani the most popular among respondents was traditional practices and enclosure, reforestation, settlement control and tree cutting protection. Stakeholders in the environmental repair program as established by the study included the community, Community base organisation, individual farmers, government, and Non-governmental organization. The study established that majority of the respondents indicated that all the stakeholders played very important role in the effort to repairing the degraded environment. Of the listed stakeholders, a larger percentage of the general respondents believed that community played a very important role in environmental repair amongst all. The study found out that a larger percentage of the respondents strongly agrees that the Maasai traditions practiced various approaches that maintained rangelands,

and they also believed that the approaches used in 70s and 80s improved the environment. The respondents indicated that the main way in which Maasai traditions maintain rangeland was through setting a side traditional grass bank (Oloopololi/Inkaron) that acted as grass and seed banks, use of seasonal grazing calendar, livestock migration and enforcement of traditional laws and customs.

5.2.2 Effectiveness of Repair approaches

The study established that the respondents point out that there are different environmental repair approaches being used to restore the degraded environment in Amboseli ecosystem are effective. The effectiveness of the repair approach tents to show similarity across the different level of education as strongly indicated by each respondents. The study also found that the respondents cited that the traditional repair approaches are the most effective environmental repair approaches. On the role of environmental repair, the study revealed that the general respondents indicated that environmental repair has played a very important role in restoring back the degraded environment. The study also found out that respondents point out that some of the environmental repair approaches have had both positive and negative effects.

5.2.3 Rationale for the choice of Environmental Repair approach

The study established that the general respondents indicated that there reasons for the rational for the choice of environmental repair approach. The study found out that, it's clearly evident that livelihoods strategy affects the rational for the choice of the repair approach. The study also revealed that the general respondents indicated that there are several factors that influence the rational for the choice of which environmental repair approach among them includes; cost of the repair approach and if it's easy to and managed.

5.3 Conclusions

From the summary of findings, the study concludes that people are aware of environmental repair and forms of environmental repair approaches, but a considerable proportion are still not aware of environmental repair approaches. It further conclude that half of the sampled respondents have been involved in repairing the degraded environments. The study also concludes that every repair approach had a target objective.

It also conclude that the following; community, individual farmers, government and Non-governmental organization are the major stakeholders in the environmental repair program in Amboseli ecosystem. The study further conclude that the Maasai traditional practices had maintained rangelands as confirmed by the opinion that the state of rangelands vegetation in 70s and 80s was very good. On the current state of rangelands, the study conclude that the current state of rangelands vegetation is very bad.

On environmental degradation, the study conclude that environmental degradation is a big problem in Amboseli ecosystem and is greatly affecting peoples' livelihoods. The study also conclude that the state of Amboseli rangelands vegetation has change over time, the extent of bare land has expanded. The study further conclude that environmental degradation has economic implications on people's livelihoods.

On repair approaches effectiveness, the study conclude that different environmental repair approaches are effective differently depending on the target objective of the repair approach. The study further conclude that the traditional repair approaches are the most effective approaches. The study also concludes that environmental restoration and repair activities span a spectrum of degrees of intervention, ranging from virtually none to the complete construction of novel ecosystems and all have played very important role in restoring back the degraded environment. It also concludes environmental repair is an expensive and time-consuming process that can itself cause further damaging changes if not managed correctly. It further concludes that the first focus of good environmental repair is to avoid degradation by removing existing pressures. It also conclude that there are several factors and reasons that influence the rational for the choice of which environmental repair approach to use to restore the degraded environment.

5.4 Recommendations

To Policy Makers

The study established that a significant majority of the respondents indicated that the traditional repair approaches are the most effective form of repair approach.

- This study therefore recommends that the policies that favours and strengthen traditional repair approach should be developed so to maintain or improved further the best practices.

To Amboseli Stakeholders

The study established that a reasonable percentage of the respondents were not aware of environmental repair approaches.

- ❖ This study therefore recommends that awareness creation and capacity building needs to be built across the communities in Amboseli ecosystem to feel in the awareness gap.

The study established that majority of the respondents gave their opinion on the current state of rangelands vegetation that is either bad or very bad. The study further established that environmental degradation is a big problem in Amboseli ecosystem and is greatly affecting peoples' livelihoods.

- ❖ This study therefore recommends that more environmental restoration approaches needs to be initiated to restore back the degraded environments.
- ❖ This study further recommends that livelihoods strategies needs to be diversified in order to minimized the effects of degradation.

To Community

The study established that majority of the respondents who have been involved in the different forms of environmental repair were male compared to females.

- ❖ This study therefore recommends that there should be gender equity in involvement of the different forms of environmental repair.

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7.0 APPENDICES

7.1 APPENDIX 1: TIME SCHEDULE

	YEAR 2015/2016										
Month	**Year 2015**				**Year 2016**						
Week	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**April**	**May**	**Jun**	**Jul**
Activity											
Chapter One	Introduction, Problem statement, Research Question, Objectives, Research Hypothesis, Justification and scope										
Updating the whole proposal	**X**										
Submit the updated proposal to the supervisor	**X**										
Work on Supervisors feedback and comments	**X**										
Submit the 2nd write up for approval	**X**										
Chapter Two	Literature review, Conceptual framework and conceptual framework diagram										
Align chapter 2 with chapter 1 for submission		**X**									
Work on Supervisors feedback and comments		**X**									
Submit the 2nd write up for approval			**X**								
Chapter Three	Methodology (Study area & History, Research Design and Data										

	collection and Analysis)										
Align chapter 3 with other 2 chapters for submission				**X**							
Work on Supervisors feedback and comments					**X**						
Submit the 2nd write up						**X**					
Work on Supervisors feedback and comments							**X**				
Submit the 3rd write up for approval							**X**				
Proposal Presentation								**X**			
Work on Proposal presentation comments									**X**		
Field	Data collection										
Data collection										**X**	**X**
Data Analysis	Data Analysis										
Analysis of Result											**X**
Result Discussion											**X**
	Report Writing										
Report Presentation											**X**

7.2 APPENDIX 2: DATA COLLECTION INSTRUMENT

A. Demographic profile

1. General Area **a) Pastoral b) Agricultural c) Agro-Pastoral**

2. Land proprietorship **a) Private Ownership b) AN Park c) Kimana d) Mbirikani e) Olgulului/Ololarashi**

Are you **a) resident b) migrant?**

3. Location _____

4. Sex **F** **M**

5. Ethnicity **a) Maasai b) Kikuyu c) Kamba d) Tanzanian e) Other_____**

6. Level of Education **a) No Education b) Primary c) Secondary d) University**

7. Age **< 20** **21-30** **31-40** **41-50** **50+**

8. What is your primary livelihood strategy? **a) Agriculture b) Pastoralism c) Agro-Pastoralism d) Wildlife Conservation e) Other_____**

B. Forms of environmental repair approaches

9. Are you familiar with environmental repair? **Y** or **N**

If yes,

Explain your answer above_____

10. Are you aware of any environmental repair approach? **Y** or **N**

If yes, name them_____

11. In your opinion, what are the other forms of environmental repair approaches you may be aware?

a) Traditional b) Enclosures c) Re-afforestation d) Terracing and gabions e) Trenches f) Rangeland rehabilitation g) Conservancies

h) Other_____

12. Have you ever been involved in environmental repair in anyway? **Y or N**

If yes, please explain. _____

13. What was the objective of the repair approach?

14. In your opinion, who are the stakeholders involve in environmental repair in Amboseli ecosystem?

a) Community b) NGOs/CSO c) Government d) individual farmers e) other_____

15. What have the different stakeholders done in environmental repair approaches;

Community_____

NGOs/CSO_____

Government_____

16. **(For those who said Y in 10),**

a) Which environmental repair approach do you think is effective and why?

_____

b) What has worked? _____

c) What has failed? _____

17. How did the traditional maasai communities in the Amboseli ecosystem maintain the rangelands productivity?

18. What were the environmental repair approaches that were being used in the 1970s, 1980s?
19. In your opinion have the environmental repair approaches led to improvement on environment? **Y** or **N**

    If yes, please explain. _____

C. Effectiveness of environmental repair approaches

20. Are you away of environmental degradation? **Y** or **N**

If yes,

Explain your answer above_____

21. In your opinion, what do you perceive as the causes of environmental degradation?

_____

22. What are the effects of environmental degradation to Pastoralism/wildlife?

_____

23. In your opinion, are there changes in the rangeland environments that you can identify due to degradation? **Y** or **N**

If yes,

Explain your answer above_____

24. In your opinion, what are the other changes in the rangeland environmental you may be aware?

a) Disappearance of plant species b) coming of new plant species c) Reduction in animal forage d) % increase of bare land e) Erosion

e) Other_____

25. What was the previous state of vegetation in rangelands environments in 70s and 80s? a) **very bad** **b) bad** **c) good** **d) excellent**

26. What is the current state of vegetation in rangelands environments?

a) **Very bad** **b) bad** **c) good** **d) excellent**

If bad,

Explain your answer above_____

27. What are the circumstances that might have led to such vegetation changes?

28. In your opinion, do environmental degradation have any economic implications? **Y** or **N**

If yes,

Explain your answer above_____

D. Rational for the choice of Repair approach

29. In your opinion what is role of environmental repair**?**

30. Are there any positive affects you associate with environmental repair? **Y or N**

If yes please explain your answer_____

Are there any negative affects you associate with environmental repair? **Y or N**

If yes please explain your answer_____

31. In your opinion, Is there a rationale for the choice of environmental repair approach? **Y** or **N**

If yes,

Explain your answer above_____

32. What factors may influence the choice of the above forms environmental repair approaches?

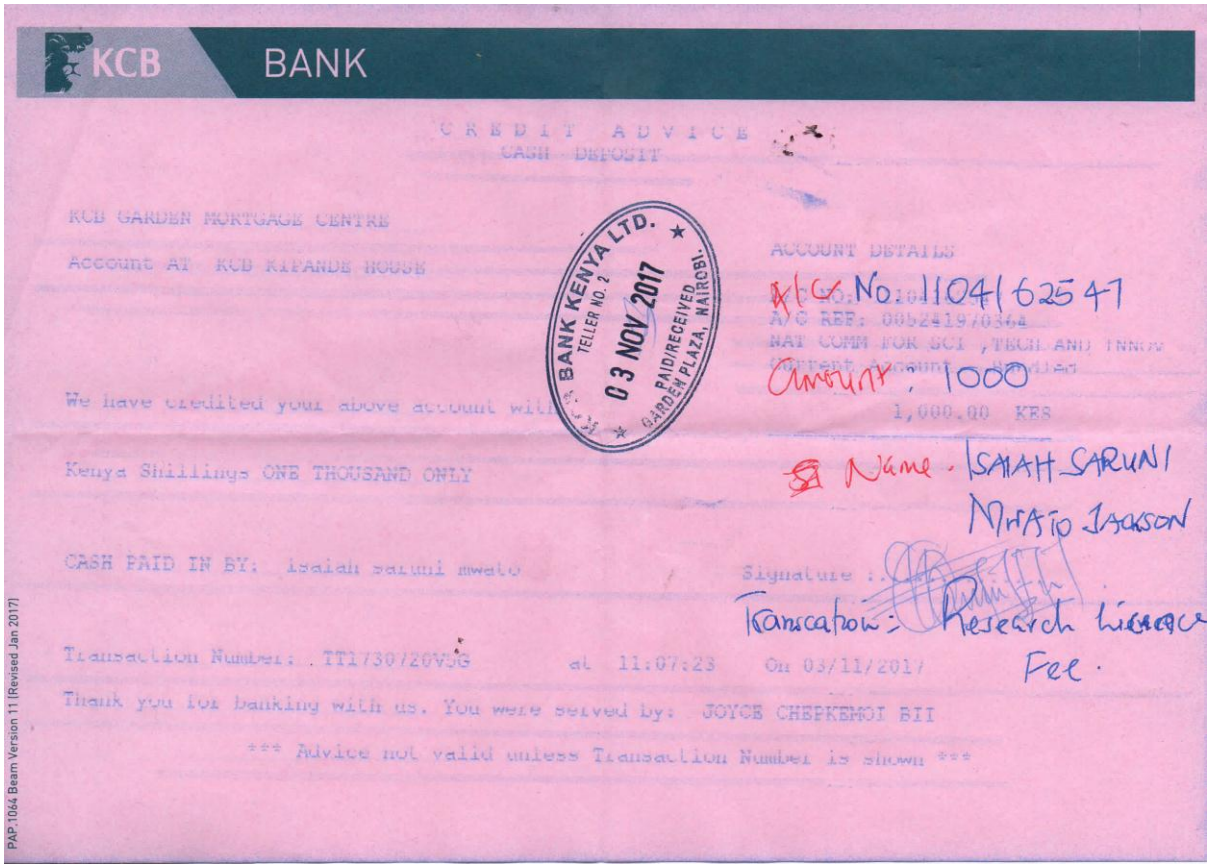
33. In your opinion, how can the choice of the above forms of environmental repair approaches can be improved?

7.3 APPENDIX 3: FGDS QUESTIONNAIRE

1. What is rangeland degradation?
2. What do you perceive as the causes of land degradation in Amboseli ecosystem?
3. What are the effects of rangeland degradation?
4. What do you understand by environmental repair?
5. Highlight the different forms of Environmental repair approaches being used in Amboseli ecosystem?
6. What is the rational for the choice of the environmental repair approach?
7. Which environmental repair approach do you think is effective and why?
8. How did the traditional communities in the Amboseli ecosystem maintain the rangelands productivity?

7.4 APPENDIX 4: KEY INFORMANT QUESTIONNAIRE

1. What do you understand by environmental degradation?
2. What are the common forms of environmental degradation in Amboseli ecosystem?
3. What do you understand by environmental repair?
4. Who are the major stakeholders involved in environmental repair approaches in the Amboseli ecosystem?
5. Highlight forms of Environmental repair approaches being used in Amboseli ecosystem?
6. What is the rational for the choice of the environmental repair approach?
7. Which environmental repair approach do you think is effective and why?
8. How are the wildlife coping/adapting the effects of rangeland degradation?
9. How pastoral communities in the ecosystem are adapting the same effects of rangelands degradation?
10. What is the frequency of drought in this ecosystem? And it's contributing to degradation?
11. How did the traditional communities in the Amboseli ecosystem maintain the rangelands productivity?
12. Where did the traditional governance systems failed in rangelands management?
13. What needs to be done to restate the traditional governance system in place?



KCB BANK

CREDIT ADVICE
CASH DEPOSIT

KCB GARDEN MORTGAGE CENTRE

Account AT KCB KIPANDE HOUSE

BANK KENYA LTD. TELLER NO. 2 03 NOV 2017 PAID/RECEIVED GARDEN PLAZA, NAIROBI.

ACCOUNT DETAILS

A/C No: 1104162547

A/C REF: 0052419703A4

NAT COMM FOR SCI ,TECH AND INNOV

Current Account - KES

Amount: 1000

1,000.00 KES

We have credited your above account with

Kenya Shillings ONE THOUSAND ONLY

Name. ISAIAH SARUNI MWATO JACKSON

CASH PAID IN BY: isaiah saruni mwato

Signature :

Transcation: Research licence Fee.

Transaction Number: TT1730720V5G at 11:07:23 On 03/11/2017

Thank you for banking with us. You were served by: JOYCE CHEPKEMOI BII

*** Advice not valid unless Transaction Number is shown ***

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