

**AN ASSESSMENT OF PERCEPTIONS TOWARDS
LAND DEGRADATION IN KASIKEU DIVISION,
MAKUENI COUNTY, KENYA**

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for the degree of master of Environmental Science
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*An assessment of
perceptions towards*



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DECLARATIONS

DECLARATION BY CANDIDATE

This thesis is my original research work and has not been presented or submitted for any award in any institution.



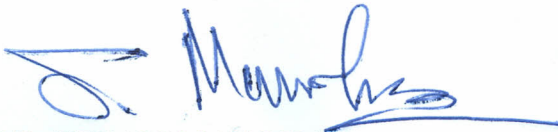
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DEDICATION

This work is dedicated to my parents Philip Kimeu and Alice Kimeu for their continued financial, physical and moral support throughout the study.

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ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
CED	Centre for Environmental Development
EA	East Africa
EEA	European Environment Agency
ETC	Educational Training Consultancy
FAO	Food and Agriculture Organization
GEF	Global Environment Fund
GLASOD	Global Assessment of Soil Deterioration
ICARDA	International Centre for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ISRIC	International Soil Reference and Information Centre
IUFRO	International Union of Forest Research Organizations
LADA	Land Degradation Assessment in Drylands
MEA	Millennium Ecosystem Assessment
NAPs	National Action Plans
NDP	Net Domestic Product
OCHA	Office for the Coordination of Humanitarian Affairs
SLM	Sustainable Land Management
SPDC	Special Programme for Developing Countries
SSA	Sub Saharan Africa

UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNCCD	United Nations Convention to Combat Desertification
UNU-LRT	United Nations University Land Restoration Training Programme
USBR	United States Bureau of Reclamation
WMO	World Meteorological Organization

OPERATIONAL DEFINITION OF TERMS

- Desertification:** Desertification is the degradation of land in arid, semi-arid, and dry sub-humid areas. It is caused primarily by human activities and climatic variations (UNCCD 2011).
- Land degradation:** Land degradation means reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation (UNCCD, 1996).
- Overgrazing:** The grazing of natural pastures as stocking intensifies above the livestock carrying capacity (Bai *et al.*, 2008).
- Class I land** Arable lands that are highly suitable for irrigated farming, being capable of sustained and relatively high yield of climatically adapted crops at reasonable cost. These lands have a relatively high payment capacity (USBR, 1951).
- Class II land** Arable lands that have a moderate suitability for irrigated farming. These are either adaptable to a narrower range of crops, more expensive to develop for irrigation, or less productive than Class 1. Potentially these lands have intermediate payment capacity (USBR, 1951).

Class III land

Arable lands that have a marginal suitability for irrigated farming. They are less suitable than Class II lands and usually have either a serious single deficiency or a combination of several moderate deficiencies in soil, topography, or drainage properties. Although greater risk may be involved in farming these lands than those of Class I and II, under proper management they are expected to have adequate payment capacity (USBR, 1951).

Shifting cultivation An agricultural system in which plots of land are cultivated temporarily then abandoned. This system involves clearing of a piece of land followed by several years of wood harvesting or farming, until the soil loses fertility. The land is then left to be reclaimed by natural vegetation or sometimes converted to a different long-term cyclical farming practice (Anderson, 1997).

ABSTRACT

This study was conducted in Kasikeu Division, Makueni County, Kenya between August 2010 and December 2010. The main objective of this study was to assess the perceptions and attitudes towards land degradation. Survey research design was used in order to take into account the different human activities and how they influence land degradation. The study relied mainly on cross-sectional primary data, which were collected from the three locations (Kiou, Mumela and Kasikeu) in the division. The study used multistage and simple random sampling methods to select the households for study. The primary data were obtained with the aid of semi-structured questionnaires. Interviews with farmers and agricultural officers in the division were conducted in order to get information on agricultural production. Secondary information from scientific journals, books, and conference proceedings was obtained. The data analysis for this study was conducted using descriptive statistics, correlation analyses and regression analyses. The results showed that the following indicators of land degradation were commonly observed in the study area; rills, gullies, pedestals, armour layer, soil accumulation around clumps of vegetation, soil deposits on gentle slopes, exposed roots, muddy water, sedimentation in streams and rivers, sandy layers, furrows in clay soils and ripples in sandy soils, barren spots, change in vegetation species, decrease in organic matter, increased runoff, reduced soil water and reduced rooting depth. The direct human activities which were found to be influencing land degradation in the study area include; deforestation, clearing of vegetation, overgrazing, steep slope cultivation, and improper fertilizer use. Land shortage, poverty and high population density are the underlying causes of land degradation observed in the study area. According to the results, the consequences of land degradation experienced in the study area include; decline in crop yields, lowering of the water table, increased inputs and greater costs, reduced responses to inputs, reduced productivity on irrigated land, loss of water for irrigation, diversion of resources to reclamation, lower and less reliable food supplies and increased labour requirements. The study concludes that anthropogenic factors are significantly responsible for land degradation and this degradation has negatively affected livelihood in the region. In order to mitigate this land degradation and its consequent effects, the study recommended a need for the government to enforce effective policies to control and prevent land degradation and these policies should be predictable, credible and reliable. The study also recommended a significant investment to be made by the government through promotion of land use systems that provide permanent vegetative cover to protect the soil, increase fertility and optimize water penetration. Soil conservation technologies that are known to work in severely degraded lands should also be assessed and evaluated with a view to exploring the possibility of transferring them in other areas with similar settings particularly in Kasikeu Division. Long term training programmes on soil conservation among farmers should also be implemented to enhance sustainable agricultural land management.

Key Words: *Degradation indicators, Desertification, Land Degradation and Logistic Regression Model*

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Land degradation is a serious problem that crosses national borders, ecological zones and socio-economic levels. It can be especially devastating for the world's poorest people living in dry land areas. Land degradation and desertification affect the economic well-being of people and undermine the integrity and stability of ecosystems. Land degradation occurs slowly and cumulatively and has long lasting impacts on rural people who become increasingly vulnerable (Muchena, 2008). Human activities can degrade the land and negatively impact water and biological resources, thus affecting the lives and livelihoods of vulnerable communities. Natural processes such as floods and earthquakes also lead to environmental degradation. Land degradation has been a major global concern during the 20th century and will remain high on the international agenda in the 21st century (Eswaran *et al.*, 2001). The problem of land degradation among other global issues is enhanced because of its impact on world food security and quality of the environment. High population density is not necessarily related to land degradation; what a population does to the land is what determines the extent of degradation. People can be a major asset in reversing land degradation. However, they need to be healthy, and also politically and economically motivated to care for the land, because agriculture, poverty and illiteracy are major causes of land and environmental degradation.

The productivity of some lands has declined by 50% due to soil erosion and desertification. Yield reduction in Africa due to past soil erosion may range from 2 to 40%, against a mean loss of 8.2% for the continent. In South Asia, annual loss in productivity is estimated at 36 million tons of cereal equivalents valued at US\$5,400

million by water erosion, and US\$1,800 million due to wind erosion. It is estimated that the total annual cost of soil erosion from agricultural land in the USA is about US\$44 billion per year, i.e. about US\$247 per ha of cropland and pasture. On a global scale, the annual loss of 75 billion tons of soil costs the world about US\$400 billion per year, or approximately US\$70 per person per year. Only about 3% of the global land surface can be considered as prime or Class I land. About 8% of global land is classified as Classes II and III and it is about 11% of the land which feeds the seven billion people today and will be expected to feed about 7.6 billion people by 2020. Desertification is experienced on 33% of the global land surface, which affects more than one billion people, and about half of this population (0.5 billion people) live in the African Continent (Eswaran *et al.*, 2001).

Although land degradation is largely man-made, and its pace is governed primarily by the speed at which population pressure mounts, irregular natural events, such as droughts, exacerbate the situation. The 1982/85 drought, for example, had a dramatic effect on the speed of land degradation in Africa. Although food aid is essential in such emergencies, it clearly does not alleviate environmental damage. In Kenya, over the period between 1981 and 2003, productivity declined across 40% of cropland: a critical situation in the context of a doubling of the human population over the same period (Bai and Dent, 2006). Additionally, the 2009 drought affected millions of subsistence farmers, herders, the environment and wildlife in the rangelands that cover three quarters of Kenya's land. The impact of the drought was not restricted to the usual drought prone areas like the Turkana, but elsewhere in the country, changes in the pattern and distribution of rainfall adversely affected food production resulting into wide spread shortages and increase in the price of food, water and other essential commodities (UNEP, 2009).

1.2 Statement of the Problem

Land degradation in Makueni County is well pronounced with its impacts emanating from activities such as crop farming, agro-pastoralism, pastoralism, sand harvesting and tree felling for charcoal burning and firewood. This has exposed huge tracks of land to continued severe soil erosion by water and wind (Emongor *et al.*, 2009; Republic of Kenya, 2002) leading to a reduction in the area available for food production hence undermining food security in the county. If these land degradation trends are not arrested, there may be eminent danger that will result in adverse land changes with serious consequences on livelihoods in the region. The sharing of water sources with animals and poor sanitation standards have further led to pollution of water sources, causing upsurge in water borne diseases. According to Jama & Zeila (2005), the spiral of land degradation facing the district is mainly anthropogenic in nature and origin and unless these human activities are controlled the environment will be rendered unsustainable due to degradation. In Kasikeu Division, land use systems include, crop farming and livestock rearing which is an indication that people totally depend on the environment for survival. Other activities in the division include sand harvesting and charcoal burning. Unsustainable farming and extraction of resources from the environment has resulted into environmental degradation which has in turn affected livelihood in the division. Although people are aware of these environmental changes and their impacts, there has not been a single study to assess their perceptions and attitudes towards land degradation and this study therefore sought to assess their insights into land degradation problem and how it can be addressed.

1.3 Research Questions

The main research questions for this study were:

1. What are the key indicators of land degradation commonly observed in Kasikeu Division?
2. How do human activities contribute to land degradation in Kasikeu Division?
3. How does land degradation affect livelihood in Kasikeu Division?
4. How can the problem of land degradation be reduced or mitigated?

1.4 General Objective of the Study

The general objective of this study was to determine the effect of human activities on land degradation in Kasikeu Division, Makueni District, Kenya.

1.4.1 Specific Objectives of the Study

The specific objectives of this study were to:

1. Identify the indicators of land degradation which are commonly observed in Kasikeu Division.
2. Assess the key anthropogenic determinants of land degradation in Kasikeu Division.
3. Analyze the consequences of land degradation in Kasikeu Division.
4. Suggest possible mitigation measures to control further land degradation.

1.5 Research Hypotheses of the Study

The hypotheses of this study were:

1. Human activities influence land degradation in Kasikeu Division.
2. Land degradation impacts on livelihood in Kasikeu Division.

1.6 Justification of the Study

Makueni County is an arid and semi-arid area with harsh ecological conditions and low unreliable rainfall. Crop farming in the county is mainly for subsistence use. The major crop grown is maize, which is the staple food in the district. Other crops grown in the county are cow peas, beans, pigeon peas and green grams. Irrigated horticultural crop farming is rarely undertaken but in smallholdings on individual farmer basis. Livestock rearing is also an important economic activity in the county. With the increasing human population (2.8% annual growth rate), there is still an increasing demand for resources and land as a resource is faced by threats of continued degradation. Soil erosion, overgrazing, poor cultivation practices, and tree felling for charcoal and fuel wood are major problems of land degradation in the area. This has affected livelihood in the region and this study sought to assess the perceptions and attitudes of people towards land degradation and how it can be controlled.

1.7 Significance of the Study

Studies on the human activities responsible for land degradation in arid and semi-arid lands such as Kasikeu Division are very important since their findings may greatly facilitate policy makers in the formulation of new policies on land use practices in efforts towards reversing or mitigating the problem of land degradation. Therefore, this study is significant because its results and recommendations will give a basis for better environmental management and hence sustainable agricultural development in the area. The findings of this research will be an addition of information to the existing literature on land degradation and ways of mitigating the adverse effects of this degradation. This will give more information to the public as well as researchers and thus contribute to the advancement of knowledge on environmental conservation.

1.8 Scope of the Study

This study involved farmers randomly sampled from the three locations in Kasikeu Division (Mumela Location, Kiou Location, and Kasikeu Location). Agricultural officers were also included for information on the impact of land degradation on food production.

1.9 Conceptual Framework

Land degradation is a complex process and its causes and impacts are varied and multiple.

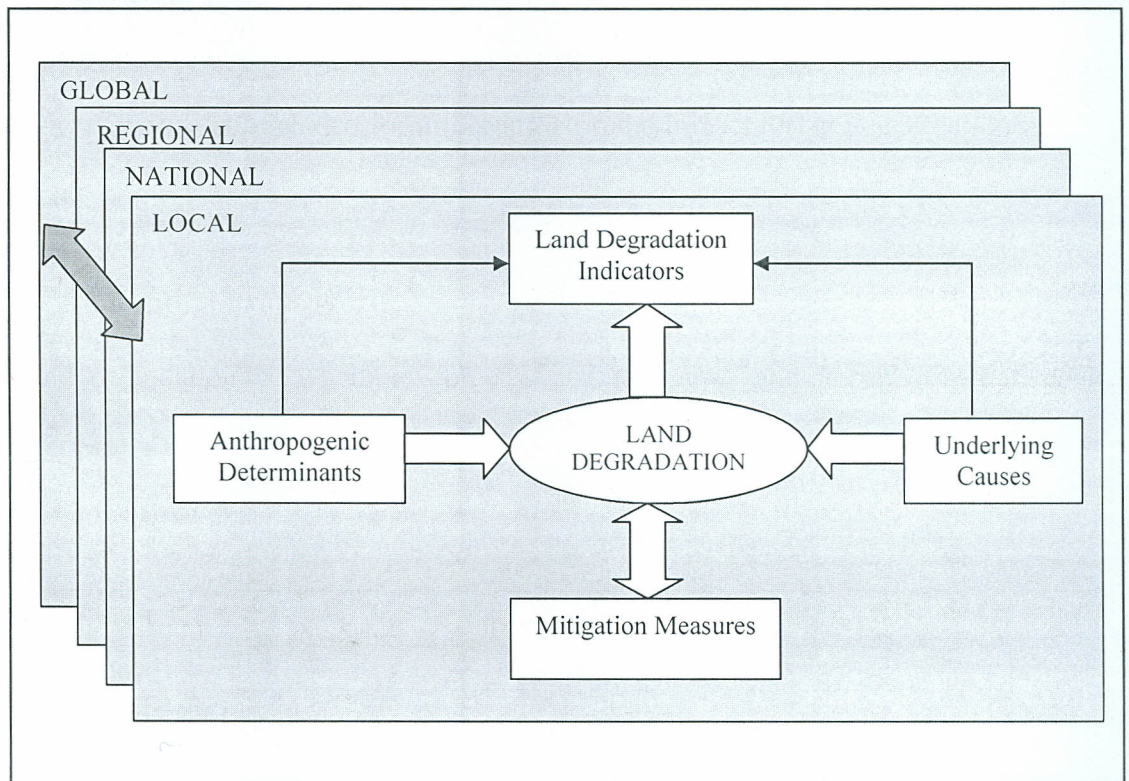


Figure 1.1: Conceptual Framework for Land Degradation in Kasikeu Division, Makueni County

Adapted from LADA (2004)

1.10 Limitations of the Study

The limitations of this study on the human causes of land degradation in Kasikeu Division included the following:

1. Financial constraints. This was as a result of the high expenditure requirement for data collection especially secondary data from satellite imagery.
2. Remoteness. Makueni County is a semi-arid region with limited infrastructural development such as road networks. Also, land degradation has rendered the district more inaccessible by road. These factors made it difficult for admission of questionnaires for primary data collection in the target study area of Kasikeu Division.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature on land degradation and desertification with respect to the United States, Asia, Europe, Africa and Kenya.

2.2 Land Degradation and Desertification

Desertification is one of the major environmental concerns of today, affecting the living conditions of hundreds of millions of people across the world. This phenomenon is not confined to the deserts or the arid regions. Human activities such as over-cultivation, overgrazing, deforestation and poor irrigation practices, along with climate change, are turning the once fertile lands into unproductive degraded lands. Per capita land availability is shrinking throughout the world, threatening food security, particularly in poor rural areas, and triggering social and economic crisis (Atlas of India, 2007).

Large swathes of land around the globe have been degraded or become deserts. Although estimates vary, over 20% of the planet's land is considered degraded. Hotspots include Africa south of the equator, South-East Asia, and south China (Bai et al., 2008). The principal cause of land degradation and desertification is the unsustainable exploitation of land productivity by pastoral, farming, and agro-pastoral land uses. This is often exacerbated by misguided or missing policies (UNCCD, 2012).

Land degradation and desertification result in poorer soil quality especially on agricultural lands with annual rainfall because of: accelerated erosion; salinization; loss of soil organic matter; decline in soil structure caused by reduction in the

magnitude and stability of aggregates; nutrient mining and imbalance; decline in the capacity to infiltrate and retain water leading to decline in the water available in the root zone for plant growth (UNCCD, 2012). Figure 2.1 shows the extent of human-induced soil degradation in the world.

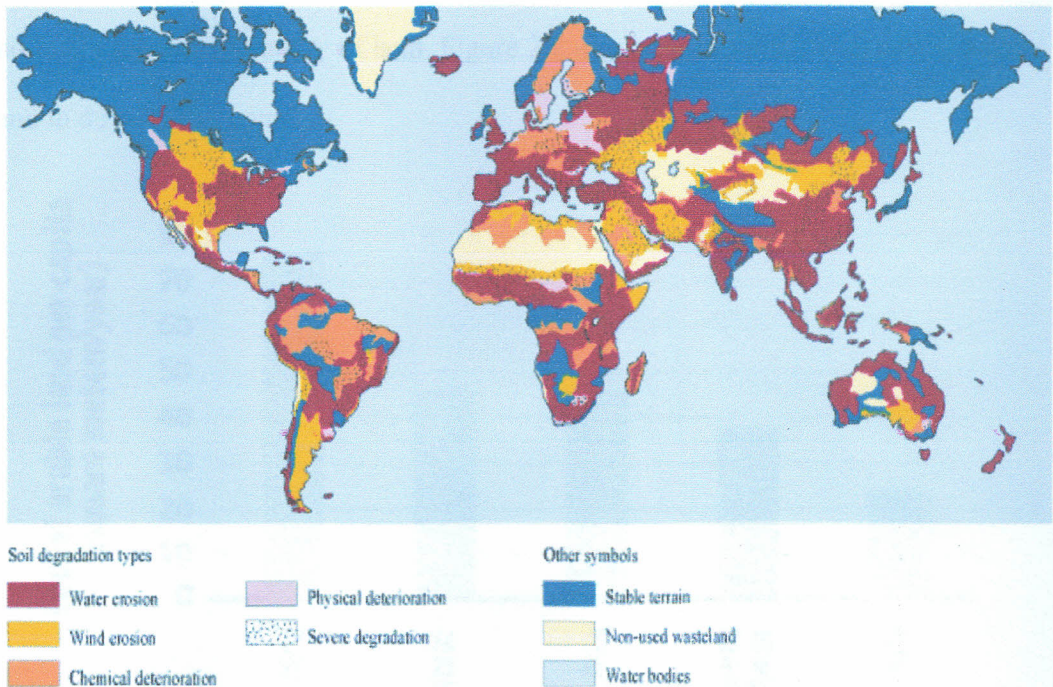


Figure 2.1: Human-induced soil degradation in the world

Source: Oldeman *et al.*, (1991)

There are two main culprits in the desertification debate: human factors and climatic influences. Climate variability and climate change have been identified as the natural factors that have contributed to the enhanced pace of desertification in the EA dry lands. Rainfall is variable in both time and space, leading to droughts and famines. “Droughts”, which may be defined as persistent below-normal precipitation, lead to mass exodus of people and their herds, forcing pastoralists to migrate to relatively better-watered areas. In the process, overgrazing of the meagre remaining vegetation

cover takes place, resulting in even more land degradation. In the areas where the herds are concentrated, new forms of land degradation take place, especially around water sources such as rivers, boreholes, water pans, etc. (Jama & Zeila, 2005).

Land and its soils, is fundament for life; it is the substrate for the vast majority of agricultural production and biodiversity on the planet. Land degradation directly and indirectly reduces the utility of land. Figure 2.2 shows annual loss per capita of arable land in developing countries.

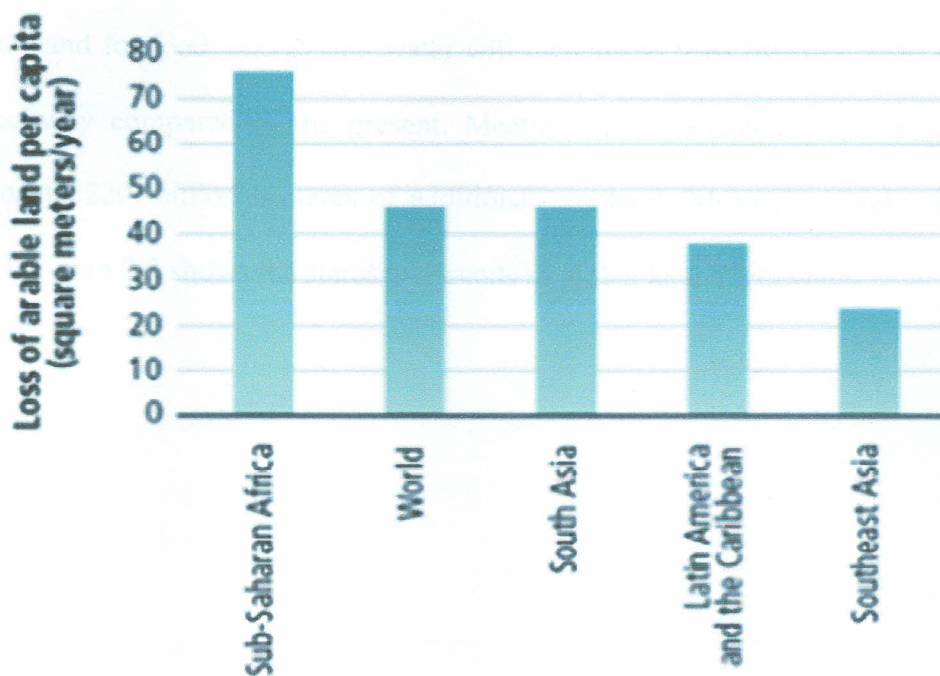


Figure 2.2: Annual loss per capita of arable land in developing countries (1961-2009)

Source: IFPRI, 2012

2.3 Land degradation on a global scale

Land degradation is a global challenge of major importance and has a severe impact on the environment, climate and human society. Land degradation, manifested in the deterioration of vegetation, soil erosion, biodiversity loss, and eventually in a more

persistent form as desertification, has led to conflicts, grinding poverty, hunger, and abandonment of farms and villages for cities in many parts of the world. Large proportions of developing countries and countries in transition are confronted with severe land degradation and problems resulting from unsustainable land use and climate change (UNU-LRT Strategic Plan, 2011-2016).

Global trends such as population dynamics and the increasing demands for energy, food, and water are expected to dramatically increase pressure on the land. By 2030, the demand for food, energy and water will increase at least by 50%, 45% and 30% respectively compared to the present. Meeting those demands would require 175 million to 220 million hectares of additional cropland (McKinsey Global Institute, 2011). Figure 2.3 shows the status and trends in global land degradation

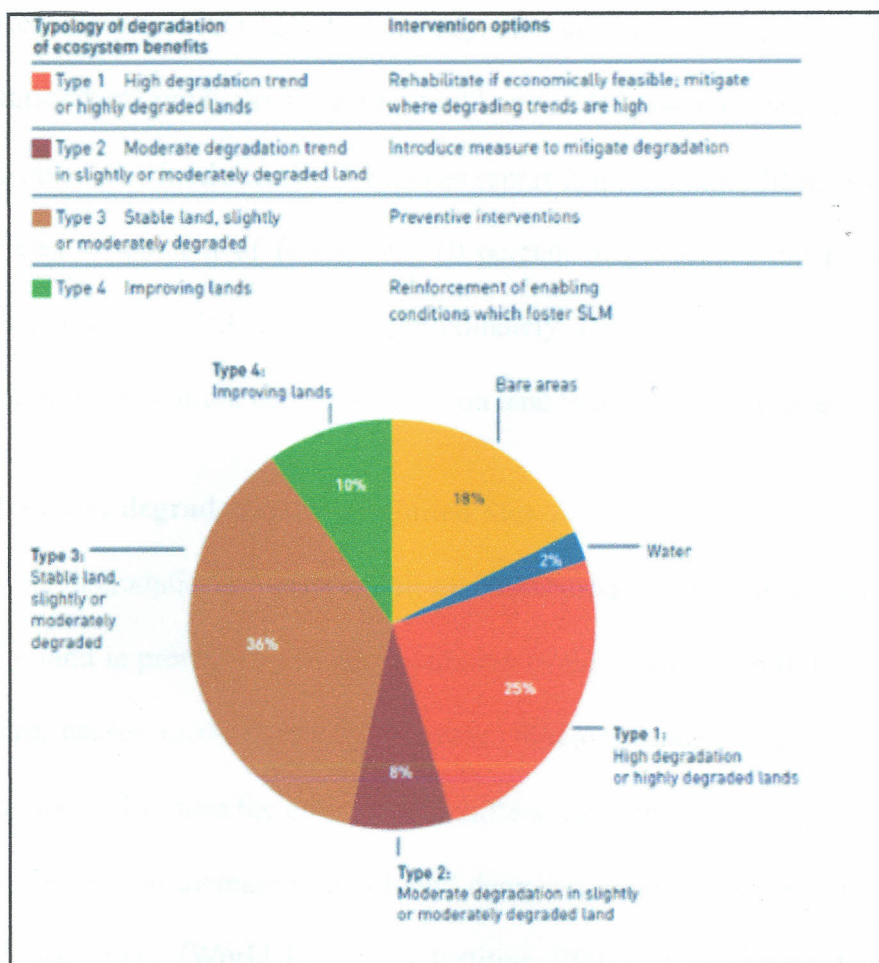


Figure 2.3: Status and trends in global land degradation

Source: FAO, 2011

Globally, land degradation adversely affects the ecological integrity and productivity of land. Land degradation is a worldwide challenge which affects productivity in more than 80 countries and especially serious in Africa where 36 countries face dry land degradation and desertification. The impact of land degradation has already put at risk the livelihoods, economic well-being, and nutritional status of more than 1 billion people in developing countries. Agricultural lands in both dry land and forest areas have been most severely affected by land degradation. About two-thirds of agricultural land has been degraded to some extent during the last 50 years, and up to 40 percent of the world agricultural land is seriously degraded (GEF, 2009).

According to FAO (2010), land degradation is one of the root causes of declining agricultural productivity in the world and if left uncontrolled, it will exacerbate the problems of food security. Estimates report that more than 20 percent of all cultivated areas, 30 percent of forests and 10 percent of grasslands are presently undergoing degradation (FAO, 2008). Approximately 1.5 billion people, or a quarter of the world's population, depend directly on land that is being degraded (Bynoe, 2005).

2.4 Land degradation in the United States

Land degradation is occurring all over the world. In the United States, only 15.8% of the land is protected. Human population in there is constantly increasing and this, in turn, causes food demand to increase. When consumer demand increases, industry grows, and in turn the environment suffers. Growth of industry has led to the decline of forests and increased rate of land degradation hence the loss of biodiversity in the United States (World Resources Institute, 2006). It is estimated that in the United States soil erosion is costing \$44 billion a year in damage to farmland, waterways, and health. It is also predicted that if farmers do not replace the lost water and nutrients, US crop yields will drop by 8% per year (Kaiser and Proffitt, 2004).

Soil degradation naturally occurs from water and wind, but poor agriculture methods are the main cause of this problem in the United States. One of the main problems with agriculture there is the practice of sowing crops without fertilizer season after season. This practice causes the soil to be drained of all its nutrients, and in turn this causes the soil to be less and less fertile. Another problem is poor irrigation methods which cause chemical imbalance in the soil. When land is improperly irrigated, salinization occurs (soil becomes oversaturated with salt) and this makes the land infertile (Kaiser and Proffitt, 2004).

Deforestation is another environmental threat in the United States. 831 square miles of forest in the US was lost between 2000 and 2005. The forests lost were the older forests which hosted the highest number of animal and plant species. The main reasons for the deforestation are to get timber for business, road construction, industrialization, and paper consumption. Of these, business logging is the main cause of deforestation since the United States' forest service which is meant to protect the forests, is influenced greatly by the timber industry. This Forest Service subsidizes timber companies up to an amount of \$500 million a year in tax paying. These practices make wood and paper cheaper and provide jobs in the timber industry but making it harder for the recycling industry to be successful (Buttler, 2007).

2.5 Land degradation in Asia

The five Central Asian countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) share common land degradation problems, due to their geographic proximity and the soviet legacy of environmental mismanagement. Central Asia's arid and semi-arid lands (dry steppe, semi-desert, desert, salt marshes) are particularly vulnerable to degradation of different types, particularly soil degradation (loss of soil fertility, salinization, water logging); degradation of pastures (due to overgrazing and excessive agricultural and timber harvesting); degradation of forests (due to illegal logging, fires, grazing, erosion); and erosion, landslides and mud flows. The desiccation of the Aral Sea, and its devastating effects on soil quality in the Aral Sea basin, are poignant illustrations of these problems, which directly affect the livelihoods and health of some 20 million inhabitants. Agricultural yields are reported to have declined by 20-30 percent across the region in the last decade. Annual losses of agricultural production from salinization alone are estimated at \$2 billion. Central Asia's dry land, mountain, and riparian biodiversity resources –many of which are

globally unique – are under threat from population growth, particularly from rural populations desperate to sustain their livelihoods. Macroeconomic policy frameworks and poverty reduction efforts in these countries must increasingly integrate the sustainable land management practices needed to underpin long-term economic growth in rural areas, where most of Central Asia's poor are located (Mikhalev & Reimov, 2008).

Pakistan is facing numerous environmental threats that are affecting its sustainable economic future. Amongst, land degradation emerges to be the worst warning. The costs of land degradation in South Asian countries (India, Pakistan, Bangladesh, Iran, Afghanistan, Nepal, Sri Lanka, Bhutan) is at least US\$ 10 billion annually. This is approximately 2% of the region's GDP which is equal to 7% of the value of its agricultural output. The breakdown of losses, according to types of land degradation, is: water erosion US\$ 5.4 billion; wind erosion US\$ 1.8 billion; fertility decline US\$ 0.6-1.2 billion; water logging US\$ 0.5 billion and salinisation US\$ 1.5 billion. Altogether 140 million hectares, which is equal to 43% of the region's total agricultural land, suffers from one or the other form of land degradation. Of this, 31 million hectares are strongly degraded and 63 million hectares moderately degraded. The worst affected country is Iran, with 94% of agricultural land degraded, followed by Bangladesh (75%), Pakistan (61%), Sri Lanka (44%), Afghanistan (33%), Nepal (26%), India (25%) and Bhutan (10%) (Zia & Muhammad, 2006).

Of the world's 1.2 billion hectares with moderate to severe soil degradation, the largest areas are in Asia and Africa. Central America has the highest percentage and worst degrees of soil degradation (Oldeman *et al.* 1990). Figure 2.4 shows the areas of concern for soil degradation in the world.

Areas of Concern for Soil Degradation

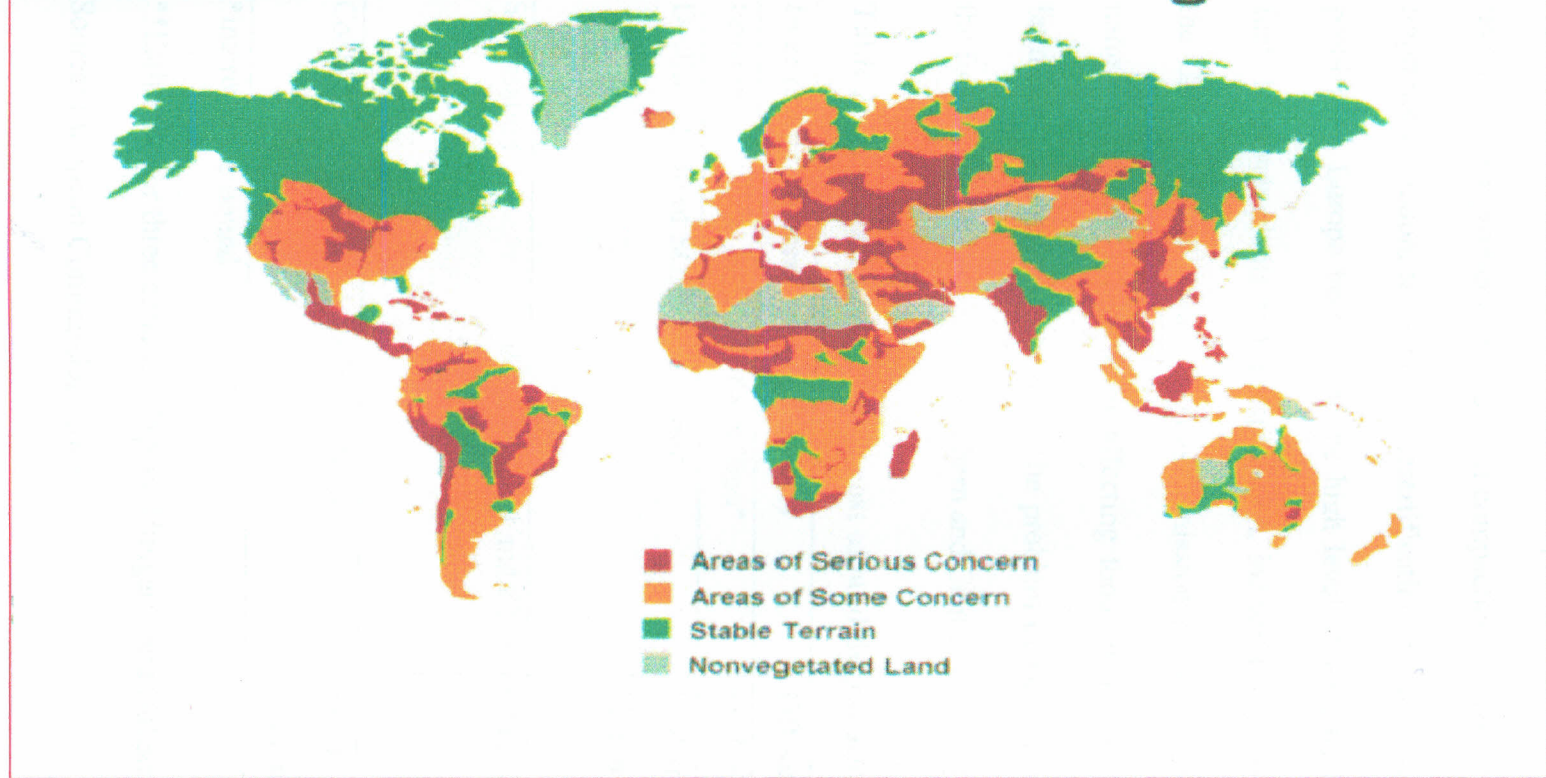


Figure 2.4: Areas of concern for soil degradation in the world

Source: Oldeman *et al.* (1990)

2.6 Land degradation in Europe

The process of land degradation is reaching high levels and becoming very dangerous in Europe. Erosion, acidification, and pollution are among the leading causes of this degradation. Unfortunately, once these processes occur, they basically cannot be undone. Other problems include soil compaction, loss of organic matter, overgrazing, improper irrigation, salinization, desertification and water-logging. Pollution is also a problem in Europe because of the high level of industrialization. The use of fossil fuels in power plants and transportation, industrial processes, and accidents such as the Chernobyl explosion, all cause emission of pollutants. This pollution disrupts natural ecosystem functions by affecting food chains and decreasing production on farmlands by poisoning the soil. The problem of land degradation is most severe in the former Soviet Union, and Southern and Central Europe (UNEP, 1999).

Table 2.1: Estimated total annual cost of land degradation in Europe

Degradation process	On-site costs	Off-site cost	Total
Erosion	€588 million*	€6,7 billion*	€7,3 billion
Decline of soil of SOM	€2 billion	€1.4 and 3.6 billion	Between €3.4 and 5.6 billion
Salinisation	Between €114 and €277 million	€44 million	Between €158 and 321 million**
Contamination	€192 million*	€17,1 million*	€17,3 million*

*Intermediate bound

**Estimates for three countries (Spain, Hungary, and Bulgaria)

Source: European Commission, 2006

The EEA (1995) provides a rough estimation of the area in Europe (excluding Russia) affected by major types of soil degradation processes.

Table 2.2: Areas affected by major types of soil degradation in Europe

Soil degradation type	Area affected (million ha)	Percentage of total European land area
Water erosion	115	12
Wind erosion	42	4
Acidification	85	9
Pesticide contamination	180	19
Nitrates and phosphates	170	18
Soil compaction	33	4
Organic matter losses	3.2	0.3
Salinisation	3.8	0.4
Water logging	0.8	0.1

Source: (EEA, 1995)

2.7 Land degradation in Africa

The dry lands of Africa amount to about 2,100 million hectares. Land degradation is one of the biggest problems in Sub-Saharan Africa, threatening the lives of people in those regions. The problem occurs in all the three zones of the region, the humid, sub humid and dry lands, albeit at different levels. Key factors of degradation in the humid lands are: clearing of trees for agricultural expansion, logging, firewood gathering and charcoal burning, mining, human settlements, and infrastructural and industrial developments. The same factors are also important in the sub-humid zones

although overgrazing and uncontrolled fires are more important. Within the dry lands, overgrazing combined with unsustainable agriculture and over exploitation of natural resources are driving factors. Additionally, there are various underlying causes among which population growth, rural poverty and poor policies are key. Very large areas of Sub-Saharan Africa are already or becoming degraded as a result of these factors, the result of which is desertification in the dry sub-humid and dry land zones (Blay *et al.*, 2004).

The wealth of Africa depends on the ability to conserve and manage its land resources. Soil degradation not only results in decreased food production but also in droughts, ecological imbalance and consequent degradation of the quality of life. In Africa, the most conspicuous symptoms of the negative impact of land degradation on food production are stagnating and declining yields and increasing levels of poverty. Throughout the continent, regardless of the climatic zone, unpredictability of rains is a common feature. In most cases, the rainfall is rarely gentle and even. It usually comes as torrential downpours, which are destructive to soils and harmful to natural and cultivated plants (Jama & Zeila, 2005).

Some soil salinity problems are caused by the overexploitation of groundwater on the fringes of the north-west Delta. In addition, the existing soil resources and the physiography are of low quality, and there are inappropriate land management practices (Abdel-Kader, 2003). Water logging and the mismanagement of irrigation coupled with restricted drainage conditions are leading to increased soil salinization and soil sodicity development (Kotb *et al.*, 2000). Wind and water erosion are aggravating the problem and leading to a loss of plant cover and genetic resources. In the north-west coastal zone, the effect of tillage and inappropriate land use leads to

high annual soil losses (10.6 tons/ha), which are 93 per cent higher than losses occurring through wind erosion. The use of pesticides and other agricultural chemicals leads to soil pollution and other serious environmental hazards. For example, the use of chemical fertilizers increased fourfold in the last two decades, and the same holds true for herbicides, which are used to control submerged weeds and water hyacinths in canals and drains. The expansion of irrigation into desert lands is increasing the pressure on the available and often non-renewable groundwater resources. The demand for water has increased due to the high population growth and the expansion of irrigated agriculture, which has further aggravated the conflict for water. The overexploitation of groundwater resources is leading to an intrusion of seawater into coastal aquifers and this is causing deterioration of the quality of water, which is becoming more and more saline. Its use in irrigation further adds salts to the soil, and this is negatively affecting land productivity. The problem is more severe in the reclaimed areas of the north-west coast where groundwater is the main source of freshwater resources. Over the upcoming decades, the coastal north-western part of the Delta is expected to be affected by climate change and a possible sea rise, the overall impact of which will largely depend on the degree of coastal alterations. An intensified use of land in the coastal region will inevitably be due to the continued growth of the population. The anticipated agricultural intensification and increased land reclamation, irrigation, urbanization and other activities that negatively affect the soil and water quality will amplify the negative impact that climate change and sea rise will have on the area (Wassif et al., 1999).

2.8 A Review of Case Studies of soil degradation in the world

A research by Holden and Shiferaw (2003), using a bio-economic model of Andit Tid, presents a severely degraded agro-pastoral farming system with high population density and good market access in the highlands of Ethiopia. Land degradation, population growth, stagnant technology, and drought, threaten food security in the area. The risks of drought and weather changes appear to have increased in recent years. The bio-economic model is used to analyse the combined effects of land degradation, population growth, market imperfections and increased risk of drought on household production, welfare and food security. The researchers found that the indirect effects of drought on household welfare through its impact on crop and livestock prices are larger than the direct ones. They concluded that provision and adoption of credit for fertiliser, although risky in itself, may lead to increased grain production and improved household welfare and food security. Provision of credit may have a negative effect on conservation incentives, but this effect may be mitigated by linking a conservation requirement to the provision of credit for fertiliser.

According to Campell and Berry (2004), land degradation in Mexico is an important factor in national economy impacting 65% of the national land area. It is estimated that loss of nutrients and productivity in agricultural and grazing areas costs over \$2 billion a year, losses due to salinization approach \$1 billion and the cost of deforestation is up to \$0.5 billion, making a total impact of 6-5% of NDP. Land degradation is an important factor in rural-urban migration in Mexico and the Mexico-U.S.A migration streams. About 700,000 to 900,000 people migrate from Mexico's dry lands annually.

Land degradation in Egypt is due to the low natural resilience of the soil as well as various environmental and human pressures. The low soil fertility and weak structures are due to the overall characteristics of these soils, which are sandy and silty with low organic matter content. This makes these soils highly vulnerable to wind and water erosion. With the reclamation of the land, further deterioration is occurring as a result of misuse and mismanagement of land resources (Kishk, 1986). Productivity has been limited, in part, by high salinity levels and the encroachment of urban settlements onto previously cultivated lands. The natural protection from coastal erosion and the formation of coastal lagoons were due to the high sand dunes. However, coastal erosion is being accelerated by the retreat of the shores resulting from the insufficient sediment load of the Nile River water discharged into the Mediterranean Sea (Suliman, 2001).

2.9 Land degradation in Kenya

Kenya is subjected to several environment-related worrying trends, which put sustainable development at risk. Land degradation, and soil erosion in particular, poses one of the most serious threats to sustained food production and Kenya's development in general. Substantial negative effects on yield due to soil erosion have been observed. Fertilizers and other inputs cannot fully compensate for yield losses caused by soil erosion; the soil degradation may thus be irreversible. Hence, there is great need to support soil and water conservation, and to intensify the efforts to arrest further land degradation. Beside the environmental constraints, costly input prices, low output prices and delayed payments discourage farmers to invest in their land or in modern technology (UNEP, 2009).

In Kenya, over 80 percent of the land area is classified as Arid and Semi-Arid Land (ASAL) and a most of this area is affected by moderate to severe land degradation. About 10 million people (30 percent of Kenya's population) live in the ASALs and over half of these live below the poverty line (subsisting on <US\$1/day). Like several other countries, the government is committed to overcome degradation in view of its implications on poverty and food security. Most of the population in Kenya's ASALs is pastoralists and agro-pastoralists but increasingly, farmers from the overcrowded higher potential areas have migrated into the dry lands causing changes in land use, privatization of communal land and increasing pressure on land resources. ASALs and their inhabitants have long been marginalized politically, socially and economically. The challenge in the ASALs in the country and the rest of SSA is to develop an innovative approach to sustainable land management (SLM) where resource conservation and land rehabilitation can be combined with improved livelihoods and income generation for local communities and farmers/herders.(FAO, 2004).

In the last decades, population growth and the resulting expansion in agriculture and livestock production have increased pressures on land and natural resources. Among the main land degradation processes currently taking place in Kenya are water erosion, soil nutrient depletion, deforestation and degradation of dry land pastures. About 30% of Kenya's land is affected by very severe or severe land degradation and this degradation has important consequences for the productivity of agricultural land and other natural resources, and is closely linked to poverty (TerrAfrica, 2008).

2.10 Human impact on land

The major service of land is the provision of food and other ecosystem services required to sustain this provision. Interacting micro-organisms, plant and animal species, that is biodiversity, are closely involved in the provision of all services from land (Safriel and Adeel, 2005). However, human impact reduces the land's plant cover and its rich biodiversity, which, among other benefits, provides for soil conservation. The eroded topsoil then blows or washes away along with its biodiversity, whose recovery on the denuded land is impaired. This biodiversity loss leads to failure in plant nutrient recycling, soil conservation, soil moisture regulation, local climate amelioration, pest control, pollination and the ecosystem's resilience and stability. These combined effects lead to land degradation and desertification, as well as to the loss of many significant ecosystem services (UNCCD, 2012).

Land degradation is often caused by mismanagement of land and water resources and expresses itself by processes such as soil erosion, soil surface crusting, forest fires and/or impoverishment of the vegetation. The loss of arable land has been caused by a number of factors, many or most of which are tied to human development. The primary causes are deforestation, overexploitation for fuel wood, overgrazing, agricultural activities and industrialization (Oldeman, *et al*, 1990). Figure 2.5 illustrates the relative sizes of the causal mechanisms as a function of region.

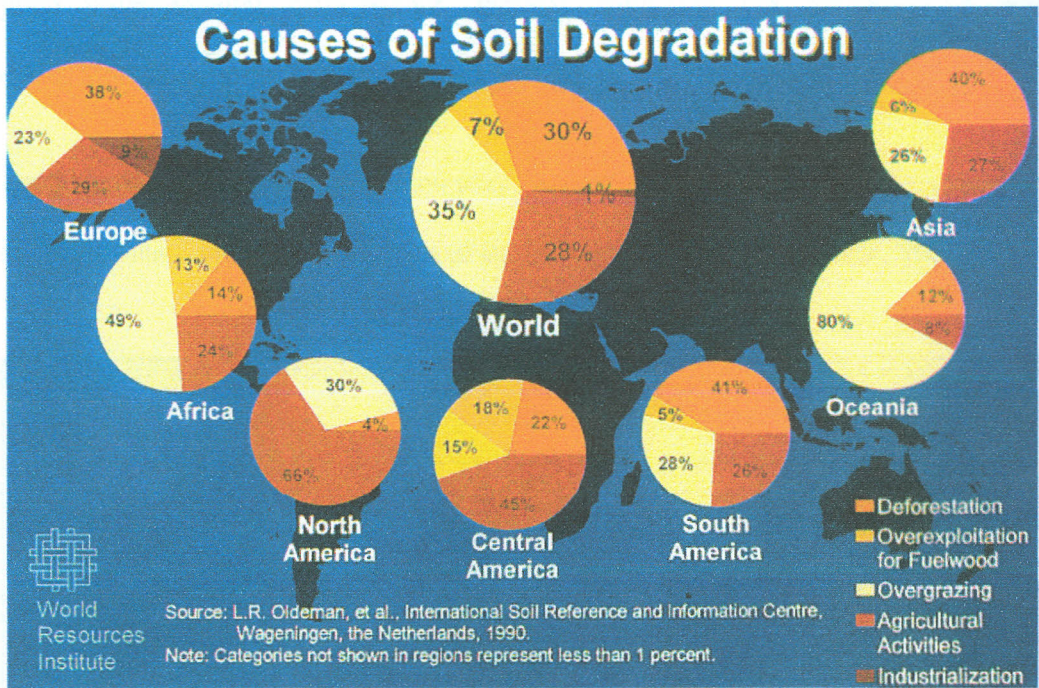


Figure 2.5: Causes of soil degradation in the world

Source: Oldeman, *et al.*, (1990)

According to Eswaran *et al.*, (2006), human impact on land has been widespread and in some cases has impaired the agricultural productivity of the land and the functions of ecosystems. This has resulted in the extinction of plant and animal species. The better quality lands are not greatly damaged although the lands that appear to have been most impacted are dominant in the tropics. The countries where maximum human impact and land degradation occur are largely low-income countries and countries with high population densities. Poverty, population density, and land degradation are thus interlinked and land quality is at the mercy of land use. A better understanding of degradation processes and the resilience characteristics of the resource base coupled with improved soil, water, and nutrient management is necessary to meet the global challenges of sustained crop production in harmony with

good environmental management, thereby mitigating the processes of land degradation.

Land degradation is due to a complex mix of many types of human activities, including many interlocking threads of the human societal system (MEA, 2005).

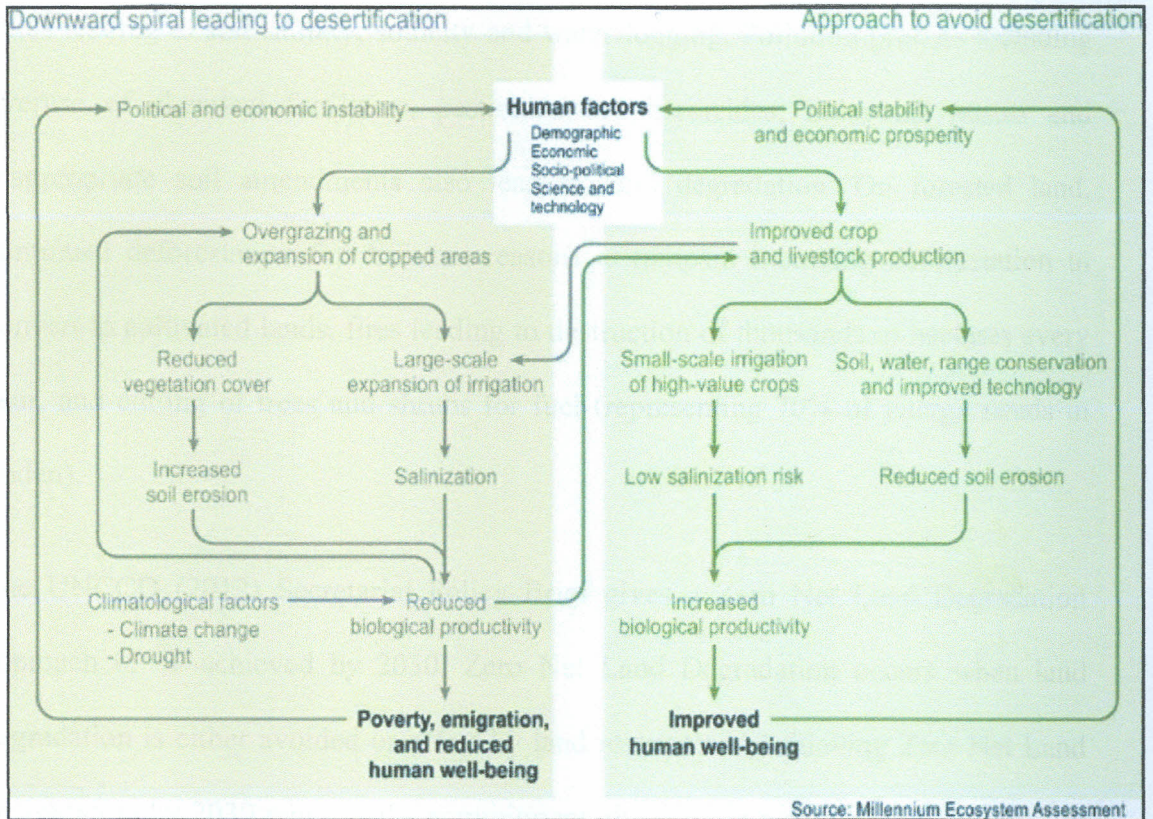


Figure 2.6: Schematic chart showing how drylands can be developed in response to changes in key human factors

Source: (MEA, 2005).

2.11 Land Degradation Control

According to Hamdi Ismail (2006), human induced degradation is rampant in North Africa regions which include Egypt, Sudan, Libyan Arab Jamahiriya, Tunisia, Algeria and Morocco. This degradation is severe in rangelands, cultivated lands and forested lands. Rangelands degradation is as a result of overgrazing that exceeds the proper

carrying capacity; cultivation of marginal lands to increase food production leading to destruction of plant cover and loss of valuable biodiversity; use of tracks for livestock transportation; and abandoning of proper grazing practices including rotational grazing and adoption of proper range rest periods. On cultivated lands, land degradation is due to inappropriate water management under conditions of irrigated lands leading to soil salinity, sodicity and water-logging. Pollution process including overuse of chemical fertilizers, pesticides and herbicides, industrial wastes and inappropriate soil amendments also lead to land degradation. On forested land, continued deforestation for different reasons is rampant including deforestation to convert to cultivated lands, fires leading to destruction of thousands of hectares every year, and cutting of trees and shrubs for fuel (representing 70% of energy needs in Sudan).

The UNCCD (2012) Secretariat Policy Brief gives a Zero Net Land Degradation approach to be achieved by 2030. Zero Net Land Degradation occurs when land degradation is either avoided or offset by land restoration. Achieving Zero Net Land Degradation by 2030 requires the commitment, the support and the active investment of all public and private sector actors, and all parts of the supply and value chain related to land use, as well as local and community stakeholders. UNCCD gives 5 pathways to Zero Net Land Degradation which include: arresting further degradation and restoring degraded land; sustainable land management; avoiding degradation of non-degraded lands; community based traditional approaches and payment for ecosystem services.

2.12 Summary

Land degradation is a major global concern that continues to threaten livelihood. However, the global community's awareness on land degradation and desertification has lagged in comparison with its awareness on climate change and biodiversity loss and therefore, the significance of land and soil to humanity remains obscure to many. As a result, the risk to livelihoods deriving from land and soil degradation does not receive the attention it deserves (UNCCD 2012). This study thus seeks to fill this literature gap.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides information on the following: the study area, the research design, data collection, validity test, reliability test, data analysis, and model specification.

3.2 The Study Area

This study was conducted in Kasikeu Division of Makueni County (Figure 3.1 and Figure 3.2). The choice of this study area was mainly based on the livelihood of people in the division, which includes production of food-crops and livestock production implying that they completely depend on the environment for survival. This provided adequate information to determine the impact of human activities on land degradation in the area. Makueni County, carved from Machakos County in 1992, is one of the 13 counties that make up the Eastern province and has an area of 7965.8km². The county has a population of 771,545 (1999 census) with an annual growth rate of 2.4%. A report by CED (2007-2008) gives a population of 9193,354 and a poverty incidence of individuals below poverty level of 52%. According to the 1999 population census, Kasikeu Division had a total population of 35,719 people. The altitude of Makueni County ranges from 600m in Tsavo at the southern end of the district to 1900m in Mbooni and Kilungu Hills. It lies between latitude 10 35⁰ south and longitude 37 10⁰ east and 38 30⁰ west.

The county is mainly arid and semi-arid and is characterised by hot and dry climate for most of the year. The mean temperature ranges from 20.20⁰C to 24.60⁰C averaging at 22.10⁰C. The county is characterised by extreme rainfall variability. Typically good seasons are interspersed with extremely bad seasons and variations in the

onset of rainy seasons add to the difficulty of ensuring adequate food. The district has two rainy seasons with two peaks in March / April (long rains) and November/December (short rains). June to October is a long dry period, while January to March is a short one. The hilly parts of the county (Mbooni and Kilungu Hills) receive 800 to 1200 mm of rainfall per year. The rest of the district receives about 500mm per annum. The northern parts of the county with medium rainfall have high potential for coffee, horticulture and dairy farming while the low-lying southern parts have good potential for ranching. About 22% of the county is considered arable, while gazetted forest covers only 2.2% of the total land surface.

The major land formations in Makueni County are the volcanic Chyullu hills, which lie along the southwest border of the district in Kibwezi division. Three main soil types are present in the county; red clays found on the hills and part of the lowlands; sandy soils, found mainly in the central parts including Kathonzweni; and the black cotton soils that dominate the southern parts. These soils are of low to moderate fertility. The overall drainage pattern in the county is from west to east. There are a few permanent rivers / streams in the district. Athi River is the only major perennial river that drains the entire county and is joined by tributaries such as Kambu, Kiboko and Mito Andei. A few other perennial streams flow from the Mbooni and Kilungu hills but their flow becomes irregular as they move to the low-lying areas. These rivers have a potential for both large and small-scale irrigation (Republic of Kenya, 2002).



Figure 3.2: Detailed Map of Makueni District showing the livelihood zones and Kasikeu Division

Source: FAO, 2006

3.3 The Research Design

This study used a survey research design in the collection of survey data on the impact of human population and activities on land degradation in Kasikeu Division, Makueni County. Multistage and simple random sampling, methods were used to select the households for study. The total number of households considered for the

study was 75 where the household heads were interviewed with the help of semi-structured questionnaires. This sample size was calculated using the following formula (IFAD, 2010)

$$n = \frac{t^2 \times p(1-p)}{m^2}$$

Where

n = required sample size

t = confidence level at 95% (standard value of 1.96)

p = estimated prevalence of land degradation in the study area (94.854%)

m = margin of error at 5% (standard value of 0.05)

$$n = \frac{1.96^2 \times 0.94854 (1-0.94854)}{0.05^2}$$

$$=75 \text{ individuals}$$

3.4 Data Collection

This study was conducted between August 2010 and December 2010. August, September and part of October are dry seasons while November and December are rainy seasons when people grow crops. The study relied mainly on cross-sectional primary data, which were collected among the sampled households in the division. The primary data were obtained with the help of semi-structured questionnaires which were used to capture information on the various human activities and their perceived consequences on land degradation. Also, visual indicator charts for land degradation, were prepared and used in the data collection for various forms of land degradation in the division. The study also relied on key informants in the division for agricultural production information. Also, secondary data were sought in order to strengthen

inferential analysis of the survey. The latter was obtained from materials such as academic journals, books, and conference proceedings.

3.7 Data Analysis

The analysis of survey data for this study was conducted using descriptive statistics, correlation and regression analyses. The descriptive statistics considered included the measures of central tendency as well as the measures of dispersion. The estimations of proportions and partial correlation coefficients were used too. The descriptive statistics were used to analyze the socio-demographic information of the households sampled for this study. The indicators of land degradation were analyzed using the box and whisker diagrams together with estimations of proportions (percentages). In order to estimate the causes of land degradation in the study area, a binary logistic regression model was used. The dependent variable in this study was land degradation, whereby farmers who reported land degradation were coded as one (1) and those who did not report land degradation were coded as zero (0). The independent variables were the factors that lead to land degradation in the division such as deforestation, overgrazing, shifting cultivation, land clearance, cultivation on steep slopes and marginal lands, improper fertilizer use, poor technology adoption, improper crop rotation and poor irrigation practices. The consequences of land degradation were analysed using partial correlations and ranking method in order to determine their severity. The postulated hypotheses were tested using z-tests tests to ascertain their statistical significance whereby 5% level was set as the apriori in the study. The survey data for this study were analyzed using Stata computer software.

3.8 Model Specification

In statistics, logistic regression (sometimes called the logistic model or logit model) is used for prediction of the probability of occurrence of an event by fitting data to a logit function curve (Greene, 2002). It is a generalized linear model used for binomial regression. Like many forms of regression analysis, it makes use of several predictor variables that may be either numerical or categorical. The logits, natural logs of the odds, of the unknown binomial probabilities are modelled as a linear function of the X_i :

$$\text{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_{1,i} + \dots + \beta_k x_{k,i} + \varepsilon_i$$

Where:

The estimated binary logistic regression model for anthropogenic factors affecting land degradation in Kasikeu Division has the following specifications:

P_1 = There is land degradation in the study area

P_0 = There is no land degradation in the study area

X_1 = Gender of household head

X_2 = Age of household head

X_3 = Income

X_4 = Education level

X_5 = Family size

X_6 = Farm size

X_7 = Farming experience

X_8 = Deforestation in the study area

X_9 = Clearing vegetation in the study area

X_{10} = Shifting cultivation in the study area

X_{11} = Overgrazing in the study area

X_{12} = Poor technology adoption in the study area

X_{13} = Steep slope cultivation in the study area

X_{14} = Improper crop rotation in the study area

X_{15} = Improper fertilizer use in the study area

X_{16} = Over pumping ground water in the study area

β_0 = Constant of the model (i.e. the intercept)

β_i = Regression coefficients of the model

ε_i = Error term of the model

The estimated binary logistic regression model for the underlying factors influencing land degradation in Kasikeu Division has the following specifications:

P_1 = There is land degradation in the study area

P_0 = There is no land degradation in the study area

X_1 = Age of household head

X_2 = Income

X_3 = Education level

X_4 = Family size

X_5 = Farm size

X_6 = Farming experience

X_7 = Land shortage in the study area

X_8 = Open access resources in the study area

X_9 = Poverty in the study area

X_{10} = Population density in the study area

β_0 = Constant of the model

β_i = Regression coefficients of the model

ε_i = Error term of the model

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter examines the results that emerged from the analysis of the information collected, and hence the discussion of these results. Specifically, the information is concerned with the indicators, direct causes, underlying causes, and the consequences, of land degradation with regard to livelihood in the study area.

4.2 Descriptive statistics

According to the results, the sample surveyed constituted household heads aged between 26 years and 76 years (Table 4.1). The mean age of the household heads from the sample analyzed was 48 years with a standard deviation of 10.3. The family size ranged from 2 to 8 members with an average of 6 members per household and a standard deviation of 1.7. The sampled households had farm sizes ranging from 0.5 to 16 acres of land. From the analysis of the survey data the mean for the farm size was 4 acres per household with a standard deviation of 3.6.

Table 4.1: Summary statistics for demographic data

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Age	75	48.0	10.3	26	76
Family size	75	6.4	1.7	2	8
Farm size	75	4.0	3.6	0.5	16

The descriptive statistics for gender, income, education, and farming period, were done by an estimation of their respective proportions. According to the analysis, the gender of household heads constituted 68% males and 32% females both with a

standard error of 0.054 (Table 4.2). The estimations of proportions show that 52% of the sampled households derive their livelihood from employment, 29% from farming and 19% from businesses. The standard errors from the estimations of proportions for sources of income for employment, farm, and business are 0.058, 0.053, and 0.045, respectively. The results from the analysis show that, 36% (*Std. Error* =0.056) had tertiary education, 35% (*Std. Error* =0.055) had secondary education, 12% (*Std. Error* =0.378) had primary education, .05% (*Std. Error* =0.0261) had university education and 12% (*Std. Error* =0.378) never went to school. According to the sampled households, 59% have been farming their pieces of land for more than 15 years, 24% for a period of 11-15 years, 12% for 6-10 years and .05% for less than 6 years with standard errors of .057, .049, .037 and .026, respectively.

Table 4.2: Demographic profile of Kasikeu Division

Variable	Proportion	Std. Err. (SE)
Gender		
Female	0.32	0.054
Male	0.68	0.054
Income		
Farm	0.29	0.052
Business	0.19	0.045
Employed	0.52	0.058
Education		
Never went to school	0.12	0.037
Primary education	0.12	0.037
Secondary education	0.37	0.055
Tertiary education	0.36	0.056
University education	0.05	0.026
Farming period		
<6years	0.05	0.026
6-10years	0.12	0.037
11-15years	0.24	0.049
>15years	0.59	0.057

4.3 Land degradation indicators

The land degradation indicators were analyzed using the box-and-whisker diagrams (Figure 4.1) which were compared against the estimation of proportions (Table 4.3) in order to reinforce the discussion. These indicators included: rills, gullies, pedestals, armour layer, soil deposits on gentle slopes, exposed roots, muddy water, sedimentation in streams and rivers, dust storms sandy layers, furrows in clay soils and ripples in sandy soils, barren spots changes in vegetation species, decrease in organic matter, increased run off, reduced soil water, and rooting depth (Figure 4.1).

The land degradation indicators for this study were analyzed using a 5-point Likert Scale: 1 = strongly disagree, 2 = disagree, 3 = neither, 4 = agree, 5 = strongly agree. The box-and-whisker diagrams show that the following land degradation indicators were commonly observed in majority of the farms: rills, gullies, pedestals, armour layer, soil deposits on gentle slopes, exposed roots, muddy water, sedimentation in streams and rivers, furrows in clay soils and ripples in sandy soils, barren spots changes in vegetation species, decrease in organic matter, increased run off, reduced soil water, and rooting depth. However, dust storms were not common in the study area. This is an indication that land degradation is highly widespread in most parts of the study area.

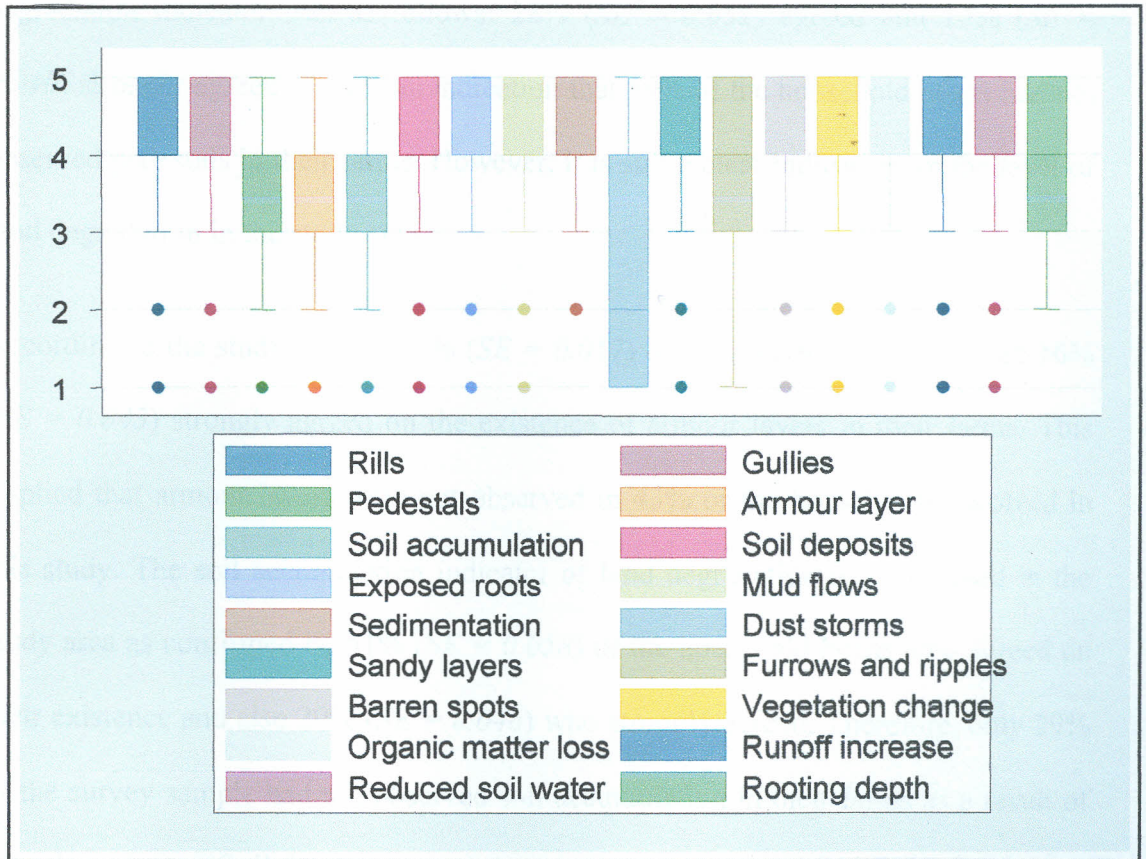


Figure 4.1: Box plots for land degradation indicators in Kasikeu Division

The intensity of land degradation in the study area was based on the estimation of proportions of observed indicators as structured in the Likert-Scale. From the study results, farmers were found to be aware of land degradation and its occurrence in their farms. The results of the study showed that: 53% ($SE = 0.057$) agreed and 33% ($SE = 0.054$) strongly agreed that there were rills in their farms (Table 4.3). This is a significant indication that there is severe land degradation in the study area since only 14% of the surveyed households had not observed rills in their farms. The results from the study showed that 48% ($SE = 0.058$) of the household heads strongly agreed that there are gullies in their farms and that 36% ($SE = 0.056$) agreed on the existence of the land degradation indicator. This implies that only 16% of the households never

reported any existence of gullies in their farms. The presence of pedestals as a land degradation indicator was as follows: 28% ($SE = 0.052$) agreed and 13% ($SE = 0.040$) strongly agreed. This is an indication that 59% of the household heads had not observed pedestals in their farms. However, it is still a clear indication on the level of land degradation in the study area.

According to the study results, 41% ($SE = 0.057$) of the households agreed and 16% ($SE = 0.043$) strongly agreed on the existence of armour layers in their farms. This implied that armour layers were not observed in 43% of the households involved in this study. The soil accumulation indicator of land degradation was observed in the study area as confirmed by 51% ($SE = 0.058$) of the household heads who agreed on their existence and also 20% ($SE = 0.046$) who strongly agreed. Therefore, only 29% of the survey sample had not observed soil accumulation in their farms as a result of land degradation. Soil deposits on gentle slopes in the farms are an indicator of land degradation. There were 41% ($SE = 0.057$) household heads who agreed on the observation of soil deposits on gentle slopes of their farms. Also, 37% ($SE = 0.056$) of the household heads strongly agreed that the soil deposits indicator was observed. However, 22% of the households did not have soil deposits on gentle slopes in their farms. The existence of exposed roots is a common indicator of land degradation in arid and semi-arid lands. There were 53% ($SE = 0.058$) respondents sampled for this study who strongly agreed that their farms had exposed roots and also 40% ($SE = 0.057$) agreed on the same. Thus, only 7% households did not have exposed roots in their farms as a result of land degradation.

In most ASALs where soil erosion takes place, there is mud flows during the rainy seasons and as observed in Kasikeu Division, 48% ($SE = 0.058$) of the sampled

household heads strongly agreed and 37% ($SE = 0.057$) agreed on the existence of this indicator in the land. Thus, 15% of the respondents did not agree on the existence of this indicator on their farms. This shows that there is an extensive loss of soil as muddy water during the wet seasons. Another indicator of land degradation, which is commonly experienced after rains, is the sedimentation in streams and rivers. The results from this study showed that 47% ($SE = 0.058$) of the interviewed respondents strongly agreed on its prevalence while 37% ($SE = 0.057$) agreed. Therefore, 16% household heads interviewed in this study did not observe any sedimentation in streams and rivers around their farms. This high proportion of respondents who were able to observe sedimentation explains the extent to which the study area is affected by land degradation. Dust storms were not a significant indicator of land degradation in this study area. This might be due to rugged terrain which influences the flow of wind after gathering dust in the bare lands. According to the study 21% ($SE = 0.048$) agreed while 9% ($SE = 0.034$) strongly agreed on the incidences of dust storms in the study area. Hence, 70% of the interviewed household heads disagreed on the existence of dust storms in their pieces of land.

The results obtained from this study showed that 46% ($SE = 0.058$) of the respondents agreed that they had observed sandy layers, while 33% ($SE = 0.055$) strongly agreed. Therefore only 21% of the household heads did not observe this indicator of land degradation in their farms. Furrows in clay soils and ripples in sandy soils are used as indicators of land degradation in this study. According to the results from this study, 41% ($SE = 0.057$) of the household heads interviewed agreed that they had observed furrows in clay soils and ripples in sandy soils while 31% ($SE = 0.054$) strongly agreed. These proportions left only 28% of the respondents who had not observed the land degradation indicator in their farms. In the survey results, there were 55% ($SE =$

0.058) respondents who strongly agreed and 32% ($SE = 0.054$) who agreed that they had barren spots on their land. This implies that only 13% of the interviewed respondents for this study did not have barren spots on their land. This might be used to explain the extent of degradation of once productive land in the area of study.

Land degradation can be observed through a change in vegetation species over time. The results from this study showed that 44% ($SE = 0.058$) strongly agreed and 36% ($SE = 0.056$) agreed on the change in vegetation species in their land over time. Considering that only 20% of the household heads interviewed had not observed the change in vegetation species, it is certain that land degradation has significantly affected biodiversity in the study area. According to the study results, 51% ($SE = 0.058$) of the respondents agreed that there was a significant decrease in organic matter over time while 36% ($SE = 0.056$) of the respondents strongly agreed that there was decrease in organic matter. There are only 13% respondents who have not experienced the decrease in organic matter in their lands. This explains the decline in soil fertility and hence a drop in crop yields over time. The results from this study showed that 55% ($SE = 0.059$) of the interviewed household heads strongly agreed and 29% ($SE = 0.053$) agreed that there was increase in run-off during rainy seasons. However, 16% of the household heads did not agree on the existence of this indicator in their farms.

The reduction in soil moisture is an important indicator of land degradation in arid and semi-arid lands. This argument is re-affirmed by the results from this study whereby 47% ($SE = 0.058$) of the respondents strongly agreed while 39% ($SE = 0.057$) agreed that they were experiencing reduced soil water in their farms. This implies that its only 14% of the respondents in the sample surveyed who did not

experience loss of soil moisture in their farms. This is more severe during the dry season when most households in the study area rely on ground water for domestic and livestock use as well as for irrigation. The rooting depth was considered an important indicator of land degradation in this study. This is mainly because of the effect of the loss of soil through erosion hence rendering the soils shallow for deep rooted plants. The 43% ($SE = 0.057$) household heads interviewed agreed that there was a problem with rooting depth of plants in the study area. Similarly, 31% ($SE = 0.054$) of the respondents strongly agreed that the problem of rooting depth was common in their farms. Therefore, only 26% of the interviewed household did not agree on the existence of this indicator in their farms.

Table 4.3: Indicators for the intensity of land degradation in Kasikeu Division

Variable	Proportion	Std. Err. (SE)
Rills		
Strongly disagree	0.01	0.013
Disagree	0.07	0.029
Neither	0.06	0.026
Agree	0.53	0.058
Strongly agree	0.33	0.055
Gullies		
Strongly disagree	0.01	0.013
Disagree	0.03	0.019
Neither	0.12	0.038
Agree	0.36	0.056
Strongly agree	0.48	0.058
Pedestals		
Strongly disagree	0.13	0.039
Disagree	0.05	0.026
Neither	0.4	0.057
Agree	0.28	0.052
Strongly agree	0.14	0.039

Armour layer		
Strongly disagree	0.06	0.026
Disagree	0.12	0.038
Neither	0.25	0.051
Agree	0.41	0.057
Strongly agree	0.16	0.043
Soil accumulation		
Strongly disagree	0.10	0.036
Disagree	0.04	0.023
Neither	0.15	0.041
Agree	0.51	0.058
Strongly agree	0.2	0.046
Soil deposits on gentle slopes		
Strongly disagree	0.04	0.023
Disagree	0.07	0.029
Neither	0.11	0.036
Agree	0.41	0.057
Strongly agree	0.37	0.056
Exposed roots		
Strongly disagree	0.01	0.013
Disagree	0.03	0.019
Neither	0.03	0.019
Agree	0.4	0.057
Strongly agree	0.53	0.058
Muddy water		
Strongly disagree	0.01	0.013
Disagree	0.04	0.023
Neither	0.08	0.032
Agree	0.39	0.057
Strongly agree	0.48	0.058
Sedimentation in streams and rivers		
Disagree	0.06	0.029
Neither	0.08	0.032
Agree	0.39	0.057
Strongly agree	0.47	0.058
Dust storms		
Strongly disagree	0.31	0.054
Disagree	0.32	0.054
Neither	0.07	0.029
Agree	0.21	0.048
Strongly agree	0.09	0.034

Sandy layers		
Strongly disagree	0.05	0.026
Disagree	0.11	0.036
Neither	0.04	0.023
Agree	0.47	0.058
Strongly agree	0.33	0.055
<hr/>		
Furrows in clay soils and ripples in sandy soils		
Strongly disagree	0.04	0.023
Disagree	0.16	0.041
Neither	0.08	0.032
Agree	0.41	0.057
Strongly agree	0.31	0.054
<hr/>		
Barren spots		
Strongly disagree	0.01	0.013
Disagree	0.05	0.026
Neither	0.07	0.029
Agree	0.32	0.054
Strongly agree	0.55	0.058
<hr/>		
Changes in vegetation species		
Strongly disagree	0.01	0.013
Disagree	0.13	0.039
Neither	0.05	0.026
Agree	0.37	0.056
Strongly agree	0.44	0.058
<hr/>		
Decrease in organic matter		
Strongly disagree	0.05	0.026
Disagree	0.05	0.026
Neither	0.03	0.019
Agree	0.51	0.058
Strongly agree	0.36	0.056
<hr/>		
Increased run off		
Strongly disagree	0.07	0.029
Disagree	0.01	0.013
Neither	0.08	0.032
Agree	0.29	0.053
Strongly agree	0.55	0.058
<hr/>		
Reduced soil water		
Strongly disagree	0.03	0.013
Disagree	0.05	0.026
Neither	0.08	0.032
Agree	0.37	0.057
Strongly agree	0.47	0.058

Reduced rooting depth		
Disagree	0.09	0.034
Neither	0.17	0.044
Agree	0.43	0.057
Strongly agree	0.31	0.054

4.4 Anthropogenic factors affecting land degradation

The anthropogenic factors of land degradation were estimated using a regression model that comprised of anthropogenic independent variables against land degradation level. The results from the survey data showed that gender of household head, age of household head, income level, education level, farming experience, steep slope cultivation deforestation, and overgrazing were significant at 1% level in explaining land degradation. Family size and clearing of vegetation were significant at 5% level while poor technology adoption was significant at 10% level in explaining land degradation. According to the results of the study, a unit increase in men as household heads increases the probability of land degradation by 34% ($S.E. = 0.06$, $t=3.74$, $p=0.01$). This is probably due to the fact that men do most of farming since most women are left at home to take care of children. The results also showed that a unit increase in age of household head increases land degradation probability by 29% ($S.E. = 0.02$, $t=4.92$, $p=0.01$). As age increases, the period of farming increases and this can lead to land degradation if conservation measures are not put into place. A unit increase in income level and education level decreases the probability of land degradation by 22% ($S.E. = 0.24$, $t=-2.96$, $p=0.01$) and 17% ($S.E. = 0.03$, $t=-4.87$, $p=0.01$) respectively. This negative relationship is due to the fact that as people get more educated and have increased income, they are more knowledgeable and they have the ability to employ soil conservation technologies. A unit increase in family

size increases the probability of land degradation by 31% ($S.E. = 0.31, t=0.42, p=0.05$). When population increases, there are many people who rely on the environment for survival and in this case, increase in family size would mean increased demand for resources and if the methods of extracting these resources are not sustainable, the result is land degradation. A unit increase in farm size decreases the probability of land degradation by 42% ($S.E. = 0.17, t=-0.32$). As land owned increases in size, people reduce the intensity of farming in one piece of land and in the case of grazing, rotational grazing is applied. This gives land time to regenerate hence reduced land degradation. A unit increase in farming experience reduces land degradation probability by 36% ($S.E. = 0.08, t=-3.70, p=0.01$). As farming experience increases, the farmers get to know better which conservation technologies work best for them and this leads to better land management.

According to the study results, a unit increase in deforestation raises the probability of land degradation by 28% ($S.E. = 0.80, t=1.73, p=0.01$). Deforestation in the study area occurs as people cut trees for timber, fuel wood and farming. The significance of deforestation to land degradation may be because this exposes land to direct sunlight, rainfall, wind and consequently soil erosion (Plate 4.1).



Plate 4.1: Rampant clearing of vegetation (logging of timber) in Kasikeu Division, Makueni County, Kenya

Researcher: 10/11/2010

The results of this study shows that a unit increase in clearing of vegetation increases land degradation probability by 22% ((*S.E.* = 0.20, *t*=2.58, *p*=0.05). Clearing of vegetation exposes land to factors responsible for soil erosion. Overgrazing was observed to be a significant factor responsible for land degradation in the study area. The survey results showed that a unit increase in overgrazing increased land degradation probability by 28% ((*S.E.* = 0.27, *t*=3.73, *p*=0.01). Overgrazing results from keeping more livestock than the carrying capacity of a given parcel of land. This leads to degradation of the vegetation beyond the critical level for regeneration, hence rendering the land bare and exposed to soil erosion. Cultivation along steep slopes was found to significantly affect land degradation. According to the results a unit increase in steep slope cultivation increases land degradation probability by 45% (*S.E.* = 0.97, *t*=1.53, *p*=0.01). This may be as a result of rendering the soil loose hence

being easily erodible. Poor use of soil conservation technologies appropriate for steep slopes may also increase the vulnerability of soils to erosion (Plate 4.2).



Plate 4.2: Steep slope cultivation and consequent soil erosion in Kasikeu Division, Makueni County, Kenya

Researcher: 13/10/2010

The results of the study showed that a unit increase in improper fertilizer use raises land degradation probability by 18% ($S.E. = 1.12, t=1.06$). Almost all farmers in the study area have never had the PH of their farm soils tested and hence end up using either acidic or alkaline fertilizers in the wrong soil types leading to land degradation. Shifting cultivation without adequate fallow periods was not a significant factor affecting land degradation in the study area. However, it was observed from the study results that a unit increase in shifting cultivation without adequate fallow periods would increase land degradation probability by 19% ($S.E. = 1.04, t=0.74$). This might be attributed to the failure to give the soil enough time to stabilize well enough to resist erosion. According to the study results, a unit increase in poor technology adoption was observed to increase land degradation probability by 21% ($S.E. = 1.01, t=1.90, p=0.1$). This may be because the use of poor technologies for soil conservation promotes soil loss and hence land degradation. Also, poor technologies in cultivation may negatively affect soil aggregate and consequently lead to soil erosion. Improper crop rotation was also found not to be a significant factor in land degradation. However, the results showed that, a unit increase in improper crop rotation increases land degradation probability by 32% ($S.E. = 1.30, t=0.48$). This is because the appropriate crop rotation allows soils to accumulate essential nutrients to support crop life as well as soil micro-organisms. Healthy soils are less prone to soil erosion and consequent land degradation.

Table 4.4: Logistic regression results for anthropogenic factors affecting land degradation

Variable	Coefficient	Std. Err.	t-test	Probability
Gender of household head (1 if male, 0 otherwise)	0.21***	0.06	3.74	0.34
Age of household head (Years)	0.08***	0.02	4.92	0.29
Income (Kshs)	-0.72***	0.24	-2.96	0.22
Education level (Years)	-0.16***	0.03	-4.87	0.17
Family size (Members)	0.13**	0.31	0.42	0.31
Farm size (Acres)	-0.06	0.17	-0.32	0.42
Farming experience (years)	-0.29***	0.08	-3.70	0.36
Deforestation (1 if yes, 0 otherwise)	1.38***	0.80	1.73	0.28
Clearing vegetation (1 if yes, 0 otherwise)	0.52**	0.20	2.58	0.22
Shifting cultivation (1 if yes, 0 otherwise)	0.76	1.04	0.74	0.19
Overgrazing (1 if yes, 0 otherwise)	1.03***	0.27	3.73	0.28
Poor technology adoption (1 if yes, 0 otherwise)	1.92*	1.01	1.90	0.21
Steep slope cultivation (1 if yes, 0 otherwise)	1.49***	0.97	1.53	0.45
Improper crop rotation (1 if yes, 0 otherwise)	0.62	1.30	0.48	0.32
Improper fertilizer use (1 if yes, 0 otherwise)	1.19	1.12	1.06	0.18
Constant	-2.36	2.27	-1.04	0.06
LR chi square	23.97***			
Log likelihood	-30.36			
Pseudo R square	32.19			
Observations	75			

Note: *10% significance level, **5% significance level, ***1% significance level

4.5 Underlying factors influencing land degradation

The regression model for the underlying causes of land degradation considered land shortage, open access resources, poverty and population density (Table 4.5). According to the study results, a unit increase in land shortage was found to raise land degradation probability by 21% ($S.E. = 0.59, t=1.76, p=0.1$). Land shortage is an important incentive for landless to encroach the vulnerable lands such as the steep slopes. Once farming on steep slopes is allowed unabated, land degradation is bound to occur. A unit increase in open access resources was found to increase land degradation probability by 31% ($S.E. = 0.10, t=3.70, p=0.01$).

Extraction of open access resources involves sand harvesting along the rivers, which in turn lowers the water table in the rivers (Plate 4.3).



Plate 4.3: Excessive sand harvesting in Kasikeu River and consequent lowering of the water table in Kasikeu Division of Makueni County

Researcher: 10/11/2010

Poverty was found to affect land degradation in the study area. The results showed that a unit increase in poverty raised the probability of land degradation by 23% ($S.E. = 0.12, t=4.95, p=0.01$). This may be attributed to inability of the people to afford conservation technologies which are more efficient. Also, poverty may deprive people of their livelihood forcing them to engage in negative activities such as charcoal burning. The effect of increased population density on land degradation may not be over-emphasized. According study results, a unit increase in population density was found to increase land degradation probability by 13% ($S.E. = 1.04, t=0.94,$). This may be attributed to high competition for space to farm as population rises hence threatening the stability of ecosystems.

Table 4.5: Logistic regression results for underlying factors influencing land degradation

Variable	Coefficient	Std. Err.	t-test	Probability
Gender of household head (1 if male, 0 otherwise)	0.11***	0.03	3.94	0.24
Age of household head (Years)	0.09***	0.03	2.80	0.11
Income (Kshs)	-0.26**	0.12	-2.27	0.15
Education level (Years)	-0.33***	0.05	-6.73	0.09
Family size (Members)	0.05**	0.02	2.26	0.20
Farm size (Acres)	-0.09	0.13	-0.65	0.18
Farming experience (years)	-0.04	0.07	-0.57	0.28
Land shortage (1 if yes, 0 otherwise)	1.04*	0.59	1.76	0.21
Open access resources (1 if yes, 0 otherwise)	0.36***	0.10	3.70	0.31
Poverty (1 if yes, 0 otherwise)	0.60***	0.12	4.95	0.23
Population density (1 if yes, 0 otherwise)	0.98	1.04	0.94	0.13
Constant	-3.69	2.18	-1.70	0.32
LR chi square	17.42***			
Log likelihood	-27.39			
Pseudo R square	29.12			
Observations	75			

Note: * 10% significance level, ** 5% significance level, *** 1% significance level

4.6 Consequences of land degradation on livelihood

The consequences of land degradation on crop production in the study area were categorized into the following: decline in crop yields; reduced responses to inputs; increased inputs and greater costs; total abandonment of land; reduced productivity on irrigated land; loss of water for irrigation; morphological irregularities; loss of flexibility in land management; lowering of the water table; and diversion of resources to reclamation. In order to assess the severity of each consequence of land degradation on the households sampled for this interview, the variables were ranked basing on the 5-point Likert scale responses.

The decline in crop yield was the most critical outcome of land degradation in this study and hence was ranked number 1 (Table 4.6). This may have been as a result of

soil erosion, which means the top soil is washed as mud flows, leaving less developed soils for crop production. Also, land degradation in the study area has meant that the once productive land has now been reduced to wasteland full of gullies. This implies that land degradation has been drastically reducing the land available for farming. The results from this study showed that the other considered consequences of land degradation on crop production could be ranked as follows: increased inputs and greater costs (2); reduced responses to inputs (3); lowering of the water table (4); loss of water for irrigation (5); reduced productivity on irrigated land (6); diversion of resources to reclamation (7); loss of flexibility in land management (8); morphological irregularities (9); and total abandonment of land (10).

Table 4.6: Consequences of land degradation on crop production in Kasikeu Division

CONSEQUENCES OF LAND DEGRADATION	RANKING					ORDE
	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	
1. Decline in crop yields	0	0.02	0	0.35	0.63	1
2. Reduced responses to inputs	0.01	0.08	0	0.43	0.48	3
3. Increased inputs and greater costs	0	0.03	0.03	0.33	0.61	2
4. Total abandonment of land	0.09	0.25	0.09	0.36	0.21	10
5. Reduced productivity on irrigated land	0.07	0.05	0.05	0.45	0.38	6
6. Loss of water for irrigation	0	0.04	0.13	0.51	0.32	5
7. Morphological irregularities	0	0.15	0.16	0.36	0.33	9
8. Loss of flexibility in land management	0.03	0.01	0.17	0.45	0.34	8
9. Lowering of the water table	0.01	0.05	0.07	0.32	0.55	4
10. Diversion of resources to reclamation	0	0.09	0.09	0.49	0.33	7

The consequences of land degradation on people in the study area were categorized into the following: increased landlessness; lower incomes; increased labour requirements; and lower and less reliable food supplies. The study established that lower and less reliable food supplies was the most serious outcome of land degradation in the study area. This might be due to reduced productivity as a result of land degradation. The other considered consequences of land degradation on people

could be ranked as follows: lower incomes (2); increased labour requirements (3); and increased landlessness (4) as it is in Table 4.7.

Table 4.7: Consequences of land degradation on livelihood in Kasikeu Division

CONSEQUENCES OF LAND DEGRADATION	RANKING					ORDER
	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	
1. Increased landlessness	0.05	0.16	0.05	0.24	0.49	4
2. Lower incomes	0.00	0.03	0.03	0.25	0.69	2
3. Increased labour requirements	0.03	0.07	0.05	0.33	0.52	3
4. Lower and less reliable food supplies	0.01	0.03	0.00	0.31	0.65	1

Partial correlations were used to assess the significance of relationship between land degradation level and the consequences of land degradation in the study area. According to the survey data obtained from this study, the correlation between land degradation and decline in crop yields is 78.25% ($p = 0.000$). This high correlation may be attributed to devastation caused by land degradation of the potential of farmlands to produce crops in the study area.

The correlation between land degradation and morphological irregularities is 41.16% ($p = 0.312$). Land degradation and lowering of water table correlation is 71.96% ($p = 0.001$). This lowering of water table provides an incentive for households to excavate deeper to obtain ground water. The study established that land degradation correlates at 45.81% ($p = 0.448$) with total abandonment of land. This may be because of the possibility to abandon land as a result of severe degradation. The study assessed the correlation between increased inputs use and land degradation, which was observed to be 73.85% ($p = 0.000$). This may be as a result of loss of top soil to erosion hence necessitating increased demand for fertilizer application. The correlation between reduced response to inputs and land degradation was observed to be 68.29% ($p =$

0.002). This may be explained by excessive leaching of the soils hence making the dose-response low, and thus lowering yields.

The reduced productivity on irrigated land was observed to correlate at 63.11% ($p = 0.012$) to land degradation in the study area. This may be partly attributed to a decline in the amount of water available for crop production through irrigation. According to the study results, the loss of flexibility in land management was correlated to land degradation at 50.46% ($p = 0.911$). This may involve high cost required in rehabilitation of wasteland as a result of land degradation. The correlation between land degradation and loss of water for irrigation is 71.83% ($p = 0.003$) according to the study results. This may be explained by a drastic drop in water table around the degraded areas included in this research. The diversion of resources to reclamation and land degradation are correlated at 66.42% ($p = 0.010$). This is explained by the high cost required for reclamation of land.

The results from this study showed that increased landlessness was correlated to land degradation at 43.42% ($p = 0.095$). The relationship may be as a result of much arable land which goes to waste due to land degradation (Plate 4.4 and 4.5). According to the survey data from this study, lower food supplies is correlated to land degradation at 77.58% ($p = 0.000$). Since as land degradation increases in farms the soils are rendered unproductive, food supplies from the affected areas are greatly compromised. There is 69.47% ($p = 0.001$) correlation between increased labour requirements and land degradation in the study area. This may be attributed to a lot of effort needed in order to rehabilitate waste and unproductive lands. The high labour requirement is mainly to construct soil conservation structures, especially across the steep slopes where some farmers have invested in crop husbandry. Based on the

results obtained from this study, lower income correlates with land degradation at 66.75% ($p = 0.010$). Since low crop yields and high cost of conservation are significant engagements in the study area, this correlation is justifiable.

Table 4.8: Partial correlations for consequences of land degradation in Kasikeu Division, Makeni District, Kenya

Variable	Correlation	Significance
1. Decline in crop yields	0.7825	0.000
2. Morphological irregularities	0.4116	0.312
3. Lowering of the water table	0.7196	0.001
4. Total abandonment of land	0.4581	0.448
5. Increased inputs and greater costs	0.7385	0.000
6. Reduced responses to inputs	0.6829	0.002
7. Reduced productivity on irrigated land	0.6311	0.012
8. Loss of flexibility in land management	0.5046	0.911
9. Loss of water for irrigation	0.7183	0.003
10. Diversion of resources to reclamation	0.6642	0.010
11. Increased landlessness	0.4342	0.095
12. Lower and less reliable food supplies	0.7758	0.000
13. Increased labour requirements	0.6947	0.001
14. Lower incomes	0.6675	0.010



Plate 4.5: Severe land degradation in Mang'ethe village of Mumela location in Kasikeu Division, Makueni County, Kenya

Researcher: 01/12/2010

4.7 Summary

According to this study, it is clear that land degradation is a serious environmental issue and is largely as a result of land mismanagement. Unsustainable human activities, some taking place in already fragile areas lead to the loss of many significant ecosystem services resulting into land degradation and desertification. This has long lasting impacts on rural people who become more vulnerable (Eswaran *et al.*, 2006; Muchena, 2008). The most significant impact of land degradation is reduced land productivity leading to food insecurity (UNCCD, 2012). Land degradation bears long-term environmental externalities to which people in marginal lands are

especially vulnerable (UNEP 2004). Unless this problem of land degradation is addressed, the environment will be rendered unproductive and the growing food demand as a result of increased population will not be met. People will therefore continue to live in poverty and this will be a challenge to achieving the Millennium Development Goals.

5.2 Key recommendations

Based on the findings, the study recommends the following:

- There is need for the Government of Kenya to support and encourage small scale farmers and to provide them with credit facilities and access to their efficient and productive technologies.
- Conservation techniques such as crop rotation, mulching and cover crops should be assessed and encouraged.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

There is widespread environmental degradation in Kasikeu Division. This is evidenced by the presence of various land degradation indicators which include rills, gullies, pedestals, armour layers, accumulation of soil around clumps of vegetation, soil deposits on gentle slopes, exposed roots, muddy flows during the rainy seasons, sedimentation in rivers, sandy layers, barren ground, change in vegetation, organic matter loss, increased runoff, reduced soil water and reduced rooting depth. Land degradation in Kasikeu Division is heavily influenced by human activities. This is because people in the area directly depend on the environment for their survival and unsustainable harvesting of these environmental resources has led to land degradation. Consequently, land degradation has negatively affected the livelihood of the people in Kasikeu Division. This is through reduced crop production leading to food insecurity, reduced availability of water, increased landlessness and lower incomes and this has seriously harboured economic growth in the area.

5.2 Recommendations

Based on the findings, this study recommends the following:

- There is need for the government of Kenya to enforce policies that aim at controlling and preventing land degradation. These policies should be predictable, credible and reliable and should be reviewed regularly in order to ensure their efficiency and effectiveness in the process of combating land degradation
- Soil conservation technologies known to work in severely degraded lands should be assessed and evaluated with a view to exploring the possibility of

transferring and implementing them in other areas with similar settings particularly in Kasikeu Division.

- The government of Kenya should provide support through the Ministry of Agriculture for farmers to be able to access affordable technologies for soil conservation in the steep slopes.
- There is a need for the government of Kenya to promote land-use systems that provide permanent vegetative cover to protect the soil and increase fertility.
- Local initiatives should be encouraged especially through the involvement of small scale farmers, local groups and local institutions for combined efforts towards prevention of the problem of land degradation.
- There is a need for long-term training programmes on soil conservation among the farmers in Kasikeu Division. This will provide the necessary continuity approach in sustainable management of arable lands in the study area.
- Agroforestry should also be practised for sustainable agricultural land management
- Afforestation and reforestation programmes should be implemented in order to control deforestation. Where possible, incentives should be given to farmers that properly manage their pieces of land in order to encourage sustainable agricultural practices.
- The community should be sensitized on the importance of controlled grazing in order to ensure that the environment's carrying capacity is not exceeded.
- Enforcement of all environmental laws by the government of Kenya should be ensured to stop environmental degradation and enhance sustainable harvesting and utilization of natural resources.

- All open access resources should be protected from over exploitation in order to avoid tragedy of the commons
- There is need for further research to establish sustainable land use management options that are possible in Kasikeu Division. Research efforts among other arid and semi-arid lands (ASALs) which have similar problems of land degradation should be pooled together and the obtained research results shared by establishing simple research networks or by building a research component into existing networks thus benefiting a vast region in Kenya.

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APPENDICES

Appendix 1: Questionnaire

QUESTIONNAIRE: RESEARCH QUESTIONNAIRE ON ASSESSMENT OF PERCEPTIONS TOWARDS LAND DEGRADATION IN KASIKEU DIVISION, MAKUENI COUNTY, KENYA

Dear Respondent,

I am a postgraduate student in the School of Environmental Studies in Kenyatta University. In partial fulfilment for the award of my master of environmental studies degree, I am collecting survey data to enable me compile a research thesis entitled: “AN ASSESSMENT OF PERCEPTIONS TOWARDS LAND DEGRADATION IN KASIKEU DIVISION, MAKUENI COUNTY, KENYA”. The results of this research will be used to make recommendations on how to confront the consequences of land degradation in Kasikeu Division. This is hoped to have a positive impact on the welfare of smallholder farmers in the division. The results from this study will be shared by publishing them in a scientific journal for students and researchers to use. The information provided will be treated with utmost confidentiality. You should not put your name on the questionnaire. I hope you will cooperate in this exercise.

Yours Sincerely,

VIRGINIA KAVUU MUIA (BSc.)

REG. NO: N50/10678/07

SECTION A: GENERAL INFORMATION

- 1) What is the gender of household head? Male () Female ()
- 2) What is the name of your location?
- 3) What is the name of your sub-location?
- 4) What is the name of your village?
- 5) What is your age? 15-25 () 25-35 () 35-45 () 45 and above ()
- 6) What is your source of income? Farm () Business () Employed ()
- 7) What is the level of your education? (tick where appropriate)
Never went to school () Primary education () Secondary education ()
Tertiary College () University ()
Others (Specify).....
- 8) What is the size of your family? (tick where appropriate)
1member () 2 members () 3 members () 4 members () 5 members ()
6 members () 7 members () 8 and above members ()
- 9) What is your house made of? (tick where appropriate)
Grass and mud () Bricks and grass () Mud and Iron sheets () Bricks and Iron
sheets () Timber/wood () others (specify) _____
- 10) What is the size of your farm? acres
- 11) State the period within which you have been farming in this land:
Between 1- 5years () between 6-10 years () 11-15 years ()
More than 15 years ()

SECTION B: HUMAN ACTIVITIES

1. What kind of activities do you engage in? Please tick where applicable

- a. Cultivation ()
- b. Grazing ()
- c. Charcoal burning ()
- d. Commercial firewood collection ()
- e. Timber collection ()
- f. Sand harvesting ()
- g. Others (specify)

2. If (a) above is applicable,

a) How do you cultivate?

- a. Along the contour ()
- b. Across the contour ()
- c. Shifting cultivation ()

b) What kind of farming do you practise?

- a. Mono cropping ()
- b. Inter cropping ()
- c. Mixed farming ()
- d. Crop rotations ()

c) Do you apply soil conservation measures? Yes () No ()

a. If Yes in (c) above, which soil conservation measures do you apply?

b. Are these soil conservation measures effective? Explain

d) Do you apply fertilizer or manure on your farm? Yes () No ()

a. If Yes in (d) above, it is effective in terms of yield?

Explain _____

SECTION C: DIRECT CAUSES OF LAND DEGRADATION

Please indicate the extent to which you agree or disagree with each of the following statements relating to direct causes of land degradation in Kasikeu Division.

Direct Causes of Land Degradation	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. Deforestation of unsuitable land	1	2	3	4	5
2. Overcutting of vegetation	1	2	3	4	5
3. Shifting cultivation without adequate fallow periods	1	2	3	4	5
4. Overgrazing	1	2	3	4	5
5. Non-adoption of soil-conservation management practices	1	2	3	4	5
6. Extension of cultivation onto lands of longer potential and/or high natural hazards	1	2	3	4	5
7. Improper crop rotations	1	2	3	4	5
8. Unbalanced fertilizer use	1	2	3	4	5
9. Problems Arising from Planning and Management of Canal Irrigation:	1	2	3	4	5
10. Over-pumping of Groundwater	1	2	3	4	5

SECTION D: UNDERLYING CAUSES OF DEGRADATION

Please indicate the extent to which you agree or disagree with each of the following statements relating to underlying causes of land degradation in Kasikeu Division.

Underlying causes of Degradation	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. Land Shortage	1	2	3	4	5
2. Land tenure tenancy and open access resources	1	2	3	4	5
3. Poverty	1	2	3	4	5
4. Population increase	1	2	3	4	5

SECTION E: LAND DEGRADATION INDICATORS

Please indicate the extent to which you agree or disagree with each of the following statements relating to land degradation indicators in Kasikeu Division.

1. The indicators of land degradation in Kasikeu Division are:

Land degradation indicators	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. Rills	1	2	3	4	5
2. Gullies	1	2	3	4	5
3. Pedestals	1	2	3	4	5
4. Armour layer	1	2	3	4	5
5. Accumulation of soil around clumps of vegetation or upslope of trees, fences, or other barriers	1	2	3	4	5
6. Deposits of soil on gentle slopes	1	2	3	4	5
7. Exposed roots or parent material	1	2	3	4	5
8. Muddy water/mudflows during and shortly after rains	1	2	3	4	5
9. Sedimentation in streams and reservoirs	1	2	3	4	5
10. Dust storms/clouds	1	2	3	4	5
11. Sandy layer on soil surface	1	2	3	4	5
12. Parallel furrows in clay soil or ripples in sandy soil	1	2	3	4	5
13. Bare or barren spots	1	2	3	4	5
14. Efflorescence	1	2	3	4	5
15. Changes in vegetation species	1	2	3	4	5
16. Decrease in organic matter (lighter coloured soils)	1	2	3	4	5
17. Increased run off	1	2	3	4	5
18. Reduced soil water	1	2	3	4	5
19. Restricted rooting depth					

SECTION F: CONSEQUENCES OF LAND DEGRADATION

Please indicate the extent to which you agree or disagree with each of the following statements relating to the consequences of land degradation in Kasikeu Division.

1. The consequences of land degradation on production in Kasikeu Division includes:

Consequences of Degradation	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
15. Decline in crop yields	1	2	3	4	5
16. Increased incidence of plant disease/morphological irregularities (e.g. stunting)	1	2	3	4	5
17. Lowering of the water table	1	2	3	4	5
18. Total abandonment of land	1	2	3	4	5
19. Increased inputs and greater costs	1	2	3	4	5
20. Reduced responses to inputs	1	2	3	4	5
21. Reduced productivity on irrigated land	1	2	3	4	5
22. Loss of flexibility in land management	1	2	3	4	5
23. Loss of water for irrigation	1	2	3	4	5
10. Diversion of resources to reclamation	1	2	3	4	5

2. The consequences of land degradation on people in Kasikeu Division includes:

Consequences of Degradation	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. Increased landlessness	1	2	3	4	5
2. Lower and less reliable food supplies	1	2	3	4	5
3. Increased labour requirements	1	2	3	4	5
4. Lower incomes	1	2	3	4	5

Appendix 2: Coded research data

GENERAL INFORMATION

	gender	age	income	education	Family size	Farm size	Farming period
1	male	64	Farm	Secondary	8	10	>15years
2	male	53	Employed	Secondary	8	5	11-15years
3	male	36	Employed	Tertiary	4	6	6-10years
4	female	44	Employed	Secondary	6	3	11-15years
5	male	58	Business	Secondary	8	2	>15years
6	female	45	Employed	Secondary	8	2	6-10years
7	male	35	Employed	Tertiary	5	2	6-10years
8	male	40	Business	Tertiary	4	2	<6years
9	male	45	Employed	Tertiary	8	3	>15years
10	male	47	Employed	Secondary	8	2	>15years
11	male	57	Employed	Tertiary	7	1	>15years
12	male	53	Business	Tertiary	7	4	11-15years
13	male	28	Business	Tertiary	3	2	11-15years
14	female	32	Employed	Secondary	3	1	6-10years
15	male	30	Farm	Secondary	2	3	>15years
16	male	49	Employed	Tertiary	8	15	>15years
17	male	40	Employed	Tertiary	4	8	>15years
18	male	42	Employed	Tertiary	5	2	>15years
19	male	43	Employed	Tertiary	8	3	>15years
20	male	52	Employed	Tertiary	7	4	>15years
21	male	44	Employed	Tertiary	5	3	>15years
22	female	42	Employed	Secondary	5	3	>15years

23	male	46	Employed	Secondary	7	3	>15years
24	male	61	Employed	Secondary	7	10	>15years
25	male	32	Employed	Secondary	8	0.5	>15years
26	male	26	Employed	Tertiary	8	4	>15years
27	male	50	Employed	Secondary	5	1	>15years
28	male	47	Farm	Secondary	8	1.5	11-15years
29	male	48	Farm	Primary	7	2	6-10years
30	male	42	Employed	University	4	5	>15years
31	male	57	Farm	Secondary	7	3	>15years
32	male	41	Farm	Secondary	8	2	>15years
33	male	49	Farm	Tertiary	7	2	11-15years
34	female	62	Employed	Tertiary	6	10	>15years
35	female	62	Farm	No school	8	10	>15years
36	male	45	Business	Primary	8	5	6-10years
37	female	47	Employed	Tertiary	4	6	>15years
38	female	44	Employed	Secondary	7	3	11-15years
39	male	58	Business	Tertiary	8	2	>15years
40	female	40	Employed	University	6	2	11-15years
41	male	40	Farm	Secondary	5	2	<6years
42	male	45	Employed	Tertiary	7	2	<6years
43	female	55	Farm	No school	8	3	>15years
44	female	47	Business	Primary	6	2	11-15years
45	male	58	Employed	Tertiary	8	1	>15years
46	female	53	Business	Secondary	5	4	>15years
47	female	41	Employed	Tertiary	3	2	6-10years
48	female	40	Business	Primary	3	1	11-15years
49	male	47	Farm	Primary	4	3	>15years

50	male	65	Farm	No school	8	15	>15years
51	male	56	Employed	Secondary	7	8	11-15yea
52	female	66	Farm	No school	5	2	>15years
53	male	52	Employed	Secondary	6	3	>15years
54	male	46	Business	Secondary	4	4	>15years
55	female	44	Business	Secondary	8	3	>15years
56	female	42	Business	Primary	8	3	11-15years
57	male	53	Employed	University	8	3	>15years
58	female	63	Farm	No school	7	10	>15years
59	male	70	Farm	No school	8	1	>15years
60	male	29	Employed	University	8	4	<6years
61	female	49	Employed	Secondary	5	1	11-15years
62	male	68	Farm	No school	7	1.5	>15years
63	male	48	Business	Secondary	4	2	11-15years
64	male	42	Employed	Tertiary	8	5	>15years
65	female	43	Employed	Tertiary	6	3	11-15years
66	male	41	Farm	Primary	4	2	>15years
67	male	47	Farm	Primary	7	2	6-10years
68	male	58	Employed	Tertiary	8	10	>15years
69	female	53	Farm	Primary	8	2	>15years
70	male	70	Farm	No school	8	16	>15years
71	female	47	Employed	Tertiary	6	3	11-15years
72	male	76	Farm	No school	8	14	>15years
73	female	44	Business	Secondary	6	3	11-15years
74	male	49	Farm	Tertiary	7	2	11-15years
75	female	41	Employed	Tertiary	6	2	6-10years

INDICATORS OF LAND DEGRADATION

	rills	gullies	pedestals	Armour layer	Soil accumulation	Soil deposits	Exposed roots	mudflows	sedimentation	Dust storms	Sandy layers	Furrows and ripples	Barren spots	Vegetation change	Organic matter loss	Runoff increase	Reduced soil water	Rooting depth
1	4	5	2	2	4	2	4	4	5	5	4	2	1	4	2	1	2	5
2	4	4	3	3	3	4	4	4	4	4	4	3	4	2	4	4	4	3
3	4	4	4	4	4	5	5	5	5	4	4	5	4	4	5	5	4	4
4	4	5	1	2	1	1	4	2	4	1	4	2	4	5	4	5	4	5
5	4	5	2	5	1	3	4	4	5	4	4	4	4	4	1	1	4	4
6	4	4	3	3	3	3	4	3	3	4	2	2	2	4	4	4	4	4
7	5	5	2	3	2	2	5	5	5	5	5	5	5	5	2	5	5	4
8	4	2	4	3	4	4	4	2	2	4	4	4	5	2	4	4	4	5
9	4	3	4	4	5	4	5	4	5	2	5	5	3	5	5	3	5	4
10	5	5	5	4	3	4	5	3	3	1	5	4	5	5	4	5	4	3
11	5	4	4	3	4	4	4	5	4	4	4	4	4	4	4	5	5	4
12	3	1	5	4	5	5	5	5	5	1	2	2	4	5	5	5	5	3
13	3	3	1	5	4	5	5	5	5	4	2	4	5	5	5	4	5	5
14	2	5	1	1	1	5	5	5	5	2	1	5	5	5	5	5	5	2
15	2	5	1	1	1	5	5	5	5	5	1	5	5	4	5	5	5	2
16	4	5	3	3	5	5	4	5	5	4	4	2	5	4	4	4	5	4
17	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
18	5	4	3	4	3	4	4	4	2	1	4	5	2	4	5	3	4	4
19	5	5	4	4	4	4	5	4	4	2	4	4	4	4	4	5	5	4
20	5	5	4	4	4	4	4	4	4	1	4	4	4	4	4	5	5	4
21	4	5	3	3	4	4	5	4	4	2	4	4	5	2	4	4	5	4
22	4	5	3	3	4	4	5	4	4	2	4	4	5	2	4	4	5	4
23	4	5	3	3	3	3	3	3	2	4	4	3	3	3	4	3	4	3
24	4	4	3	3	4	5	4	5	5	4	4	4	5	4	3	5	5	3
25	5	3	3	4	4	4	5	5	4	1	5	4	3	3	5	4	3	5

26	4	4	2	2	4	4	5	4	4	2	4	4	5	4	4	5	5	3
27	4	4	3	4	4	5	5	4	5	2	5	4	5	5	4	5	4	4
28	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4
29	4	4	4	4	4	4	4	4	4	1	4	4	4	4	4	4	4	4
30	4	4	3	4	4	4	3	4	4	3	2	2	3	4	4	4	3	2
31	4	5	3	3	4	5	5	5	5	1	5	5	5	2	1	5	2	3
32	4	5	3	4	4	5	5	5	5	4	5	3	5	5	5	5	3	5
33	5	5	3	5	5	5	5	5	5	2	5	5	5	5	5	5	5	5
34	5	5	3	3	3	3	5	4	4	2	3	3	5	4	4	5	1	3
35	4	5	4	2	4	2	4	4	5	1	4	5	5	4	1	1	2	5
36	4	3	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4
37	4	4	3	4	4	5	5	5	5	3	5	5	5	2	5	4	3	4
38	5	2	1	2	1	1	4	4	4	1	4	2	4	5	4	5	4	5
39	4	5	5	5	4	3	5	4	5	2	5	4	2	1	4	1	5	4
40	5	4	3	4	4	4	4	3	4	1	2	2	2	5	4	5	4	5
41	5	5	4	3	2	2	5	5	5	2	5	5	5	5	2	5	5	4
42	4	4	4	3	4	3	4	4	2	4	2	4	5	5	4	3	4	5
43	4	3	1	4	5	4	5	4	5	5	4	5	4	5	5	1	5	4
44	5	5	5	4	3	4	5	3	3	3	5	4	5	5	4	5	4	3
45	5	4	4	3	4	4	4	5	4	2	3	5	4	4	5	5	5	4
46	2	5	5	4	5	5	4	5	5	1	2	1	5	5	5	5	4	4
47	4	5	1	5	4	5	5	5	5	1	4	4	5	5	5	4	5	5
48	4	5	4	1	4	5	5	5	4	2	5	5	5	4	5	5	5	2
49	5	4	1	2	1	4	5	4	5	2	1	4	4	4	5	5	4	4
50	3	4	3	3	5	4	4	5	5	4	4	2	4	5	5	4	5	4
51	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	2	5	5
52	4	3	4	4	3	4	4	5	5	1	3	1	5	4	4	3	4	4
53	5	4	4	4	4	5	5	4	4	1	4	4	4	2	4	4	3	2

54	5	3	4	4	5	4	4	4	4	2	2	4	4	5	5	5	5	4
55	4	5	3	3	4	3	5	5	5	1	4	3	5	5	4	5	5	5
56	4	4	3	2	4	4	5	4	4	2	4	4	4	2	5	4	4	4
57	5	4	3	5	3	3	4	3	2	1	4	5	3	4	4	3	4	3
58	4	4	3	3	4	5	4	5	5	4	5	4	5	2	3	5	5	4
59	5	3	3	4	4	5	5	5	4	1	5	4	5	3	4	4	5	5
60	3	4	4	2	4	4	5	5	3	2	4	5	5	4	4	5	5	3
61	4	4	3	4	4	5	5	4	5	2	4	4	5	5	2	5	4	4
62	4	5	4	4	4	4	4	5	4	1	5	1	4	4	4	4	4	3
63	4	5	4	4	5	2	4	5	4	1	4	4	4	5	5	4	4	4
64	2	4	3	4	5	4	5	4	4	3	5	2	5	2	4	5	5	2
65	4	5	4	3	4	5	4	5	3	4	5	5	5	4	1	5	2	4
66	4	4	3	4	4	4	5	5	5	5	4	3	4	5	4	5	3	5
67	5	5	5	5	3	5	5	5	4	2	5	5	5	5	5	4	5	5
68	4	4	5	4	2	4	4	4	4	1	4	2	4	4	4	5	4	5
69	5	5	3	5	5	5	5	5	5	2	5	5	5	5	5	5	5	5
70	5	3	3	4	4	5	5	5	4	1	5	4	5	3	4	4	5	5
71	5	5	5	4	3	4	5	3	3	3	5	4	5	5	4	5	4	3
72	4	4	3	4	4	5	5	4	5	2	5	4	5	5	4	5	4	4
73	4	5	1	2	1	1	4	2	4	1	4	2	4	5	4	5	4	5
74	5	5	3	5	5	5	5	5	5	2	5	5	5	5	5	5	5	5
75	2	5	1	1	1	5	5	5	5	2	1	5	5	5	5	5	5	2

CAUSES OF LAND DEGRADATION

	Land shortage	Open access resources	Poverty	Population density	Deforestation	Clearing vegetation	Shifting cultivation	Overgrazing	Technology adoption	Steep slopes cultivation	Improper crop rotation	Fertilizer use	Ground water
1	4	2	5	4	4	4	2	4	5	2	3	5	4
2	4	4	4	4	4	4	4	4	4	4	4	4	2
3	4	4	4	4	2	5	2	2	4	4	4	4	1
4	2	3	1	4	5	2	2	5	2	1	1	2	2
5	4	4	4	4	4	5	2	5	4	5	4	2	4
6	4	4	4	4	2	2	4	4	4	4	4	4	3
7	5	2	5	3	2	5	4	4	4	1	4	4	2
8	4	2	5	5	4	5	2	5	2	2	1	1	1
9	5	1	5	5	4	4	5	5	4	3	4	5	1
10	5	2	5	4	2	5	4	3	4	5	5	5	4
11	4	3	4	4	5	5	4	5	5	5	4	5	2
12	5	1	5	5	4	4	1	4	3	4	4	5	5
13	5	4	5	5	4	4	1	4	2	4	4	4	4
14	2	2	5	4	2	3	1	2	5	4	2	3	1
15	4	1	5	5	5	5	1	2	2	1	5	5	1
16	5	4	2	5	5	5	5	5	5	5	5	5	5
17	5	5	5	5	4	4	5	5	5	5	5	5	5
18	4	4	5	4	5	5	4	4	4	3	4	4	2
19	5	4	5	5	5	5	4	2	5	3	4	5	3
20	5	3	5	5	5	5	4	2	5	3	4	5	3
21	4	4	5	5	5	5	4	4	5	3	4	4	2
22	4	4	5	5	5	5	4	4	5	3	4	4	2
23	5	3	4	3	5	5	5	4	3	4	4	4	3
24	4	2	5	5	1	1	1	1	2	2	1	2	3
25	3	5	5	4	5	3	5	5	5	5	5	3	4

26	4	4	4	2	2	4	1	2	2	3	4	3	3
27	4	2	5	4	5	4	5	4	4	4	4	5	5
28	4	4	5	4	4	4	4	3	4	4	4	4	4
29	4	4	5	4	4	4	4	3	4	4	4	4	4
30	2	4	4	4	5	4	5	5	4	3	3	3	3
31	5	2	5	2	5	5	5	5	5	5	2	1	5
32	5	5	4	4	5	5	5	5	5	5	5	2	2
33	5	5	5	5	5	5	3	5	5	3	5	5	5
34	5	4	4	5	5	5	4	5	5	4	4	5	4
35	4	1	5	4	4	4	4	5	4	5	4	4	5
36	5	4	5	5	4	5	4	4	5	4	1	4	1
37	4	5	4	4	2	5	2	2	4	5	4	5	2
38	2	3	1	2	5	2	4	5	5	1	4	2	2
39	4	4	4	4	4	4	5	4	4	4	4	5	3
40	5	4	5	4	2	2	2	4	5	4	5	4	4
41	5	1	5	5	4	5	4	5	4	1	1	3	2
42	4	2	5	5	4	4	2	1	2	5	4	1	1
43	3	4	4	5	4	5	5	5	4	4	4	5	2
44	5	2	5	4	3	5	4	4	4	5	4	5	4
45	5	4	4	5	5	5	4	4	5	4	5	3	2
46	5	1	5	5	4	4	1	5	4	4	4	5	3
47	4	4	4	5	1	5	4	4	2	5	2	4	4
48	2	2	5	4	2	5	2	1	5	4	4	5	4
49	3	3	5	5	5	5	4	2	2	5	5	5	1
50	5	4	4	4	4	5	5	4	4	5	4	5	5
51	5	5	5	5	4	4	4	5	5	4	5	4	2
52	4	4	5	4	4	5	4	4	4	3	3	4	2
53	5	5	5	5	5	5	5	5	5	5	4	5	3

54	4	3	5	4	5	5	4	2	4	5	5	5	4
55	4	5	4	5	4	4	5	4	5	5	4	4	2
56	5	4	5	5	5	5	4	3	5	3	3	5	2
57	5	4	4	5	5	5	5	4	5	4	4	4	4
58	5	2	5	5	1	4	5	1	2	5	5	4	3
59	3	4	5	4	5	3	4	5	5	4	5	3	4
60	5	4	4	2	3	4	4	5	2	3	4	3	3
61	4	1	5	3	5	5	1	4	4	4	5	5	5
62	4	4	5	4	4	5	4	3	5	5	4	2	4
63	4	5	1	5	5	5	2	5	4	4	3	4	1
64	3	4	4	5	5	4	5	5	5	5	4	3	3
65	5	1	5	5	4	5	4	4	5	3	5	1	4
66	4	5	4	4	5	5	5	5	4	5	5	5	2
67	5	3	5	5	5	5	4	5	5	3	4	5	5
68	1	4	5	4	4	5	5	4	4	5	5	4	4
69	5	5	5	5	5	5	3	5	5	3	5	5	5
70	3	4	5	4	5	3	4	5	5	4	5	3	4
71	5	2	5	4	3	5	4	4	4	5	4	5	4
72	4	2	5	4	5	4	5	4	4	4	4	5	5
73	2	3	1	4	5	2	2	5	2	1	1	2	2
74	5	5	5	5	5	5	3	5	5	3	5	5	5
75	2	2	5	4	2	3	1	2	5	4	2	3	1

CONSEQUENCES OF LAND DEGRADATION

	Crop yields	Morphological irregularities	Water table	Land abandonment	Production cost	Input response	Reduced productivity	Land flexibility	water loss	Reclamation	Landlessness	Food insecurity	Labour requirement	Lower income
1	3	4	5	4	2	4	4	5	5	1	2	5	4	5
2	2	4	4	4	4	4	4	4	4	4	4	4	4	4
3	1	5	4	5	2	4	4	4	4	5	5	4	4	4
4	1	5	2	4	2	1	4	2	5	2	2	2	5	2
5	2	5	4	5	1	5	2	4	4	4	4	2	5	5
6	3	4	4	4	4	4	4	5	1	5	5	5	5	5
7	2	4	4	4	2	5	5	5	5	5	5	3	5	5
8	5	4	4	4	2	2	4	2	4	5	2	2	4	5
9	1	5	5	5	5	4	5	4	4	5	3	5	5	5
10	2	5	4	4	5	4	5	5	5	5	5	5	5	2
11	1	4	4	5	4	4	4	4	3	4	3	5	5	4
12	5	5	5	5	1	5	4	3	3	3	4	5	5	4
13	4	5	5	5	1	5	4	3	3	3	4	5	5	4
14	3	5	5	5	5	1	3	3	4	4	5	5	5	3
15	2	5	5	5	1	3	3	4	4	5	5	5	5	3
16	2	5	5	5	2	5	5	5	3	5	5	3	5	5
17	5	4	4	5	4	4	5	4	4	5	4	4	5	4
18	2	4	4	5	5	4	4	4	4	5	4	4	4	5
19	2	5	5	5	5	5	4	5	4	5	4	5	5	5
20	2	5	5	5	5	5	4	5	4	5	4	5	5	5
21	2	5	4	5	4	4	4	5	4	5	4	5	5	5
22	2	5	4	5	4	4	4	5	4	5	4	5	5	5
23	1	4	2	3	3	4	3	2	3	3	3	4	5	4
24	2	5	5	5	2	5	4	2	5	4	4	2	2	5

52	4	5	5	2	5	4	3	2	3	5	5	5	5	5
53	1	5	4	5	4	5	4	5	4	5	4	5	5	5
54	3	5	5	5	5	5	5	5	5	3	5	5	4	5
55	2	4	4	4	2	4	4	4	4	5	4	4	5	4
56	4	5	4	5	4	5	4	5	4	5	5	5	5	5
57	1	4	5	5	5	4	5	4	4	4	3	4	5	4
58	2	5	5	5	2	5	4	4	5	4	4	2	2	5
59	5	5	5	5	4	4	3	3	3	5	4	1	5	4
60	4	5	4	5	4	5	4	4	4	4	4	5	5	4
61	2	5	5	4	5	4	5	2	5	5	4	4	4	5
62	3	4	4	4	4	4	4	4	4	4	5	4	4	4
63	4	5	5	5	4	4	2	5	4	5	4	4	5	4
64	3	2	4	4	4	3	4	3	5	4	3	5	3	5
65	1	5	2	5	3	5	4	4	4	5	4	1	5	1
66	2	5	5	5	2	5	5	5	5	4	4	4	4	5
67	5	4	4	5	4	5	4	5	4	5	4	5	5	5
68	4	5	4	4	4	4	5	4	4	4	5	5	4	4
69	5	5	5	5	3	5	5	5	5	5	5	5	5	5
70	5	5	5	5	4	4	3	3	3	5	4	1	5	4
71	2	4	5	4	5	4	5	5	5	5	5	2	4	2
72	2	5	5	5	2	4	4	2	4	4	4	2	4	5
73	1	5	2	4	2	1	4	2	5	2	2	2	5	2
74	5	5	5	5	3	5	5	5	5	5	5	5	5	5
75	3	5	5	5	5	1	3	3	4	4	5	5	5	3

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