

**ECONOMIC ANALYSIS OF CLIMATE CHANGE ADAPTATION STRATEGIES  
AT COMMUNITY FARM-LEVEL IN IJARA, GARISSA COUNTY, KENYA**

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## DECLARATION

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This thesis is my original work and has not been presented for a degree or award in any other university

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## **DEDICATION**

This thesis is dedicated to Winnie and Helen and to all their age mates. Decisions made today on sustainable adaptation to impacts of climate change and variability mean much more to them.

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## LIST OF ACRONYMS AND ABBREVIATIONS

ALRMP	Arid Lands and Resource Management Project
AMU	Aloe Management Units
ASALs	Arid and Semi-Arid Lands
AR	Assessment Report-IPCC
BAU	Business as Usual
CBA	Cost Benefit Analysis
CBR	Cost Benefit Ratio
CEPS	Centre for European Policy Studies
CORDEX	Coordinated Regional Downscaling Experiment
CVM	Contingent Valuation Method
DM	Dry matter
EWT	Emergency Water Trucking
FFS	Farmers' Field Schools
GDP	Gross Domestic Product
GHG	Green House Gas
I&FF	Incremental Investment and Financial Flows
ICPAC	IGAD Climate Prediction and Applications Centre
IDRC	International Development Research Centre (Canada)
IPCC	Intergovernmental Panel for Climate Change
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
KACCAL	Kenya Adaptation to Climate Change in Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KU	Kenyatta University
KWS	Kenya Wildlife Service
MCA	Multiple Criteria Analysis
NAPAs	National adaptation programmes of action
NCCRS	National Climate Change Response Strategy
NPV	Net Present Value

NWP	Nairobi Work Program
RCMs	Regional Climate Models
UNFCC	United Nations Framework for Climate Change

## DEFINITION OF KEY TERMS

Adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects
Adaptation benefits	Benefits accrued after the adoption and implementation of adaptation options or avoided damage costs
Adaptation costs	Costs of planning, preparing for, facilitating and implementing adaptation measures, including transition costs
Adaptation deficit	Failure to adapt sufficiently to existing climate risks largely accounts for the adaptation deficit
Climate Variability	Divergence of climate statistics over a given period of time
Adaptive capacity	using existing resources to achieve different benefits throughout and proximately after uncommon, irregular and hostile conditions of a disaster occurrence or process
Net Present Value	The difference between the discounted value of the future benefits and costs related to a project, calculated at a required rate
Internal Rate of Return:	The break-even discount rate at which the present value of project's benefits equals the present value of its costs. The higher the internal rate of return, the more economically attractive the project
Cost Benefit Ration	The ratio between the present value of a project's benefits and the present value of its costs. The higher the cost-benefit ratio, the more economically viable the project, as it means that it is earning more than the required rate of return
Vulnerability	The rate at which systems affected by climate change are susceptible to and unable to cope with adverse impacts
Resilience	Amount of change a system can undergo without changing state (in reference to natural systems).

## ABSTRACT

The semi-arid Ijara sub-county borders Fafi sub-county to the north, Lamu and Tana River counties to the south and west respectively and republic of Somalia to the east. It occupies agro-ecological zones IV to VI, that change to V and VI, moving away from Boni forest with an estimated 1000km<sup>2</sup> arable land suitable for crop agriculture. Temperatures range 15°C – 38°C with average relative humidity 68%. Rainfall data from Kenya Met Services 1970-2008 indicated shift from the traditional trend to erratic and definite decline. However recent predictions across models showed positive rise in both precipitation and temperature year 2030 onwards along the coastal belt where study sites locate. But, the high temperature-induced evapotranspiration annul gains from rainfall increases. The climatic changes expose the area to shocks arising from frequent drought and flooding. Given the shocks that outwit traditional coping mechanisms, farmers spontaneously took to water harvesting pans, Aloe crop and pasture enterprises as adaptation strategies. The spontaneity translated into unclear costs and benefits which the study clarified by isolating them for analysis and measuring the strategies' viability for adaptation. Significance of the assessment was reduction of existing data scarcity and informing climate-smart agriculture productivity and realization of the most valuable policy results. Costs-benefit-analysis was the design used, complemented by the financial market-driven 15% discounting rates and net present values. Also co-ordinated regional downscaling experiment models were used to ascertain climate performance and projection. Household questionnaire was administered to 240 sample size calculated from 9000 farmer population. Based on the sample size, households in Handaro, Sangole-Ijara and Bothai were randomly selected for interview. Results showed 57% pastoralists had embraced agro-pastoralism to incorporate Aloe, and on-farm rain-fed Sudan grass, whose input costs were Kshs 120,000/ha/season with estimated yields of 1.8 tons/ha of dry matter. Cash flow across three rain-fed seasons netted Kshs 1,925,091, 4,069,234.55 and 6,103,851.83 per hectare from one, two and three seasons respectively. Overall net present value was Kshs 180,041p.a. Equal to 50.5% agro-pastoralists produced fodder that cushioned against the high costs on inter-county importation. Land size inadequacy and the communal tenure upset 86.26% producers whereas 47.5% were concerned that drought raised production costs the most after that lack of skills 53.08%, feed deficit at 30.41%, and diseases 20.41% in that order. Aloe crop netted Kshs 37,500/ha/season. The benefits compared favorably with investment of Kshs 125,000/ha given that some capital costs e.g. fencing were one-off. Annual water pan cash flow netted present value Kshs 512,349.25. Overall benefits from the three strategies exceeded costs, making the investment viable for adaptation. Going forward and considering the limited adaptation capacities, disease control and feed deficit costs, policies need to focus on formulating livestock improvement guidelines to include revitalizing traditional grazing management practices. Other pertinent investment opportunities include strategic value-chain linkages and infrastructure, promotion of rain-fed and irrigated fodder production technologies incorporating climate-smart water harvesting. Equally crucial is enriched soil stabilization using multi-benefits crops e.g. Aloe, supporting post-harvest feed reserves technologies, reviewing land tenure system and investing in local farmer-friendly weather data collection and application.

## CHAPTER ONE: INTRODUCTION

### 1.1 Background of the Problem

Agricultural productivity depends directly on climatic conditions that expose the sector to impacts of climate change and variability which increase adaptation costs (EU, 2014). Historical daily temperature records and long term trend analysis globally and in conformity with consensus across all models confirm that the world is warming (IPCC, 2014; Skiba, *et al.*, 2012). Substantial changes in physical and biological systems have already occurred on all continents with most of these changes pointing to increasing temperature (Brooks, 2014; Rosenzweig *et al.*, 2008). The rise in temperature predicted at 2- 4°C by the turn of 2100 century herald dramatic impacts in vital sectors, chiefly agriculture, increasing costs of adaptation with likely strong effects on the already vulnerable regions and communities (Cooper *et al.*, 2012). Moreover, the extreme weather events are likely to become both more frequent and more severe. At a warming rate exceeding 3°C, virtually all of the present maize, millet, and sorghum farmlands in sub-Saharan Africa could become unviable, thereby escalating economic costs and uncertainty related to climate change (Schaeffer, *et al.*, 2014). For instance, the fact that over 80% of employment and 30 % of Africa GDP is supported by rain fed agriculture exposes the continent more so the arid and semi-arid lands (ASALs) to the risks of high seasonal rainfall variability and costs associated with rising temperature (Calzadilla *et al.*, 2010; Commission for Africa, 2005; Tumbo *et al.*, 2012).

The risks expose the ASALs in sub-Saharan Africa to the challenge of having to contend with exponential costs occasioned by unreliable, highly variable, and scarce rainfall for their livestock and crop production (Cooper *et al.* 2011; Bhatt *et al.* 2006; Tol *et al.*, 1998). Apart from high costs of production, temperature for instance, affect the cropping pattern and type of livestock kept whereas rainfall amount, distribution, reliability and intensity determine the crops grown, livestock kept and soil treatment required (Obanyi *et al.*, 2009; Jaetzold and Schmidt,1983). Consequently, when climate change affects temperature, rainfall, land, energy and wind, it ravages the very core of economic

productivity benefits and increases costs of adaptation astronomically. However, as much as the impacts are ravaging, they provide opportunities and benefits from returns arising from implementation of climate-smart adaptation strategies.

Smit and Wandel (2006) affirms that climate change is a permanent shift in the normal patterns of climate, which may be due to natural and or human initiated processes and can be negative or positive. The positive and negative impacts differ from one adaptation option to the other and from region to region but increasingly, it has become clear that the anthropogenic element in the climate change supersede all other and the costs involved, dire. Whereas agriculture offers solution through adaptation and mitigation processes, it increases costs of adaptation by emitting two greenhouse gases (GHG): Methane and Nitrous oxide. Methane emanates from livestock digestion process and is stored in animal manure whereas nitrous oxide discharges from organic and mineral fertilizers (EU, 2014; Sere` 1996; Fischlin *et al.*, 2007).

Further, livestock farming, contributes to the most serious environmental deficits from deforestation, desertification, pollution, overuse of freshwater and emission of GHG (Janzen 2011; Steinfeld *et al.*, 2006). In Kenya climate change based on emissions is definite and intensifying alarmingly as evidenced by extreme and harsh weather with temperature rise, irregular and unpredictable rainfall due to variations across space and time, compounded by data scarcity thereby raising costs of socio-economic development (Figure 3.6; GoK, 2010, GoK, 2013; Fitzgibbon, 2012). The warming corresponds to the earth's increasing temperature at the rate of 0.85°C since 1850 with 1983 to 2012 being the warmest three decades ever for the last 1400 years (IPCC, 2014). In turn, these changes exacerbate increased costs, food insecurity, decline and change in vegetation cover and species. Also, the incessant below mean annual rainfall negatively impact on other rainfall dependent livelihoods thus increasing vulnerability shocks in key sectors, agriculture a case in point.

Costs of adaptation increasingly rise due to livestock systems and demand for livestock products in developing countries which are changing rapidly in response to a variety of

drivers to include rapid urbanization, natural resource base, markets and population increase. Globally, for instance, human population is expected to increase from the current 6.5 billion to 9.2 billion by 2050 with more than 1 billion of this increase occurring in Africa (Swift, 1988; Delgado *et al.*, 1999). These livestock-crop-poor people impacts require a mix of technological, policy and institutional innovations to include pasture feed, breeding and ecosystems management systems (Thornton *et al.*, 2009). This in effect mean that traditional coping strategies are no longer viable; which necessitated viable adaptation strategies like water harvesting pans, multiple-benefits Aloe crop and sustainable on-farm and natural pasture enterprises.

Traditional coping strategies in Ijara included minimal migration, occasioned by search for pasture during the dry period. The migration involved movement of people and livestock to Tana River Delta and the Boni forest ecosystems where water and pasture abounded all-year round. However, the condition of vegetation in the ecosystems increasingly deteriorated in quality and diminished in quantity over the years, partly due to the effects of continued droughts. Diminishing quantities of pasture and browse has reduced livestock production, contributing to food insecurity shocks. This in effect means that the uncertainty spawned by the climate-induced shocks, meagre resources, diminishing natural capital, decimation of the traditionally-relied-upon livestock herding, increased dependency on the three spontaneously undertaken adaptation strategies namely water pans, Aloe crop and pasture enterprises.

### **1.1.1 Pasture Adaptation Strategy**

Like other ASAL communities, pastoralists in Ijara bear the blunt of rising feed costs, as 60- 80% costs of livestock feeds in Kenya exceed the sum total of all other production costs (GoK, 2008; Ndungu *et al.*, 2003). The high costs not only catalyse vulnerability it also affects competitiveness of Kenya's livestock products. Additionally, the costs decimate capacities of the sub-sector to meet the protein demand of the burgeoning population and rising income per capita. The gap is further compounded by the instability of domestic supply of livestock feed given its dependence on the seasonality of supply of inputs. The basic factors affecting the supply of quality feed include its price, availability,

quality of raw material used, processing methods, handling and storage of feeds. Hitherto this has not only necessitated importation of fine vital feed ingredients but is complicated by degradation of the fragile range ecosystem hence compromising its capacity to support quality livestock in sufficient numbers for apt benefits and adaptive capacity.

To raise adaptive capacities in Kenya, the national climate change response strategy (NCCRS) (2010) proposes developing climate-smart feeds and breed to cut down on costs of adaptation and to boost resilience. Also the strategy underpins promoting diversification of economic livelihood and awareness creation among pastoral communities and highlighting the value of balancing stocking rates with the available resources. Furthermore, through Vision 2030, Kenya aims to safeguard the state of environment for economic growth and to specifically reduce losses arising from impacts of emissions such as floods and droughts, as overall goal for the ASAL climatic zones (GoK, 2007).

The country is divided into seven agro-ecological zones based on moisture index derived from annual rainfall expressed as a percentage of potential evaporation. Areas indexed more than 50% are considered high potential, useful for cropping and are designated agro-ecological zones I, II and III, and account for 20% of Kenya's land mass. The other feed-limited 80% is classified as ASALs used mainly for ranching, pastoralism and wildlife, supporting 25% of the nation's human population and over 70% of its livestock with an estimated value of Kshs. 70 billion (GoK, 2012; Sambroek *et al.*, 1982; Jaetzold and Schmidt, 1983; Kabubo-Mariara *et al.*, 2007). Overall the significant contribution from livestock to Kenya economy is valued at Kshs 308 billion. The 60 million national livestock populations comprise the major livestock species of 9 million Zebus, 3.5 million exotic and grade cattle, 8 million sheep, 11 million goats, 850,000 camels, 330,000 pigs, over 29 million chicken and 470,000 rabbits (GoK, 2010). Ijara sub-county has a population of 606,212 which is 12.81% of the livestock totals 4,731,579 found in Garissa County (Ministry of livestock, Garissa County, 2014)

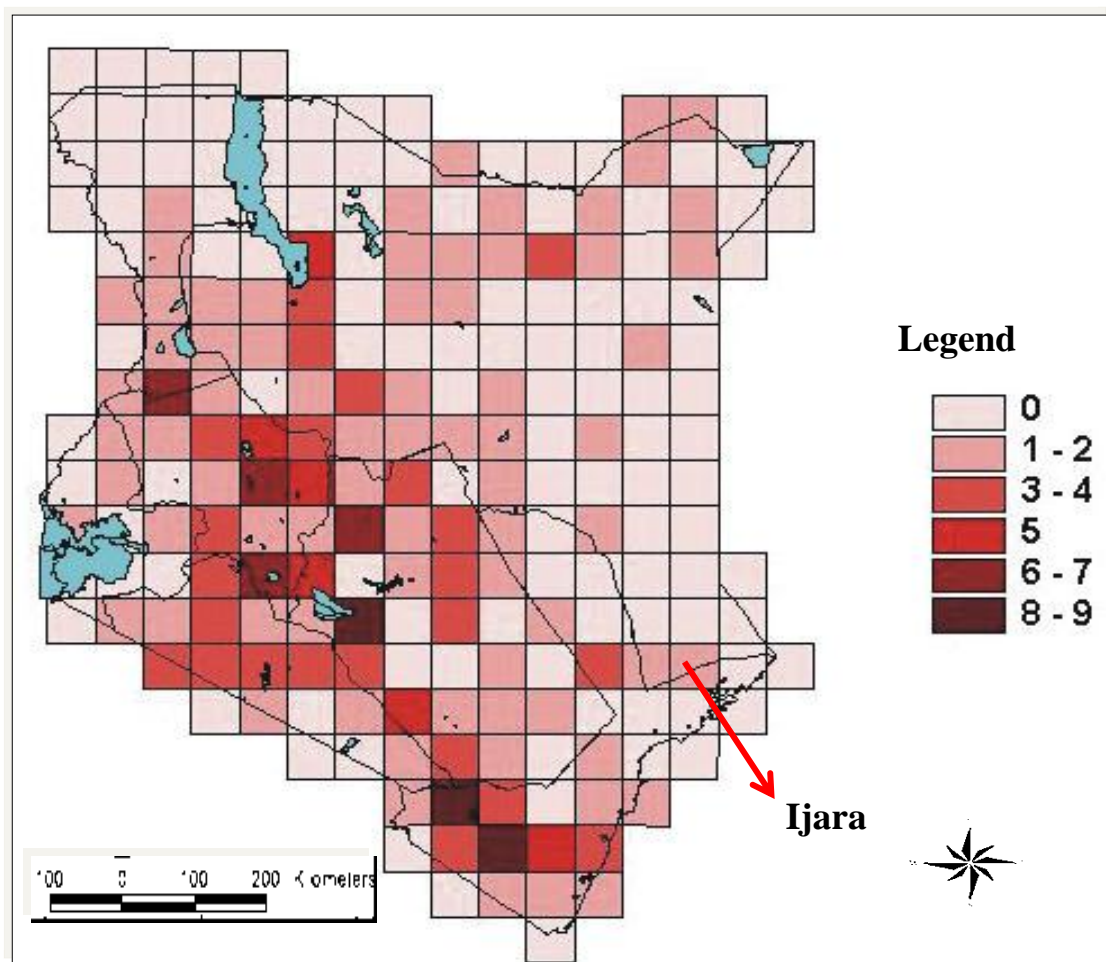
Despite feed constraints, keeping of livestock is invaluable livelihood in the ASALs that are also home to drought adapted livestock breeds such as Somali Galla goat, Somali camel breed, Boran cattle, and the Somali-black-head sheep (Fratkin *et al.*, 1999). The livestock investment is the dominant land use system in the region with estimated sum value of between US\$250-US\$ 300 million annually besides other values to include food security, transport, mobile bank and socio-cultural roles (Njanja, 2003; Ngutu *et al.*, 2011; Sara, 2013).

According to Thornton, *et al.*(2009) the economics and the link between climate change and livestock pasture enterprises is a rather neglected research area despite the vital role played by livestock in the wake of extreme weather events. Consequently, scanty data exist on the nexus between these climatic variables and other drivers of change in the wider development and livestock systems; albeit household responses to the changes vary greatly from place to place. It is worth noting that although temperature rise above 5.5°C may turn farmers' preference back to more livestock, a range of models predict that probability of engaging in livestock holding under a warming of 2-4°C reduces by 7% with feeds being the chief concern (Kabubo-Mariara, 2008; IFPRI,2009). The indication is that under acutely high temperature that lowers feed accessibility, either due to economics or climatic factors, farmers will indistinctly stick to keeping livestock despite the costs or benefits involved. The indistinct, through spontaneity in undertaking pasture enterprise, impedes effective management of scarce resources and it was partly for that reason that the economic analysis on pasture enterprises adaptation strategy was justified.

### ***1.1.2 Aloe Crop Adaptation Strategy***

Aloes are known to occur in a wide range of habitats at altitudes that vary from sea level for *Aloe massawana* to 3300 m for *Aloe juvenna* (Newton, 2006). Growing Aloe as adaptation strategy could be cost effective given their physiological adaptations to include sunken stomata and intense wax cover on the leaf cuticle all of which make the plants particularly fitted for diverse habitats, mainly ASALs. The plants have also evolved traits that aid adaptation to their environment such as spiny leaf edges and bitter taste that deters browsing as well as not being colonizers in the ecological sense (Newton,

2004). The plant's traits possibly make it suitable for adaptation strategy given costs of adaptation emanating from rising temperature and other risks impacts from climate change and variability. In Kenya, trade in Aloe supports livelihoods of thousands of people in the ASALs and the products' value chain is controlled under the Convention on International Trade in Endangered Species (CITES). The Kenyan Aloe species have been placed under CITES appendix II, where Aloe products for trade should be processed from certified sources such as established plantations or certified Aloe management units (AMU)(Mukonyi, *et al.*, 2008)



(Source: Adapted from Wabuyele *et al.*, 2006)

Figure 1. 1: Outline of Taxonomic diversity of genus Aloe

From Figure 1.1 numbers 0-9 refer to the total number of taxa recorded in each square. Ijara ecosystems fall within regions with 1-2 taxa of genus Aloe and therefore among areas with budding Aloe farming with *Aloe Secundiflora* species widely spread. From earlier discussion, it is clear that relatively reliable data exist on the distribution of Aloes, their status and threats-which include habitat destruction, grazing and direct exploitation through over-harvesting. Paradoxically, harvesting of wild aloes in Kenya is outlawed both by the presidential decree of 1986 and CITES to the effect that all international trade of plants and products must be regulated. However, save for the fledgling Aloe Working Group of 2004 and conservation Act of 2007, there exist no clear regulation as yet to streamline conservation, arbitrarily harvesting and mix-up of Aloe saps. As a result, Kenyan Aloe products are illegally sourced from uncertified wild sources which threaten wild populations. Also, the illegal trade has led to low prices and subsequently low income to the local communities (Mukonyi, *et al.*, 2008).

Moreover, the unregulated harvesting not only degrades the ecosystems biodiversity but also issues in 36% of Aloe being critically endangered, 32% as endangered, 12 % as vulnerable, 12% as being near threatened (Wabuye, *et al.*, 2006; Newton,2003). Aloe business is more intense in Kenya, Tanzania, Ethiopia and Somalia, in that order. But the unregulated harvesting impedes clarity on costs and benefits in Aloe business hence the need for this economic study whose results aid ease of sustainable resource management and policy formulation. Of notable concern is Somalia which has significantly high number of Aloe *taxa* at 30, and 24 species endemic to the country and equally high number threatened. This is second only to Kenya where indiscriminate harvesting abounds.

The indiscriminate harvesting is particularly detrimental to *A. turkanensis* and *A. scabrifolia* the two species exploited for export. Similarly, lack of regulation impede possible benefits from compilation of Aloe taxonomy for apt propagation and management as the varied species widely hybrid both on-farm and in the wild (Newton, 2006). In Ijara, Aloe *Secundiflora* is widely preferred as it thrives in dry, lowland areas and does well in Kenya's ASALs with potential to aptly supplement livestock production.

The Aloe has multiple benefits to include human health care products and restoration of environmentally degraded sites (Mukonyi, 2003). These benefits allude to the suitability of the Aloe adaptation strategy to increase resilience against effects of climate change. In this regard, the Ijara study set to measure the economic viability of the strategy to inform policy and better management.

### ***1.1.3 Water Harvesting Pan Adaptation Strategy***

Rain water harvesting and storage capacity remains extremely low in most of Kenya even though the country is water scarce with per capita availability of 647m, which is less than the UN-recommended 1000m per capita (Republic of Kenya, 2010). Water harvesting is the collection of runoff instead of it being left to cause erosion for productive purposes that reduce costs. In the semi-arid drought-prone areas where it is widely practised through water pans, water harvesting doubles as a direct productive form of soil and water conservation. Consequently, both yields and reliability of production can be significantly improved with this method. Water harvesting techniques have been used for millennia for domestic, agricultural, pastoral, and commercial water needs. In Kenya, development projects by county government, NGOs, national and international organizations, state ministries, and other agencies increasingly look into rain water harvesting as a decentralized solution to Kenya's water needs (Black *et al.*, 2012).

In Ijara, water sources are either natural or manmade. Natural sources are River Tana, *laghas* and Lakes Jerrei and Hadi within Boni forest. Man-made sources are mainly dug water harvesting pans and shallow wells. In the larger Ijara sub-county, there are twenty water pans spread in Bothai, Handaro, Kotile and Sangole-Ijara whose individual capacities range between 10-30m<sup>3</sup>. But the economic study purposely selected Handaro dam based on the numerous livestock and crop agricultural activity that it supports. Also it is the one dam whose construction factored in both crop and livestock whereas other water pans in the area focus on livestock. Water pans serve the major proportion of the sub-county and are key influencers on population distribution, schools, health facilities and administration posts mainly as check against insecurity (GoK, 2008). Although River Tana avails water at source to Ijara, it does not currently legally fall under the sub-

county. This illegality precipitates occasional pastoralist-farmer-livestock conflicts. Other negative environmental impacts as a result of water resources utilization include ecosystem degradation as a result of unplanned watering point, degradation of water pans due to poor or lack of a management system, underutilization of lakes Jerrei and Hadi, dismal coverage by portable water and siltation. The water resource-based impediments are also attributable to climate and social change which led to the disruption of traditional rangeland management that partitioned rangelands into dry and wet pastures. Lack of the management has resulted in under-utilization of the rather endowed pasture area, while areas in the sub-county with proliferation of water points are degraded due to over-use (IUCN, 2014).

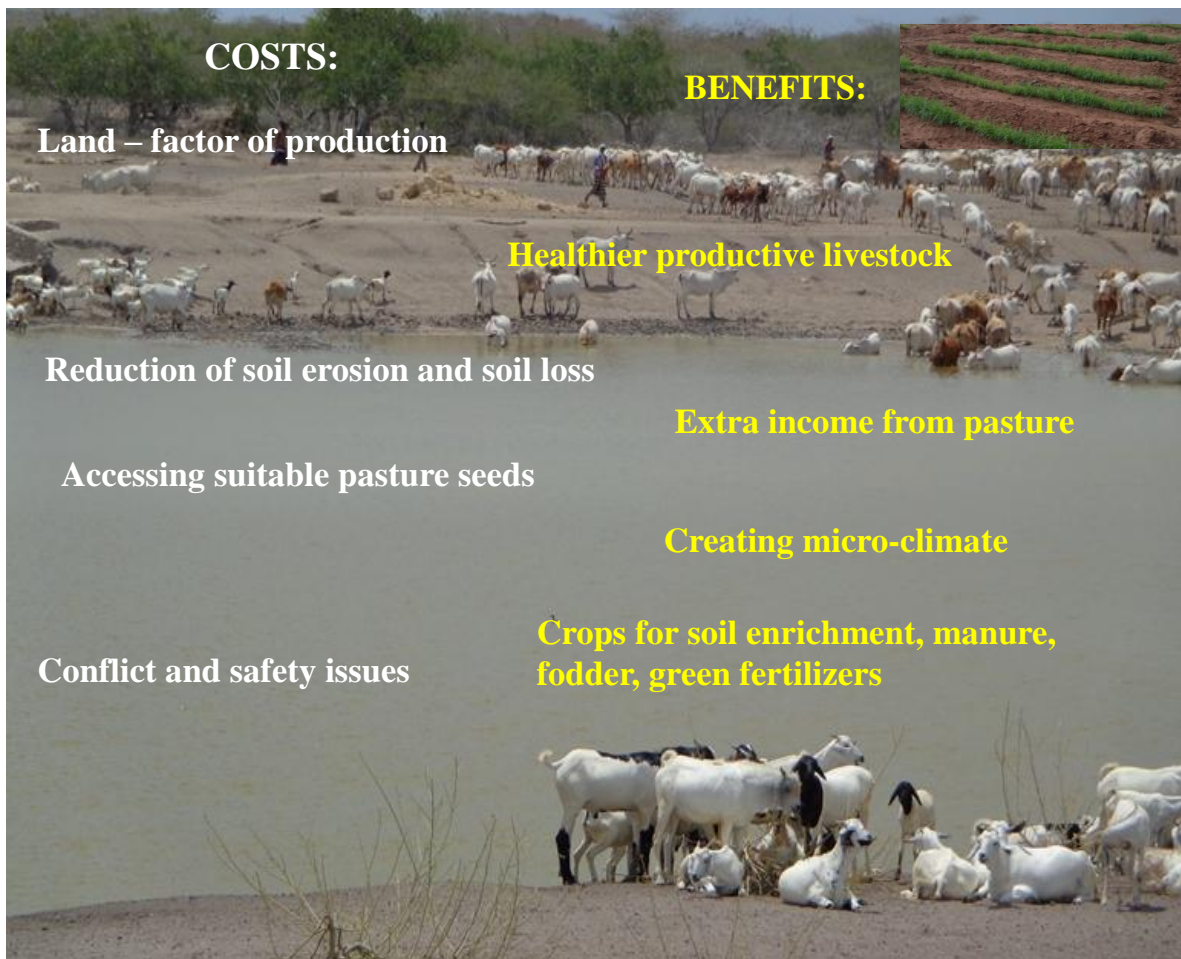


Plate 1: Handaro water pan supported cost benefit activities

The water pans were spontaneously implemented as adaptation strategies in response to prolonged drought, low erratic and patchy rainfall, high vulnerability index, floods,

decimation of livestock body size and numbers as well as shifts in seasons (KARI-IDRC, 2012). In view of the adverse impacts, “experts in Ijara adapt to new ways of providing water such as boreholes and water pans but the high salinity levels make boreholes more exorbitant but water pans are rated highly” (Guyo, S. Personal Communication, 2013). Key among water pans so constructed was Handaro water pan shown on Plate 1.

By constructing water pans in Ijara, stakeholders aimed to tackle water stress, and to net-in multiple benefits that water provide. Specific benefits included: healthier livestock, growing crops around water pans, extra income from pasture sales, creation of micro-climate supportive of environmental benefits, reducing trekking distance, increasing revenues by saving time to do other economic activities, children settling down for education and curtailing child labour. After seven years of use, Handaro water pan was assessed for benefits and costs and to ascertain its economic viability as adaptation strategy. The direct impacts of water harvesting pan are shown in Figure 1.2 below:

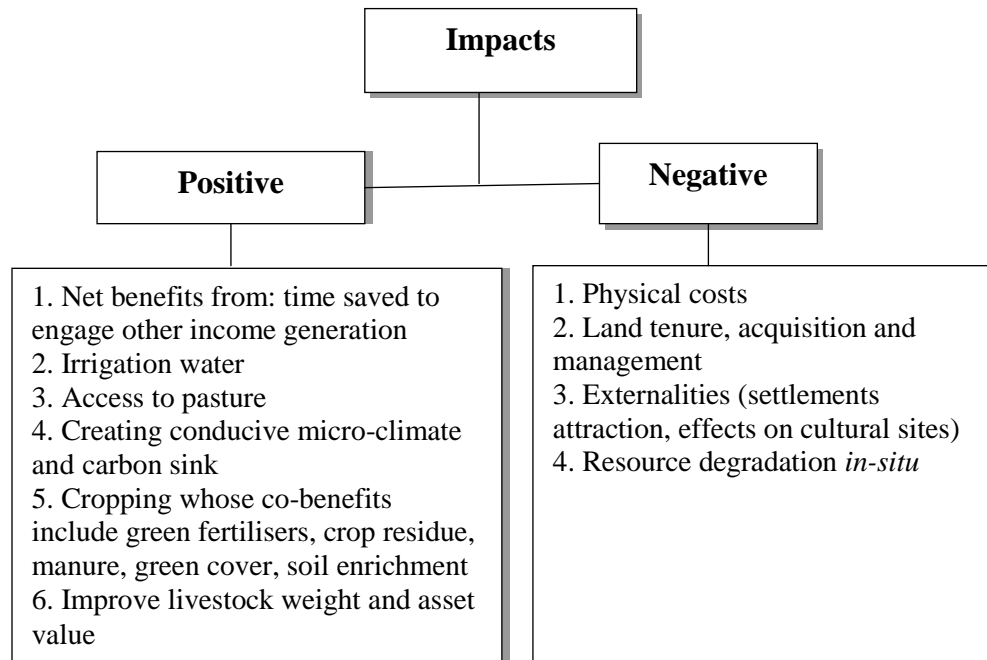


Figure 1. 2: Impacts of Handaro water pan-positive and negative

### **1.1.3.1: *Positive Impacts of Water Pan***

Water harvesting pans provide access to pasture and in turn improve livestock weight and asset value. Other benefits include net benefits arising from time saved to engage in other economic activities. Also water pan provide water that enable tackling food insecurity through crop agriculture around it.

### **1.1.3.2: *Negative Impacts of Water Pan***

Key negative impacts on the water pan were physical costs, land acquisition and externalities. Externalities considered were in-situ resource degradation, attracting informal settlement and effecting cultural sites and norms.

## **1.2 Problem Statement**

Ijara is part of Kenya's dry lands that are prone to shocks, mainly drought and floods even though rainfall ranges between 250 and 700 millimetres annually. A range of models predict increased temperature from year 2030 onwards. The changes will ravage possible gains from the predicted increase in precipitation. Given the shocks arising from the extreme weather, farmers have over time taken to water pans, pasture enterprises and Aloe crop as adaptation strategies, but their costs and benefits remained indistinct. The indistinct on costs and benefits inhibits apt management of the scarce resources. Also it impedes reduction of vulnerability occasioned by climate change and variability. As a result, it was critical to analyse costs and benefits and to establish whether costs incurred on the strategies exceeded benefits gained. Hence doing the economic analysis was imperative to aid planning for sustainable adaptation, inform policy to reduce vulnerability and tackle roots of poverty. Currently, assessment of costs and benefits of adaptation is limited and exist mainly at global-national macro-level, yearning for a need to gain sufficient insight into the economics of adaptation particularly, in local ASAL situations such as Ijara. Also, by bridging the data gap, the study makes critical contribution to adaptation research as currently, Kenya has no adequate climate change

policy but for the fledgling National Climate Change Strategy( Mutimba *et al.*, 2010) and the national adaptation policy.

### **1.3 Research Questions**

Study questions and objectives were informed partly by data collated from stakeholder registers at the ministries of agriculture and livestock in Ijara which indicated 9000 farmers were active in both crop agriculture and livestock. A rapid vulnerability assessment was done up-front to determine what crop and livestock strategies were used. From the review it was clear that the population depended on the water pan available for domestic and livestock use, aloe farming as well as pasture enterprise. Also, it was from this finite population that sample size was drawn. The study answered four questions:

1. What are the costs of livestock feed enterprise, water pans and aloe crop, as adaptation strategies at household level?
2. Which benefits arise from the adoption and implementation of the selected adaptation strategies at household level?
3. Are the selected strategies economically viable at community farm-level in Ijara, Garissa?
4. How viable are the selected strategies in coping with impacts of climate change and variability?

### **1.4 Objectives of the Study**

#### **1.4.1 General Objective**

The general objective of the study was to assess costs and benefits of water pan, pasture and aloe crop and to assess their viability as adaptation strategies.

#### **1.4.2 Specific Objectives**

1. To analyze specific costs of applying, water pans pasture enterprise and aloe crop as adaptation strategies at household-level;

2. To measure benefits of avoided damages resulting from the adoption and implementation of water pans, aloe crop and pasture enterprises as adaptation strategies at household- level;
3. To evaluate costs incurred in implementing water pans, aloe crop and pasture enterprises to establish whether they exceed benefits gained from use;
4. To assess suitability of water pans, aloe crop and pasture enterprises as adaptation strategies against impacts of climate change and variability.

### **1.5 Justification**

The study considered basic concern in economic analysis on how needs are met integrating goods and services from diminishing resources, incorporating natural capital in the analysis to enhance sustainability (Stern, 2006; Scherr *et al.*, 2008). As ASAL ecosystems are vulnerable, adaptation economics is essential so as to answer policy questions on what adaptation strategies are most suitable and their cost effectiveness. And more importantly whether costs of implementing adaptation strategies exceed benefits (Somda, *et al.*, 2013). Recent studies have shown that over 85% of farmers in the ASALs have basic knowledge on climate change and attendant shocks upon which spontaneous adaptation strategies are mounted over time (Enete and Onyekuru, 2011; Mwaura *et al.*, 2013). Given the significantly high awareness among stakeholders in ASALs on potential for adaptation, farmers have spontaneously invested in water pans, Aloe crop and pastured enterprise to cope with effects of extreme weather events. However, their re-active approach to adaptation blur costs incurred and benefits gained from the strategies which makes it difficult to manage the scarce resources, inform policy, plan for adaptation and poverty alleviation, hence justifying the economic analysis.

Also, globally, scientists have in the recent past done a lot on adaptation but their focus has been mainly on impacts, vulnerability and constraints to adaptation (Adger, 2006; Smit and Wandel, 2006; Smit, *et al.*, 2001). Moreover, similar estimates on global costs

and benefits of adaptation mainly at macro-level have been done to include World Bank (2010), UNDP(2015) , Oxfam (2007) , UNFCCC (2011); that alluded to the danger of failing to tackle economic effects of extreme weather events but not much of such studies have been done in marginalized ASAL areas such as Ijara. This means that little is known about the costs and benefits of adaptation strategies (De Bruin, 2011) in such locale hence the need for further studies. Additionally, the economic analysis is vital to ascertain the best value-for-money, inform achievement of the most effective policy outcomes and realistic assessment of risk. The contribution from the study is critical to complement the new national climate change strategy and the national adaptation programmes of action (NAPAs).

### **1.6 Significance of the Study**

The significance of the economic assessment was reduction of existing data scarcity and informing climate-smart agriculture productivity as well as realization of the most valuable policy results. The significance necessitated factoring-in of costs-benefit-analysis complemented by financial market-driven 15% discounting rates and net present values as well as historic climatic data.

### **1.7 Conceptual Framework**

The study's conceptual framework (Figure 1.3) presents graphically interrelatedness of strategies whose costs and benefits are assessed with those that are not; and resultant effect from each. In so doing it demonstrates that quantifying costs and benefits of strategies stimulates higher levels of adaptation and vice versa. The costs benefits analyses (CBA) process start at identifying key stakeholders already affected by the changing climate and have undertaken some adaptation strategies albeit spontaneously. Stakeholders identified were divided into private (households, agro-pastoralists), social (fodder associations) public (extension and government departments) and environment (water and forest associations).

Following identification of stakeholders other key steps were the potential monetary and non-monetary impacts, quantification of costs and benefits with net present value (NPV)

being main viability indicator tool. The study is based on the theory that adoption of climate-smart adaptation strategies is crucial for vulnerable communities and that clarity on costs and benefits to enhance cost-effect decision making process for improved social welfare, essential. Also the most economically viable of the strategies is highlighted for up-scaling and for informing policy. Overall, poverty and resource degradation are reduced and resilience upped (Figure 1.3 Conceptual framework).

As indicated on the conceptual framework, independent variables are costs and benefits that could be clear or indistinct, and adaptation that could be planned and therefore sustainable or autonomous/spontaneous which is reactive and unsustainable. Spontaneously implemented strategies whose costs remain indistinct issue in adaptation being compromised and short of desired outcome. The desired ultimate phenomenon (dependent variables) for the framework is cost-effective adaptation that is well planned and adopted and sustainable social welfare in Ijara. This outcome is then communicated to stakeholders as policy implications and feedback. In between independent and dependent variables are intervening variables which show the link or mechanism between costs and benefits the independent variables, and cost-effective social welfare adaptation.

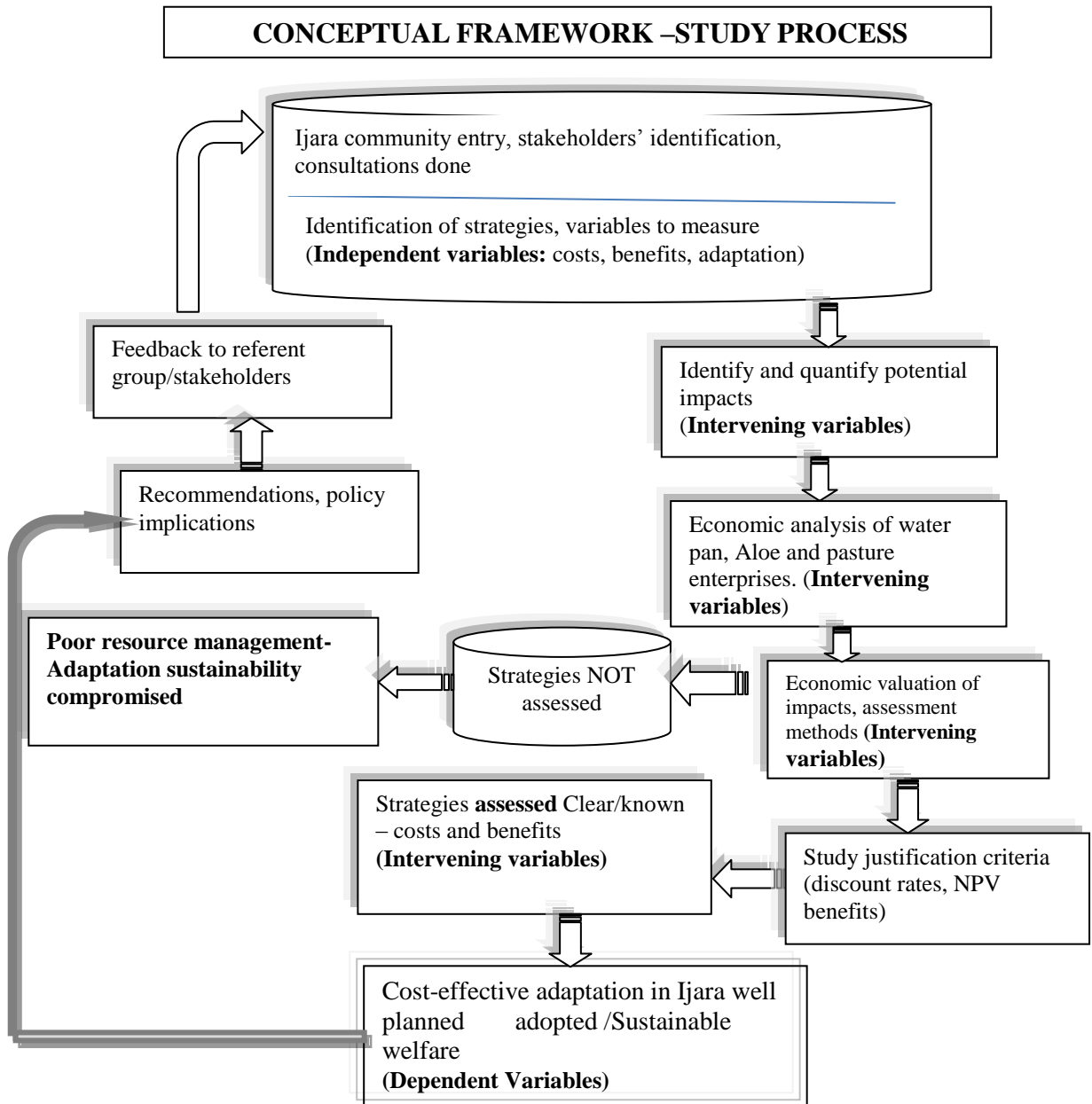


Figure 1. 3: Conceptual framework

## CHAPTER TWO: LITERATURE REVIEW

### 2.1 Costs and Benefits of Livestock Feed Enterprise

Costs and benefits of producing, harvesting, managing use and sales of livestock feed as adaptation strategy is directly affected by climate change and variability given alteration occur on biomass, natural resources and pertinent climatic factors. As temperature and carbon dioxide (CO<sub>2</sub>) levels change due to climate change, optimal growth rates for different species also change; species alter their competition dynamics, and the composition changes (Thornton *et al.*, 2007; Herrero *et al.*, 2010). Generally the greenhouse roof-effect created by the excesses of the warming greenhouse gases chiefly, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) increase uncertainty in pasture production (GoK, 2013; Jones *et al.*, 1988).

Specifically, rising temperatures increase lignification of feed tissues, reducing digestibility which leads to reduced feed available for livestock, and hence increased feed costs (IFAD, 2009; Thornton *et al.*, 2007). For instance such changes easily affect quantity and quality of pasture due to changes in species population; moisture, herbaceous cover density and dry matter (DM) yield (Leeuw and Nyambaka, 1988). Also, the decline in mean rainfall, lead to soil moisture deficits which reduces DM yield and also affect the stage of maturity for forage, all of which increase feed costs. Additionally, the stage of maturity at which the feed is cut is a major determinant of quality (TPS, 2013) with direct effect on costs and benefits of the feed, which in turn may demean pastoralists' lifestyles. To curtail rising costs and feasible greenhouse gas emissions, it probably is instructive that pasture availability and management is enhanced-both natural and on-farm. This is particularly vital as grazing could influence soil carbon in that, rangelands with lesser livestock grazing intensity have likelihood of desired higher soil carbon stocks and vice versa (Ritchie, 2014; Bulle *et al.*, 2014)

### **2.1.1 Adaptation in Reaction to Climate Variability**

Given the shocks arising from effects of climate change and variability in Kenya, communities, government and partners have over time engaged in spontaneous and planned adaptation in various sectors. Often when such adaptation is spontaneous, costs and benefits are not clear, which make management of the scarce resources difficult, hence the need for the economic estimation and adaptation. For this reason an integration of best practices is preferable for the costs estimation as it provides better understanding of social and environment systems both of which are capital assets in adaptation economics (King *et al.*, 2000; Reed *et al.*, 2006)

Agrawala and Fankhauser (2008) studied the economic aspects of adaptation to climate change: costs, benefits and policy instruments. The objective was to provide a critical assessment of adaptation costs and benefits in key climate sensitive sectors, such as agriculture, at national and global levels by using literature review method. The study concluded that costing or raising large sums of money to finance adaptation is clearly important, but will not ease the challenge of ensuring that individuals, businesses, governments and civil society make timely, well-informed, and efficient adaptation decisions. Therefore the report called for a push for policy instrument to establish the right incentives to influence such decisions.

However, Agrawala and Fankhauser were unclear on regional and sector specificity which is largely the flagship of adaptation (Stage, 2010; IUCN, 2010). Adaptation is about learning through uncertainties and like climate change variability, it is unique to existing regional and sectoral vulnerabilities (Lunduka, *et al.*, 2013). Therefore assuming wholesale cover estimation for all agro-eco zones at all-time is unrealistic as costs and benefits of adaptation vary from one region to the other dependent on myriad environment and socio-economic factors (Parry *et al.*, 2009; Lunduka *et al.*, 2012). However, some recent studies have not clearly focused on regions and sectors which are central to adaptation activities. Failure to provide pertinent vital adaptation data impedes effective policy formulation which remains a disturbing gap within economics analysis of adaptation (Bruin, 2011). This is clearly so given that clarity on costs and benefits data

from specific sites at specific time and specific sector is antidote to right incentives that influence apt policy-decision-making.

Some studies indicate that negative impacts of climate change tend to be greater in the poorer regions (Tol, 2002, Mertz *et al.*, 2009). World Bank (2010) shows that, adapting to increased temperature of about 2<sup>0</sup>C by 2050 ranges \$75 to \$100 billion per annum. In Kenya the economic impacts from climate change indicate that it exerts disproportionate stress on the most vulnerable communities (Mutimba, *et al.*, 2010). It is estimated that economic costs of the impacts of climate change adaptation on market and non-market sectors will be a disturbing 3% of Kenya's GDP per annum by 2030 with potential to rise to above 5% of GDP per year by 2050 (SEI, 2009). The rising costs of adaptation are unsettling particularly to communities living in the vulnerable ASAL areas like Ijara where costs and benefits of the spontaneously employed strategies are unclear. Therefore there is urgent need to undertake economic study on adaptation and impacts of climate change. A brief discussion on each hereby follows:

## **2.2 Adaptation to Impacts of Climate Change**

IPCC (2001) define adaptation as adjustment in natural or human systems responding to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Within adaptation are many possible responses such as change in crop management practices, choice of fields, planting dates, crop varieties, livestock feeding and health (Bryan, *et al.*, 2011). The adaptation can be carried out in response to (*ex post*) or in anticipation of (*ex ante*) changes in climatic conditions (IPCC, 2007) and entails a process by which measures and behaviours to prevent, moderate, cope with and take advantage of the consequences of climate events are planned, enhanced, developed and implemented (UNDP 2005; Willows, 2003 and IPCC, 2001). Dealing with climate change adaptation is for the present, as impacts of changing climate often demand immediate response. For this reason it is important that it is not separated from other development priorities but is mainstreamed into development planning, programs and projects (FAO, 2009; World Bank, 2008). However, it is critical to prefer climate-smart strategies given that responses aimed at adapting to climate change may have negative

consequences for food security, just as methods taken to increase food security may exacerbate emissions, as discussed earlier (CCAFS, 2009; Jones *et al.*, 1988).

Adaptation, unlike mitigation, acquired consideration only in 2001 in Morocco, during the seventh conference of parties (COP 7) where key funding mechanism: the adaptation fund (AF), the special climate change fund (SCCF) and the least developed countries fund (LDCF) were established (Adger, *et al.*, 2003). Whereas mitigation can be more cost-effective if using an integrated approach that combines measures to reduce energy use, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors, it is adaptation that answers to the immediate survival needs that are synonymous with developing regions (IPCC, 2014). Studies done by the Centre for European policy studies (CEPS, 2008) on adaptation to climate change underscored the usefulness of adaptation policy and how to implement it. The results showed that economic impacts of climate change are reduced by adaptation, and in some cases, adaptation was seen to lessen the impacts or turn climate change into an opportunity with a positive outcome.

With regards to effective adaptation approaches, Clements *et al.* (2009) identified two approaches through which adaptation is executable namely: - responding to impacts of climate change or reducing vulnerability to it. Response to the former can be through, for instance, relocating whole communities in case of floods while tackling vulnerability involves approaches that aim to better soils, infrastructure and people through specific adaptation strategies. Key component of adaptation is involvement of local community in assessing their own climatic situations and needs and includes location-specific options that help people and ecosystems reduce their vulnerability to minimize the costs of natural disasters (Clements *et al.*, 2009; Calvosa *et al.*, 2009). The adaptation strategies are developed to reduce poverty, diversify livelihoods and empower local people to manage their own vulnerability.

Indeed, it is clear from Clements's argument that although there is likelihood of costing more, an integration of both approaches for wider development is desirable for realization

of holistic approach to adaptation (Chambwera *et al.*, 2011). In this regards Reeds (2006) recommends the process such as careful analysis on the adaptation strategies that exist, fortifying policies through awareness creation, strengthening institutions, natural resources management, funding, viable adaptation strategies choices and stakeholders' involvement. Such process is important because unlike mitigation, adaptation is location-specific and provides direct benefits at the local and regional levels. Also adaptation projects differ from other global climate change projects in that the latter incorporates environmental benefits which, unlike adaptation benefits, are insignificant in the immediate terms to vulnerable communities. Economic analysis therefore, is done to ascertain, at the very least that benefits gained exceed costs incurred, for an adaptation strategy to be considered economically viable (Fankhauser, 1998; UNFCCC, 2010). In any case, the benefits of adaptation surpass enhancing farmers' resilience and incorporate co-benefits such as agricultural mitigation and productivity given that most practices that increase resilience also increase agricultural productivity and reduce emissions from agriculture (Bryan, *et al.*, 2011; Mude *et al.*, 2007). Adaptation can be anticipatory or planned and autonomous as discussed briefly below:

### ***2.2.1 Anticipatory Adaptation***

Anticipatory adaptation, takes place before impacts of climate change are observed requiring conscious intervention to prepare for potential climate change impacts (Smith, *et al.*, 1997). In essence, when adaptation is anticipated there is reduction of risk by increasing adaptive capacity and it is generally accepted that it has the potential to increase the marginal benefits and decrease the costs of reactive adaptation (Fankhauser, *et al.*, 1998). In ASALs, for most of the cases, anticipation and planning are absent in implementation of adaptation strategies

### ***2.2.2 Planned and Autonomous Adaptation***

It is assumed that unlike in planned adaptation which is carefully planned and informed by awareness of potential climate change; autonomous takes place rather spontaneously (Willows *et al.*, 2003). A key difference between planned adaptation and autonomous adaptation is that the former can be reactive and anticipatory – taking place before or

after an event but autonomous is reactive. In ASALs farmers more often than not engage in autonomous adaptation whose costs and benefits are too unclear to inform subsequent adaptation and policy direction

### **2.3 Assessing Adaptation Costs**

Since the adaptation strategies in Ijara were spontaneously implemented their costs remained indistinct, yearning for the economic assessment. Understanding the costs of adaptation strategies is crucial for determining levels and choice of investments needed to improve resilience and adaptive capacities as well as mobilizing institutional support and providing timely resources (Sova, *et al.*, 2012; ADB, 2009). But the UNFCCC secretariat (2007) hold that, the global cost of adaptation to climate change will be difficult to estimate, because climate change measures will be widespread and heterogeneous. In spite of this assertion the secretariat estimated that in the year 2030 the incremental investment and financial flows (I&FF) needed to adapt to climate change will be from \$49 to \$171B globally, from which \$28-67B will be required for developing countries. Estimating the costs of adaptation is important so as to determine levels and choice of investments needed for adaptation.

Watkiss, *et al.* (2010) analysed economic costs of climate change adaptation in Africa to help policymakers and other players towards financing, planning and implementation of adaptation programmes. The study recommended urgent and additional funding for adaptation in the continent given the potentially high economic costs of climate change for the region in the short-term. The study demonstrated a wide range of estimates of the amount of funding necessary for the continent, with 2010-2015 financing needs varying from \$5-30 billion a year. These needs are expected to rise eventually, with studies indicating a range from \$20-60 billion a year 2020-2030. However the study may have overlooked some critical issues that are rampant in ASALs such as uncertainty arising from poverty, high illiteracy levels, deplorable infrastructure and inaccessibility as well as retrogressive cultural practices (Ijara District Strategic Plan, 2005-2010).

The ability and willingness of the population to invest in the adaptation of the selected interventions is crucial to the success of climate change adaptation strategies. Beilei (2010) assessed individuals' willingness to pay (WTP), for climate change prevention and whether the shares of climate change impacts borne by the poor is a cause for concern. Key results were that WTP is higher ( $p < 0.05$ ) when larger costs are borne by parties with greater responsibility for prevention and when respondents believe as they do currently, that the poor shoulder impacts of climate change unduly. The study found that those with less adaptive capacity such as ASAL communities bear the blunt of climate change costs while those responsible to pay for mitigation and adaptation have choices to do or not to.

Lunduka (2011) assessed economic return from rain water harvesting for Malawi policy makers that showed that earth dams are the cheapest per cubic meter of water of storage. Also Nissen-Petersen (2004) confirms that such water storage translates to 400 m<sup>3</sup> for ASAL household per annum. In a later study, Lunduka *et al.*, (2013) found that earth dams had a wide range of benefits from on site to off site that included covering a larger number of beneficiaries as compared to underground and above ground tanks.

World Bank (2010) assessed the costs to developing countries of adapting to climate change. The objective was two-fold: 1. develop a global estimate of adaptation costs for informing the international community's efforts in the climate negotiations, and 2. to help decision-makers in developing countries assess the risks posed by climate change and design national strategies for adaptation. The study conducted two parallel tracks: (1) a global track - a top-down approach, in which national databases were used to generate aggregate estimates at a global scale, drawing on a wide variety of sector studies; and 2. A country-level track bottom-up approach, in which sub-national data were aggregated to generate estimates at economy-wide levels. The results indicated that the cost of adapting to an approximately 2<sup>0</sup>C warmer world by 2050 is up to \$100 billion a year. The approach used may have missed out on economic hurdles that prevail in marginalized ASAL areas that were not captured neither in the national nor-national and how expected

results would clearly inform decision-makers in ASALs given the uncertainty that surround climate change and variability (Cooper *et al.*, 2013).

The more precise approach would be to collate adaptation costs bottom-up starting with costs at lowest end areas, using multi-stakeholders compliant methods (Lunduka, *et al.*, 2013). Fankhauser (2009) concluded that adaptation costs are only one dimension of climate change; others being mitigation and residual damage costs and that since research on adaptation costs is still in its infancy and knowledge gaps in terms of scope and depth that tend to underestimate costs.

Sova (2012) used participatory social return on investment (PSROI) methodology – a 4-step process in three separate pilot initiatives in, Kenya and Senegal. The study generated credible costs-benefits pathway on how to bridge the divide between national and international-level resources and local-level priorities. The conclusion from the study was that costs and benefits of adaptation options can be estimated with reasonable accuracy for only a few options because knowledge gaps exist; data are missing or are unreliable for the majority of them. It was De Bruin, *et al.*, (2009) who generated sector-based inventory of climate adaptation options in the Netherlands and ranked alternatives by use of multi-criteria method. De Bruin highlighted data gaps and possible hurdle it presents on costs and benefits analysis, and recommended use of alternative methods to seal the gap and requisite solution so as to inform adaptation policy suitable for ASAL sites.

Nkomo and Gomez (2006) compared costs of adaptation projects in South Africa and Gambia using observed climatological data and River Dynamic Spatial Equilibrium Model. The objective was to develop the capacity to estimate and compare the benefits and costs of projects in natural resource sectors that reduce the expected damages from climate change in the two regions. The result showed that it was economical to construct Berg Dam but not so for Gambia Dam, as benefits from irrigation did not match the costs incurred by farming households. For this reason the study pushed for further policy measures amendment to support irrigation to tackle uncertainty.

Leary (1999) point out that where uncertainty on adaptation benefits exists and investment costs are irreversible, it is preferable to delay adaptation project even though NPV is positive. Based on the study Leary concluded that by adapting the management of resources, the mix and methods of producing goods and services, choices of leisure activities, and other behavior, people can lessen the damages that would otherwise result. On choices and resource management, Burton, *et al.* (2002) concluded that in vulnerable regions there is insufficient data upon which to base good adaptation policy choices and that requisite adaptation studies were crucial. However the study recommended that carrying out such studies must not delay the design and implementation of adaptation policies, barring adaptation costs involved.

Recent assessment by the World Bank (2010) estimated adaptation costs at US\$ 70-100 billion a year between 2010 and 2050. Oxfam (2007) estimated annual costs at close to US\$ 50 billion per year, while the UNDP suggests that adaptation costs may amount to US\$ 86-109 billion per year (Watkins, 2007). The UNFCCC (2007) estimated the additional investment and financial flows needed worldwide to be \$60–182 billion in 2030, some \$28–67 billion of which would be needed in developing countries. Obviously, adaptation costs as a percentage of GDP are considerably higher in Sub-Saharan Africa than in any other region largely because of the lower GDPs but also owing to higher costs of adaptation for water resources, driven by changes in precipitation patterns (World Bank, 2010). These costs estimates not only build case for adaptation funds in developing countries but emphasize that the longer it takes to reduce emissions, the more the damage and suffering and consequently the higher the adaptation costs (Parry, *et al.*, 2009)

An economic analysis on adaptation and livestock activity choices in Kenya by Kabubo-Mariara, (2008) concluded that farmers adapt livestock management decisions to climate change. Through use of a cross-sectional household level data supplemented by long-term averages of climate data, probit and ocean global circulation models, the results further showed that as it gets hotter, farmers change their livestock choices from dairy cattle and sheep to beef cattle and goats.

## **2.4 Adaptation Benefits**

Turner, *et al.*, (2004) points that benefits from a strategy are contrasted with the associated costs, including the opportunity costs and that net benefit is the difference between the costs and benefits; the most economically efficient measure being the one with the highest present value of net benefit. Some adaptation measures provide public benefits, such as protecting coastal areas from rising sea levels, whereas many others generate more private gains for individuals, firms or consortia of these actors (Lunduka, *et al.*, 2013). Fankhauser (1997) adds that adaptation benefits are the value of damages avoided by adopting adaptation strategies but, IPCC (2007) equates adaptation benefits to avoided damage costs or accrued benefits following the adoption and implementation of adaptation measures. Callaway (2004) views adaptation benefits as the fraction of climate damages that are avoided by specific adaptation actions. However, Somda, *et al.*, (2013) affirms that the benefits of adaptation are not limited to monetary but also non-monetary that contributes to the restoration of degraded ecosystems, save for residual damages. From the four schools of thought just discussed above it can be assumed that adaptation benefits range from avoided damage costs and accrued benefits following specific adaptation, and residual damages and that the benefits are not limited to monetary.

Burton, *et al.*, (2006) affirms that in regards to risk- reduction benefits, adaptation, unlike mitigation, is local and extreme event-specific based on the degree of adaptive capacity available. Giupponi, and Shechter (2003) adds that each adaptation strategy have its costs and benefits and that adaptation net benefits is a result of deducting adaptation costs from the value arrived at after quantifying climate change damages. While Callaway, (2003), further notes that the value equals adaptation benefits (avoided damages) minus adaptation costs; barring uncertainties related to the future climate and changes in vulnerabilities over time.

## **2.5 Assessing Impacts of Climate Change**

Climate change and variability are already having serious impacts in Africa as noted in erratic rainfall, drought and increased temperature. IPCC assessment report (AR) 4, indicate that the total annual precipitation projections suggest increases by 0.2 to 0.4 per

cent per year particularly along the coastline region of East Africa where Ijara project sites locate. However, the gain that may arise from the predicted increase is thwarted by equally rising temperatures (ICPAC, 2013; Ng'ang'a, 2006).

The continent also has a fast growing population, with its natural resources being depleted through environmental degradation with drought being the most serious hazard affecting Africa's agricultural sector particularly in ASALs (Thornton *et al.*, 2006). The sector is expected to expand by 60-90 million hectares that are endangered by the extreme weather events resulting in agricultural losses of between 0.4-7% of GDP in most of Africa with approximately 20 to 30% of plant and animal species expected to be at risk of extinction (IPCC, 2007; FAO, 2007). For example, the 2006 drought in Tanzania cut the overall country's GDP growth by 1% (Chaisemartin *et al.*, 2010) while in Kenya the 2008-11 drought slowed GDP by an average of 2.8% per annum and cost Kenya US\$ 12.1bn (GoK, 2012). Worse still, land available for rain-fed agriculture and crop production is projected to dip by the 2080s which translates to a drop on net crop revenues by as much as 90% in southern Africa, demanding developed countries to adopt policies to drastically reduce emissions by at least 45% by 2020 and 85-95% by 2050, relative to 1990 levels (Clements, *et al.*, 2009; Nimol *et al.*, 2012).

The continent's predicted effects from climate change include increased water stress facing more than 250 million people by 2030, crop and livestock productivity, as well increased pests and diseases due to changes and migration of diseases carrying pests (IPCC, 2007). Climate variability and droughts are already significant stressors in Africa, where rural households have adapted to the stressors for decades (Mortimore and Adams 2001; Mertz *et al.*, 2009). Such rural households particularly in arid regions tend to spontaneously execute adaptation strategies irrespective of the prognosis from climate data (Nielsen and Reenberg, 2010; Sachs, 1999). However, the costs and benefits of such strategies remain indistinct particularly on impacts of local climatic stressors as well as their economic justification.

## **2.6 Research Gaps**

The scarce data on assessed costs and benefits of adaptation in ASALs presented knowledge gap. Tackling this gap on spontaneously adopted measures needed to be thorough, incorporating culture/gender sensitivity, integrated assessment approach, doing it differently. Specifically, quantifying benefits and costs was carried out building on bests outputs from similar works by national-global macroeconomics. Also the study conducted in-depth deductive interviews with local stakeholders to gain insight into the local knowledge to aid ground-truthing of scientific data on climatic conditions and extreme weather events. This approach mitigated gaps and authenticity in scientific data for meaningful conclusions to be drawn (Chambwera, *et al.*, 2012; Nicholles *et al.*, 2012).

### **2.6.1 Scope of Adaptation**

Previous studies have largely been economical in highlighting scope of economics of adaptation in ASALs. To tackle the gap, the study focused on informing pertinent policy in a more holistic manner. The focus was on sustainable cost-effective resource management and reduction of vulnerability by poverty alleviation and food security in the face of climate change and variability (Thornton, *et al.*, 2010). Similarly, to appreciate the costs of adaptation the study examined adaptation in its larger perspective, building on IPCC (2001). Consequently adaptation costs assessed were those on planning, preparing for, facilitating, and implementing adaptation measures, including transaction costs. Callaway (2003) notes that adaptation strategy viability value, is arrived at by subtracting costs from benefits (avoided damages); barring uncertainties related to the future climate and changes in vulnerabilities over time. It was imperative to assess the economics of the three strategies; water pan, Aloe crop and pasture enterprises given that like other carefully selected land uses they offer significant sources of emissions reductions and socio-economic development (Bryan, *et al.*, 2011; Scherr, *et al.*, 2012). Quantifying costs and benefits of adaptation was at the farmers household-level, not only because they are directly exposed to climate-variability based risks but more so due to scarcity of data to inform their efforts.

### ***2.6.2 Comparing Adaptation Costs with Benefits***

The study identified a gap in that; former adaptation economic studies in the ASALs seemed to omit assessment on whether costs exceeded benefits and what if they did. The gap issued in probable failure to candidly highlight specific strategies and or concomitant viability. The clarity on costs benefits variables is critical given climatic changes pose high likelihood to perpetuate vulnerability on the already vulnerable communities (Ensor *et al.*, 2009; ETR, 1999). Also the clarity may inform sustainable adaptation given economic development is pivotal to adaptation as poverty is central to both development and adaptation (World Bank, 2010).

### ***2.6.3 Integrating Local Knowledge and Cultural Values***

A gap existed in that prior studies in the ASALs omitted culture and its salient capacity to influence decision on adaptation. The study appreciated that appropriateness of cost-benefit analysis depends on culturally-determined values, norms and beliefs regarding, say, the legitimacy of organization decision-making, stakeholder consultation and the process of value elicitation (Kerry *et al.*, 2004; NEMA, 2002). Integration of local knowledge and culture is critical particularly because culture influence action as Adger *et al.* (2003) holds and that limits to adaptation are inherent to society and hence dependent on ethics, knowledge, attitudes to risk and culture. Adger raises pertinent issues which underpinned the study in Ijara namely Islam-oriented cultural values versus adaptation and climate change. The gap was addressed through holistic inclusivity during development of data collection tools and the eventual data collation and analysis. The inclusivity included stakeholders' incomes, cultural values and how this influenced their view on extreme weather events and in particular costs and benefits of strategies that they spontaneously implemented.

### ***2.6.4 Bottom-Up/Top-Bottom Economic Assessment***

Earlier studies have held sustained preference for either bottom-up or top-bottom economic assessment. The 'either, or' approach presents a gap in that no one approach is sufficient in and of itself. The study addressed the gap by integrating both and proceeded to work with farmers at household level and extension expertise in the economic

assessment so as to triangulate for consistency and check on possible data gaps. This is more so because expert led or top-down approach has been criticized for not reflecting realities on the ground especially in developing countries where markets are distorted or altogether non-existent (Chambwera *et al.*, 2011, Lunduka, 2013). But neither expert-led nor bottom-up costing approaches alone are to be preferred given that each has a short-coming. Both approaches are constrained by imperfect market particularly in developing countries because whereas expert-led misses out on realities on the ground, bottom-up has no capacity to accurately estimate costs.

### **2.6.5 Gender Consideration in Adaptation Economics**

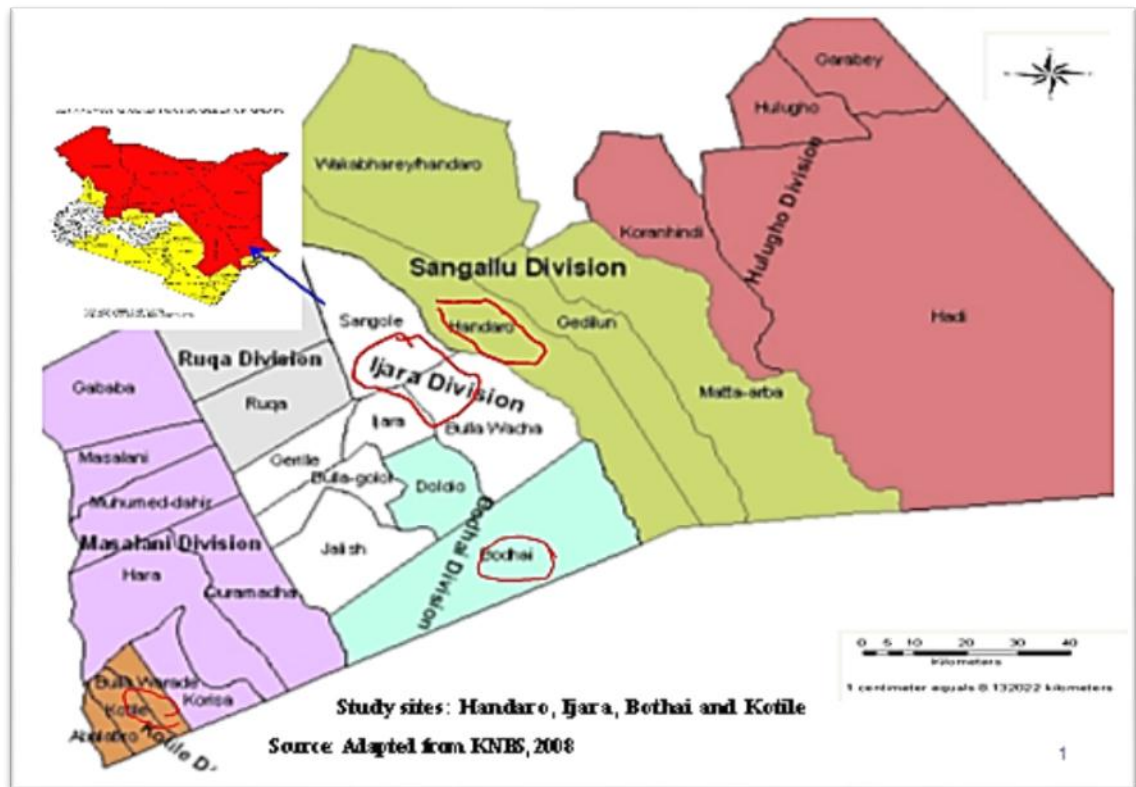
A possible gap from previous adaptation economic studies in the ASALs has been failure to stratify effects of climate change along gender. Adaptation costs and benefits contrast gender-wise as climate change impacts on gender differ markedly and also coping strategies in response to climate variability differ too (Ouma *et al.*, 2008). Moreover, women's and men's perceptions of and responses to impacts of extreme weather events, as well as their access to resources and support, vary fundamentally (Lambrou, 2010). Furthermore, social and economic roles of women also lessen the economic status of women, making them vulnerable to the impacts of climatic change. Consequently, economic status of women lessens due to their reliance on paid employments dependent on natural resources and ecosystem services (Titilope *et al.*, 2010). Additionally, men's and women's experience in climate variability differs. For instance, their coping strategies are complementary but different as they rely on institutional support but have different levels of access (Lambrou, 2010). The study tackled the gap by assessing gender reactions to costs occasioned by impacts of climate change variability and discussed results and recommendations as such.

## CHAPTER THREE: MATERIALS AND METHODS

### 3.1 Background Information

#### 3.1.1 Project Location

The study sites were Bothai, Handaro and Ijara divisions in Ijara sub-county. The sites were purposefully selected based on vulnerability assessment carried out with stakeholders up front whose results are indicated in Table 4.1. The larger Ijara in Garissa County covers 11,332km<sup>2</sup> and is administratively divided into seven divisions namely Masalani, Ijara, Kotile, Ruqha, Sangailu, Bothai and Hulugho. It borders Fafi sub-county to the north, Lamu County to the south, Tana River County to the west and Republic of Somalia to the east. The sub-county is located between latitude 1°, 7' S and 2°, 3' S and longitudes 40°, 4' E and 41, 32' east. Ijara is generally flat with Tana River on its west and the Indian Ocean and Boni forest to the south east.



(Source: Adapted from Kenya National Bureau of Standards, 2008)

Figure 3. 1: Map of Ijara and study sites

### **3.2 Biological and Physical Attributes**

Ijara is both arid and semi-arid and is strategically positioned between the lower River Tana riparian belt to the west and the expansive Boni forest to the east, both of which support pasture growth. The vegetation is generally acacia species of shrubs and grasses particularly star and elephant species. Nearly a quarter of the sub-county is covered by the forest, which is an indigenous open canopy forest that forms part of the Northern Zanzibar-Inhamdare coastal forest mosaic. The ecosystem is without mountains and is characterised by low undulating plains that have low-lying altitude ranging between 0 and 90 metres above sea level. The climatically strategic position, places Ijara in agro-ecological zones IV to VI gradually changing to V and VI, moving away from Boni forest which is influenced by coastal climate.

Temperatures range from 15°C – 38°C and the average relative humidity is 68%. It is estimated that up to 1000km<sup>2</sup> is classifiable as arable land suitable for crop agriculture. A section of the forest, the Boni national reserve is under the management of the Kenya Wildlife Service (KWS) as a protected conservation area. Migration in the sub-county is occasioned by search for pasture during the dry seasons and this mainly involves movement of people and livestock to the Tana River Delta and the Boni forest itself where water and pasture are abundant long after the rains.

#### **3.2.1 Soils Characterization**

Ijara is characterized by reddish brown to red clay-loam to clay soils. In some areas the soil is rocky, stony, gravelly and alluvial along the River Tana basin. These soils are mainly pulverized and acidic with high heavy metal toxicity and P-fixation. The main constraints in the soils are high acidity and low soil organic matter (Obanyi *et al.*, 2010). Other soil types in the sub-county are grey cotton, black saline cotton, red soils and white sandy (FAO, 1998). The land is under communal tenure system, substantially degraded and the small-scale farming is mainly rain-fed with minimal irrigation along River Tana and around a few water pans. Given the ecosystem degradation, a key threat is depletion of soil organic matter. Decimation of the much-needed organic matter is of concern now that climate change will further affect its status as well as the rainfall pattern and intensity (COM, 2009; Woomer and Swift, 1994).

### 3.2.2 Rainfall Trend

The IPCC AR4 total annual precipitation projections suggest increases by about 0.2 to 0.4 per cent per year particularly along the coastline region of East Africa. Kotile and Bothai project sites are expected to receive the peak rise in rainfall. However, the increase will be annulled by the increased evapo-transpiration resulting from rising temperatures (Figure 3.1.11). Hence even with the potentially increased rainfall, costs of agricultural productivity and adaptation in Ijara may be considerably high due to possible eruption of new diseases, breakdown of the already weak infrastructure and soil erosion.

Traditionally, long rains in Ijara occur in March to May whereas short rains occur in October and November with the latter being the wettest season. Conversely, rainfall in the area has increasingly become uncertain and the trend analysed using KMS data (40 years) period indicate a definite decline. Figure 3.2 below illustrates this decline graphically. Actual data provided in annex K.

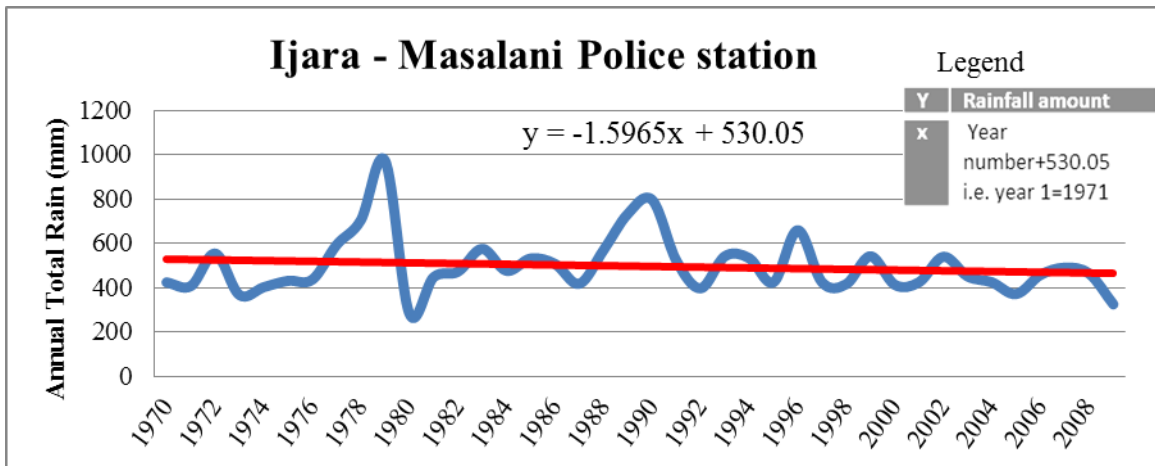


Figure 3. 2: Rainfall trend 1970-2008; Ijara station

As Figure 3.2 indicates, regression equation:  $y$  (rainfall amount) =  $-1.5965x$  (year number) + 530.05, where year 1 is 1971. For instance, rainfall total for 1982 according to the trend-line is  $y = (-1.5965 \cdot 12) + 530.05 = 510.9$  mm. However, predictions from across all models (Figure 3.3a) indicate an upward trend in rainfall with the area becoming increasingly wet and humid from around year 2030. For year 2050 an increment up to

402.3 mm is expected. Predicted rainfall trend in Bothai, Kotile and Ijara division sites indicate a positive, rising trend (Figure 3.3b). The figure shows a time series analysis for rainfall both observed and simulated during twentieth to twenty-first centuries. Each rainy season reveals a trend toward predominantly positive precipitation anomalies in the long rains of the Twenty-first century time series. The analysis shows presence of increased rainfall by 2030, 2050 and 2080 as compared to the current mean rainfall. The increment in both precipitation and temperature may augur well for productivity of pasture and Aloe crops and favorable recharge in water harvesting pans. However, benefits are likely to be outsmarted by costs due to increased run off, new diseases, pest control costs and inaccessible markets.

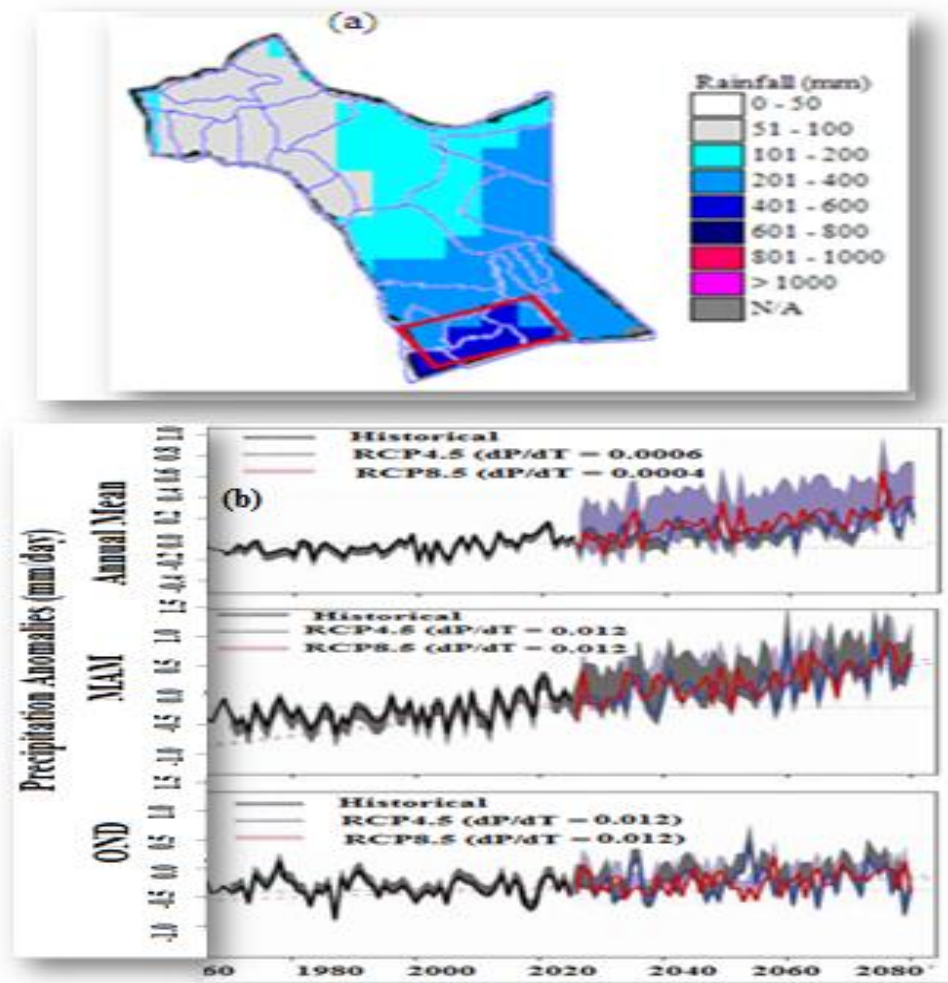


Figure 3. 3: (a) Rainfall distribution (b) Time series analysis

Recent study by IGAD Climate Prediction and Applications Centre (ICPAC) (2013) and as Figure 3.3 clearly shows, the performance of models in projection, effectively reproduced the annual rainfall cycle of the Ijara sub-county. This again confirms validity of the observed data and the increased confidence levels since it agrees with the projected data. The synchrony in the data also confirms increases in precipitation and temperature and the ensuing potential costs impacts on agriculture productivity and on adaptation.

Costs of climate adaptation are likely to have further positive impact as the spatial rainfall assessment over the sub-county (Figure 3.5) confirms the presence of Inter-Tropical Convergence Zone (ITCZ) as large scale signal causing the two rainfall seasonality of March April May (MAM) and October November December (OND). These changes in OND MAM seasons will alter agricultural calendar and productivity in Ijara given traditionally OND rainfall has been higher (Figure 3.3).

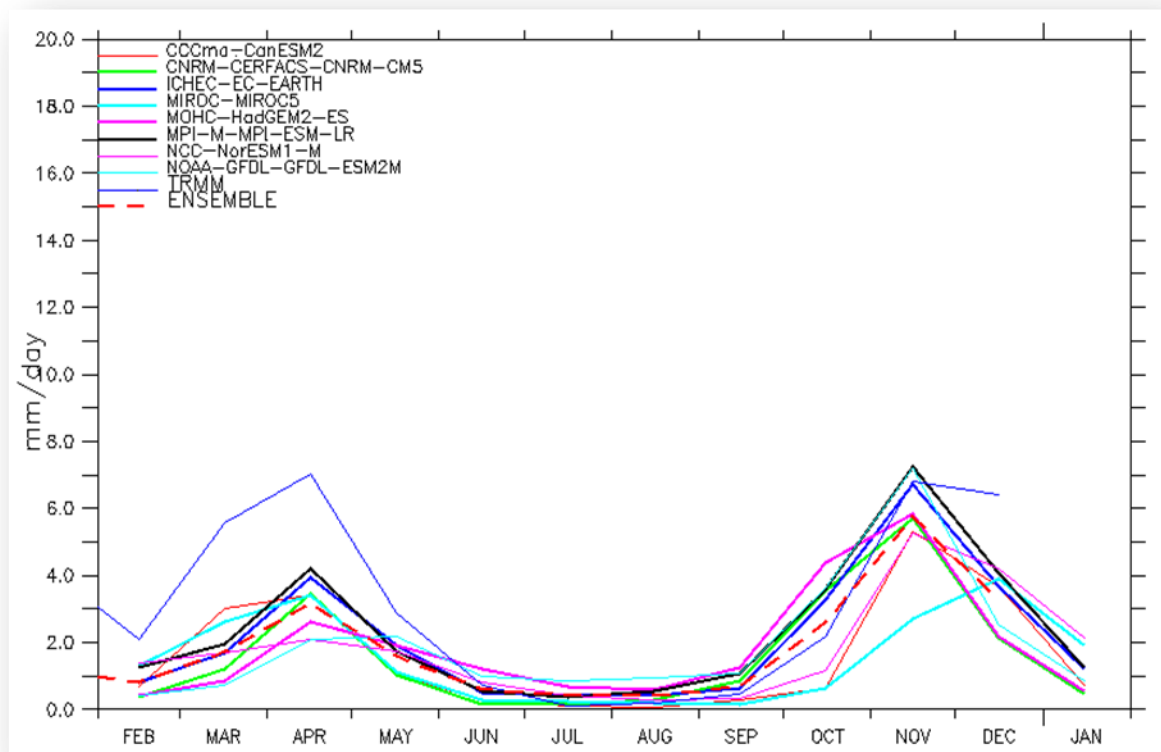


Figure 3. 4: CORDEX Model Assessment of the Annual Rainfall Cycle, Garissa County

The intensity for MAM is highest compared to OND seasons. These projections are in agreement with the fourth assessment report of the IPCC (2007) which indicates that eastern Africa region will be wetter compared to other regions of Africa.

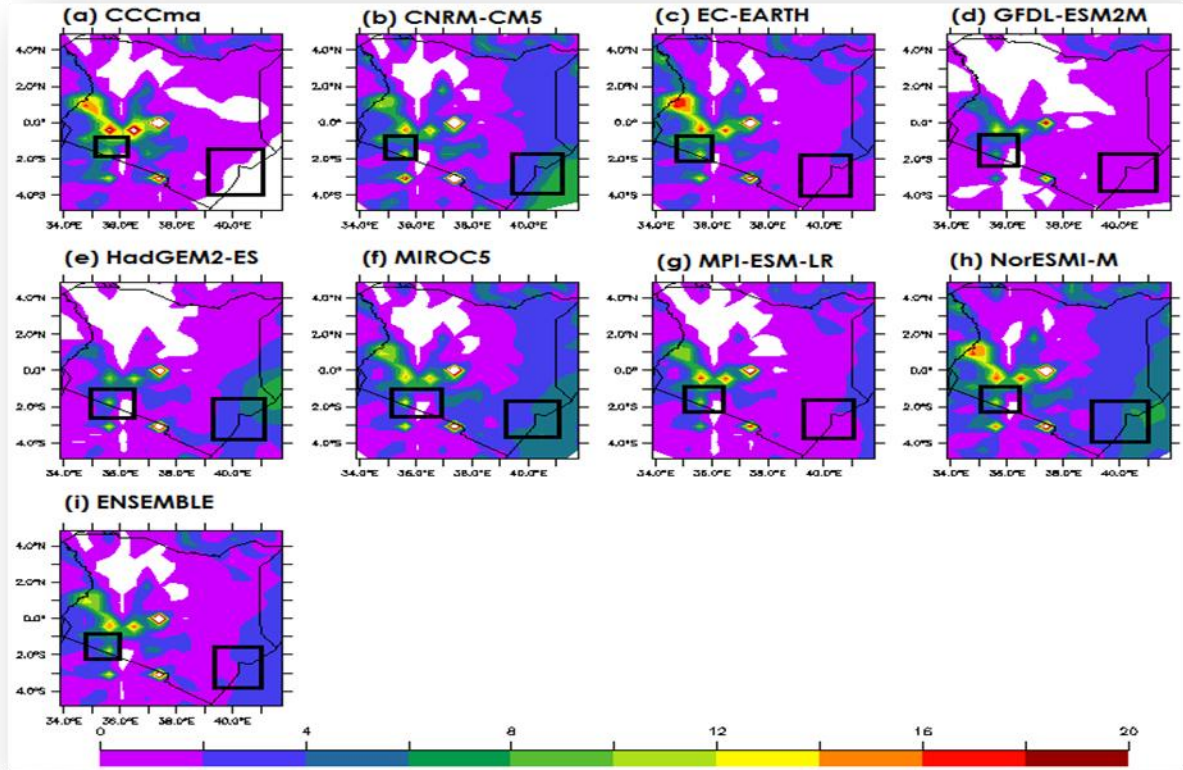


Figure 3. 5: Spatial Rainfall Assessment over Ijara Sub-county

Overall, rainfall prediction from the downscaled climate analysis shows that simulations exhibit negligible dispersion from the observed. The increasing linear trend in the projection is probably an indicator of the sensitivity of the Ijara region's extremes to climate change due to possible external enhancement of the natural climate disturbance. The disturbance and imbalanced ecosystems driven by human activities may result in increased flood risks and dismal agricultural productivity, hence upped costs of adaptation.

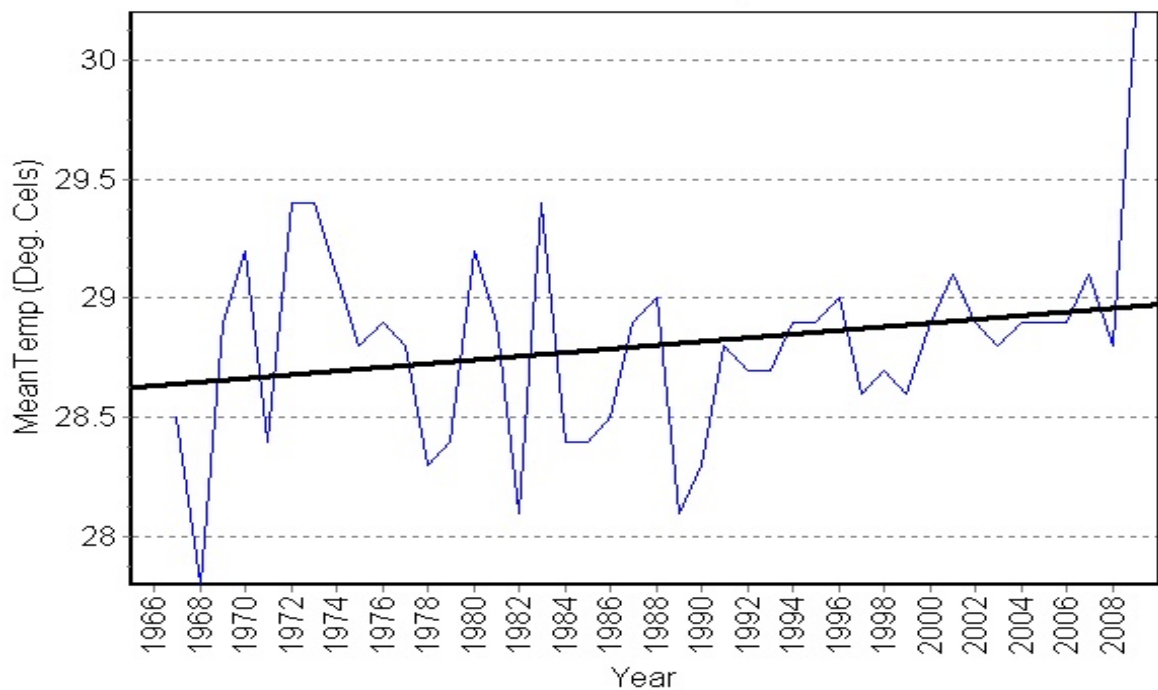
### **3.2.2.1** *Vulnerability, Risk Assessments and Strategies Selection*

Vulnerability and risk assessments focused on natural and socio-economic conditions, current climate risks, local perceptions about climate risks impacts and identification of adaptation strategies. Vulnerability or inability to cope with negative impacts from climate variability is influenced by climate risks and adaptive capacity (IPCC, 2007). Vulnerability assessment followed risk assessment in the three study sites and identified adaptation options to assess. Multi-stakeholder workshops and focus group interviews were used. Sampling procedure applied was random selection of two villages per site. Risk assessment comprised quantitative and qualitative information and realization of risk, its physical, social, economic, and environmental features and values. Risk assessment used available information to determine the likelihood of weather events occurrence and the degree of their possible values. The levels of risk awareness depended largely upon the quantity and quality of available information and on the people's perceptions of risk. A climate risk matrix was developed in a participatory manner in stakeholder workshops; during which three steps were followed:

The study participatorily identified key climatic factors of interest, analysed them and generated possible level of confidence using local knowledge and data from Kenya Met Services (Figure 4.1). Next was risk assessment which focused on climate change impacts to identify their threats, consequences and likelihood of occurrence on which a value was assigned (Annex L). As part of risk assessment, climate information was downscaled from global climatic models (GCMs) to regional models (RCMs), highlighting the study sites. The downscaled data gave the climatic scenarios for 2030, 2050 and 2080 (Figure 3.3). Risk assessment was followed by development of impact and adaptation scenarios whose objective was to evaluate the likely impacts of climate change on variables of interest and potential adaptation strategies using local and expert knowledge. For each impact identified, potential adaptation options were selected through stakeholder consensus. Identification of adaptation options were finalized in a participatory manner using the risk and vulnerability assessment results. Water harvesting, pasture enterprises and multi-benefits aloe cropping were singled-out as the preferred adaptation strategies

### 3.2.3 Temperature Trend

Temperatures in Ijara are often high ranging from 20 to 38 degrees centigrade. The hottest months are September, January and March, while the period between April and August is relatively cool. The mean temperature in the region is expected to increase by 3–4°C by the end of the 21st century, which is roughly 1.5 times the global mean response (Skiba *et al.*, 2012). The rise is evident from the long term observed records from Garissa meteorological station (Figure 3.6)



Source: Garissa MET station

Figure 3. 6: Mean annual temperature trend (1966-2008)

The rise in temperature predicted at 2-4°C by 2100 denote dramatic impacts on vital sectors, chiefly agriculture, with likely virulent effects on the already vulnerable communities (Cooper *et al.*, 2012) particularly in the ASALs such as Ijara where Handaro harvesting water pan, pasture enterprises and Aloe crop under study are to be found. The strategies which are a shift from the traditional strategy of migration are resultant to the realization of the uncertainty initiated by climatic shocks discussed earlier, meagre resources and diminishing resources, decimation of the traditionally-

relied-upon livestock keeping that drove Ijara communities to spontaneously initiate the three strategies. Aloe farming for instance was initiated as alternative livelihoods in 2009-10. To that end and to diversify risks, Aloe production commenced on-farm and a processing equipment set up in Kotile, Ijara which now processes shampoos, soap and body lotions. However, the adaptation strategies in use in Ijara were impulsive and only reacted to extreme weather events that already were ravaging the ecosystems. By strengthening cost-effective adaptation measures whose costs and benefits are clear, it is feasible to thwart anticipated climatic-variability damage by 2030 (Chaisemartin, *et al.*, 2010).

### **3.2.4 Viability of Water Pan, Pasture and Aloe**

Key among costs assessed on water pan, pasture and Aloe were those on planning, facilitation, preparations and implementation in line with IPCC (2007). In relation to this the study advocated for those cost-lines whose marginal benefits exceed marginal costs. And while doing this, the researcher appreciated that a– pre-climate change scenario in the region cannot be fully restored as in every adaptation effort there would be residue damage as seen in (Fankhauser, 2009) and World Bank (2010).

#### **3.2.4.1 Viability of Water Harvesting Pans**

Water pans in Ijara are strategically positioned to hold-back surface run off, contain underground water and stabilize soils in situ and downstream. Also, the water facilities offer a much-needed source of water to livestock, wildlife, domestic use and crop agriculture. However, neither the costs of implementing the pans nor the benefits gained from the use were clear; given the strategies were spontaneously undertaken which necessitated the economic analysis, so as to inform planning, and policy framework. The analysis focused on Handaro water pan due to the combination of livestock and agriculture activities that took place around it as was anticipated at the planning stage.

#### **3.2.4.2 Viability of Pasture**

Faced with the extreme weather events and markets being elusive, a key solution to livestock feed deficits is pasture production using suitable grass species and viable seeds

from reliable dealers. Apart from natural pastures, the study assessed on-farm Sudan grasses (a kin to sorghum) as they are known for being drought resistant, and are more efficient in water absorption because they have many secondary roots per unit of primary root and have a small leaf area for reduction of evaporation. In addition, the grasses have the ability to go dormant for extended drought periods with growth resuming with the re-appearance of rains

#### **3.2.4.3 Viability of Aloe Crop**

Aloe farming in Ijara commenced spontaneously in response to impacts of the ravaging weather shocks. The farming was deemed apt alternative to the diminishing resources in particular livestock, the region's fall-back resource. The start-up was supported by Arid Lands Project in conjunction with Ministry of Agriculture in 2009. Among the initial investments was a processing plant in Korissa, Kotile centre where Aloe products are processed. To date there are 100 farmers who maintain on average, half hectare of Aloe each, having gradually transited from pastoralism to agro-pastoralism. Aloe plots are accessible in Sangailu, Ijara, Masalani, Korissa and Kotile, where processing also takes place. However the spontaneity in Aloe strategy meant costs and benefits were indistinct. The indistinct necessitated the economic analysis so as to inform policy on sustainable management of the diminishing resources and social-economic development in the ASALs.

### **3.3 Socio-Economic Characteristics**

The total population in Ijara sub-county is 92,663 comprising of 50,165 male and 42,498 female. The area's population growth rate is 3.7% (KNBS, 2012) while poverty index stood at 63% with over 90% depending on pastoralism (GoK, 2005). There are 13,180 households with an average size of 6 members. The number of female headed households is 4,006 and children headed households 572 (Ijara District Strategic Plan 2005-2010). Approximately 640 people are disabled while about 1246 children need special attention. The sources of income in the sub-county are as follows; 60% (agriculture, mainly livestock); 20% (rural self-employment); and 15% (wage employment) (GoK, 2009). The key drivers of poverty in the sub-county include poor governance and weak institutions;

high population growth rate; high illiteracy levels; limited access to capital and markets; poor infrastructure; ecosystem degradation; inter-clan-ethnic conflicts; cyclic complex disasters primarily drought and floods; and over-reliance on livestock (Ijara District Strategic Plan 2005-2010).

Livestock keeping is the main economic activity in the district and pastoralism the key management practice. The main livestock types include: indigenous Boran cattle, Galla goats, Black Headed Persian sheep, indigenous poultry and donkeys. However, this is constrained by among others; low carrying capacity due to poor soils, low rainfall and high rate of surface evaporation; high prevalence of diseases and pests; poor marketing; and frequent droughts. Tourism is a possible alternative livelihood in the sub –county due to the presence of myriad wildlife species but has not been fully exploited. Secondly, there is fishing potential in the nearby Tana River that can provide alternative livelihood option. Key constraints to the optimal utilization of natural resources in Ijara include insecurity due in part to stiff competition for the scarce resources like water and pasture; Poor physical infrastructure including inaccessible roads; and underdeveloped telecommunication services.

### **3.4 Research Design**

The study design was survey that used purposeful sampling to identify focus groups and expert key informants for in-depth investigation given both categories were especially informative on costs benefits of the adaptation strategies in use (Newman, 1997; Creswell, 2014). For purposes of generalization inferential statistics were used to make deductions and generalizations about the whole population. According to Mugenda and Mugenda (2003) inferential statistics handle inferences about population-based results obtained from the sample. The results were presented in form of tables, and figures. The quantitative and qualitative interview tools were handy in interrogating costs and benefits of water pan, pasture and aloe crop adaptation strategies. Cost benefit analysis was used to compare the present value of a stream of benefits to a stream of costs. These values were discounted to calculate the present value of future costs and benefits. Adaptation costs quantified were those on planning, land preparation, fencing, seeding and labour,

whereas adaptation benefits were water for domestic and livestock use, incomes from sale of agricultural products around Handaro water pan and time saved from trekking far for water which is invested in other economic pursuits.

According to IPCC (2007) these costs are grouped as those on planning, preparing for, facilitating and implementing the adaptation strategies, whereas the benefits are the avoided damages from implementing the strategies. Concrete responses in the questionnaires were subjected to descriptive statistics allowing for illustrative tables, charts, graphs and diagrams to depict some trends of the findings. This was done to enhance qualitative analysis and presentation. Non-market aspects of the project namely social and environmental benefits and costs such as effects of water pan on the environment or livestock numbers as status symbol were evaluated qualitatively. In this regard contingent valuation was used to estimate the value of such benefits that do not have an established monetary value by asking stakeholders what they would be willing to pay (WTP) for specific benefits (Cameron and Quiggin, 1994). These views were collated mainly through multi-stakeholder workshops and focus group discussions. A part from the methods, Student “t” test was used on arithmetical comparison of costs benefits values before and after construction of Handaro water pan. Figure 3.7 show the key factors, activities, method, data and variables that were considered in quantifying cost and benefits of adaptation strategies and the presumed relationship among them (Miles and Huberman, 1994)

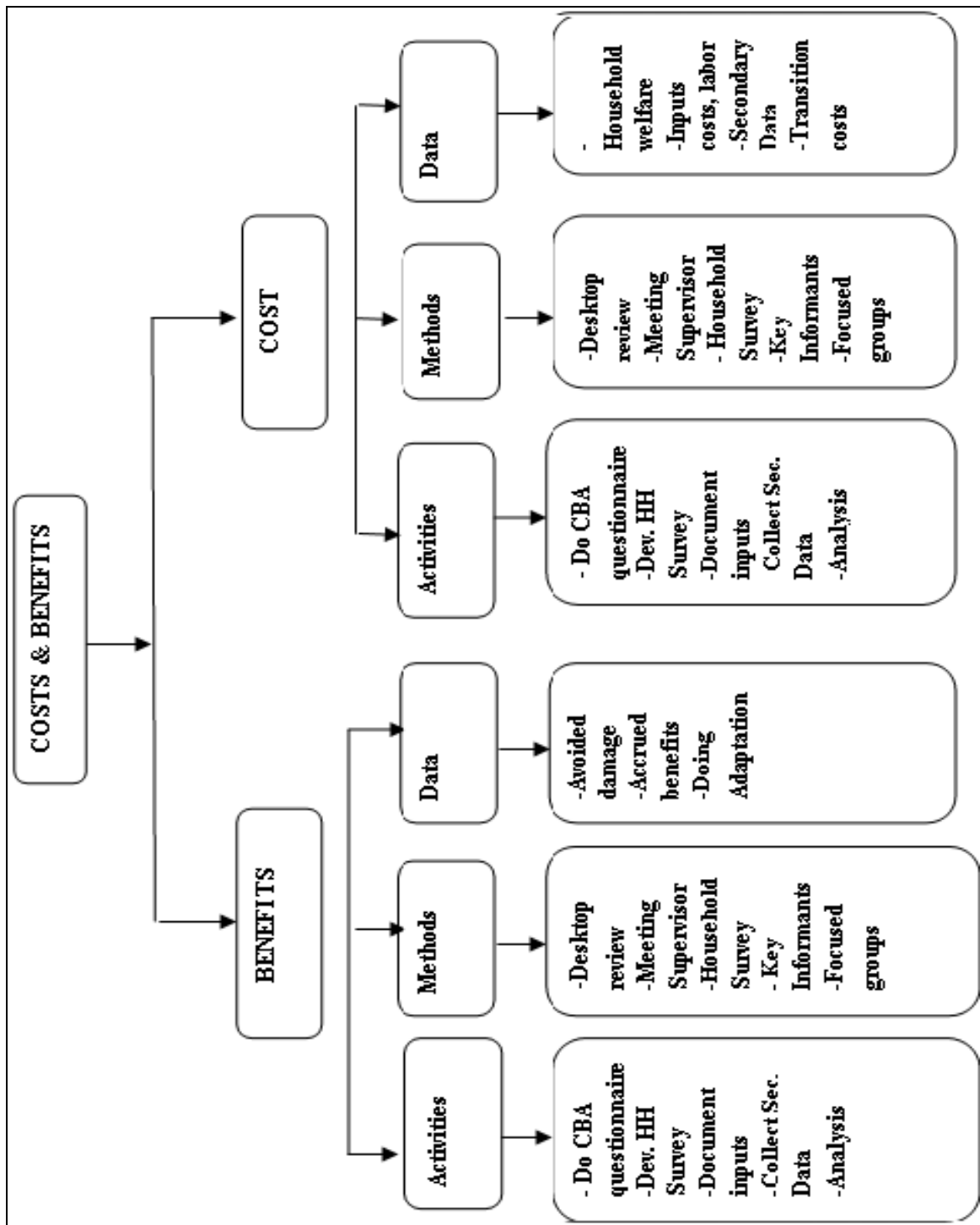


Figure 3. 7: Costs and Benefits Analysis

Cost benefit analysis complemented by NPV tools were the main methods to tap into Ijara stakeholders' knowledge on how climate change in their environment has impacted

agricultural output. Where costs or benefits did not have monetary values, contingency valuation method was used to compare non-monetary values of the strategies. Costs Benefit Analysis was used to identify, quantify and to add all the positive factors (benefits), and did the same on the negative ones and then subtract all the negatives (costs) with the difference between the two advising on viability of the adaptation strategies (Chambwera *et al*, 2012; McDonald, 2009). The net present value (NPV) is an indicator on economic viability of a project. The higher the value on the indicator, the more viable a strategy is. Also CORDEX models and climatic data prediction from Kenya Met Services (KMS) were used to predict how the changing climate and variability will impact on costs and benefits of strategies implemented and their viability prospects. Five to Ten years were used as the medium term planning period, being the phase in which it is expected that the cash inflows will outgrow the recurrent costs and provide desirable returns.

### 3.5 Sample Size

The sample was arrived at using a table developed by applying the formulae for determining sample sizes for known populations as shown below (*The NEA Research Bulletin*, 1960; Neuman, 1997): The formula discussed was used to determine the sample size drawn from a finite population of 9000 households in Ijara:

$$Size = \frac{X^2 NP(1 - P)}{d^2(N - 1) + X^2 P(1 - P)}$$

**Where:**

$X^2$  is the value of chi-square @DF=1 for desired confidence level for 0.10 =2.71

$N$  is the population size which in this case is 9000 households

$P$  population proportion (assumed to be 0.50)

$D$  is the degree of accuracy (expressed as a proportion)

For purposes of the analysis, the following values were used for the parameters in the formulae

- a. Took the value of the chi square( $X^2$ ) at degrees of freedom =1 at the desired confidence interval of 0.10 which when looked up at the Chi square distribution table yields 2.71

- b. In addition N was considered; being the population under study, that is 9000 households actively engaged in farming
- c. Took the population proportion to be 0.50
- d. The degree of accuracy expressed as a proportion, was calculated as 0.00523. Given the above values, the following was arrived at:

$$\begin{aligned}
 \text{Size} &= \frac{2.71 \times 9000 \times 0.5(1 - 0.5)}{0.0523^2(9000 - 1) + 2.71 \times 0.5(1 - 0.5)} \\
 &= \frac{2.71 \times 9000 \times 0.5 \times 0.5}{0.00274 \times 8999 + 0.677} \\
 &= \frac{6097.5}{24.65726 + 0.677} \\
 &= \frac{6097.5}{25.33426} \\
 &= 240 \text{ (Rounded to the nearest whole number)}
 \end{aligned}$$

Of the 13,180 households in Ijara; only 9000 actively engage in either livestock or crop farming. Given the sample population is 9000, sample size n=240 households, for the selected sites in Handaro, Ijara and Bothai were purposefully drawn assigning 80 households per site. Random sampling was then applied to select the 80 households from total population of each of the three sites.

### 3.6 Sampling

In line with sampling formulae discussed above, purposive sampling (Patton, 1990) was employed in the study for its capacity to guide in-depth data collection. Patton indicates that; “the logic and power of purposive sampling lies in selecting information-rich cases for an in-depth study. Information-rich cases are those from which one can learn a great deal about issues of central importance to the research”. In this study, key issues were adaptation costs and benefits and the information rich cases were those farmers who engaged themselves in pasture enterprises, aloe crop and water pans as adaptation strategies. A list of smallholder farmers using the strategies were developed by first reviewing records from respective agriculture and livestock departments from which sampling frame was generated. Subsequently, sample sizes were calculated proportionate

to the number of farmers on the compiled list and random sampling was used to obtain a sub-sample for each of the sites (Osotimehin *et al.*, 2006; Nimoh *et al.*, 2012). A total of 240 respondents were involved in the study and primary data were collected through key informants, focused group discussion and household interviews using a structured questionnaire. Secondary data were collected from government departments, UN agencies and NGOs using document review mode (Thrusfield, 1986; Weiss, 1998).

### **3.7 Data instrumentation**

Structured questionnaires were administered to 240 pastoralists and agro-pastoralists in Bothai, Ijara and Handaro divisions of the larger Ijara sub-county. The questionnaire development procedure was a kin to works by Thrusfield (1986) and Osotimehin *et al.* (2006) and included open and closed-ended types of questions. The questionnaire was administered by trained enumerators under the supervision of the researcher. The enumerators had been recruited during pre-visits, and were employed to ease language barrier and acceptability within the communities. Concrete responses in the questionnaires were subjected to descriptive statistics allowing for illustrative tables, charts, graphs and diagrams to depict some trends of the findings. This was done to enhance qualitative analysis and presentation. For secondary data records of accounts were sourced from the National Drought Management Authority, Ministry of Agriculture and Livestock, Ijara, Ministry of Water and Irrigation and reviewed.

### **3.8 Piloting of the questionnaires**

Pre-testing of the data collection tools was carried out in Sangailu Division in the larger Ijara district which was chosen because it had similar characteristics with the study sites. Fifteen respondents were interviewed in order to determine the effectiveness of the research tools primarily with regard to the validity and reliability. The results indicated that the instruments had capacity to pick valid responses and that data so collated was reliably effective to assess costs and benefits of the adaptation strategies under study.

### **3.9 Data Presentation and Analysis**

#### **3.9.1 Study variables**

The variables in the study were costs, benefits and adaptation (independent variables). The desired phenomenon (dependent variable) was sustainable social welfare and upped resilience. In between independent and dependent variables were intervening variables that showed linkage between the two variables. Along the variables, data was collated and so analysed.

Statistical package for social science (SPSS) and Excel software packages were used to analyse the data. Excel sheets were handy in storing, organizing and manipulating data as it uses numbers, text and formulas to perform basic calculations and to find the average, maximum, or minimum values in a specified range of data. It was found convenient for data entry, and for quickly manipulating rows and columns prior to statistical analysis and once this was done SPSS (Version 17) computer programme was used for analysis descriptively using frequencies, percentages, mean and cross tabulation. The methodology used to calculate economic returns was cost benefit analysis (CBA) employing the net present value (NPV) tool to show strategy viability. The cost benefit analysis was used as a standard method decision tool to guide resource allocation, impacts assessment, comparability of costs and benefits, as they are expressed in monetary terms and the value they present to the community (Commonwealth of Australia, 2006). The objective was to compare the present value of a stream of benefits to a stream of costs. Discounting was used to calculate the present value of future costs and benefits. Evaluation was based on net present value (NPV). Essentially use of the economic analysis to include environmental cost benefit analysis assessed the impacts of interventions on the economics to determine whether the intervention contributed to social welfare. Market prices were discounted by 15% to take care of distortions due to market fluctuations.

As described below, the study used the Krutilla and Fisher model Krutilla, (1975) to interrogate the cost-benefit analysis (CBA) through the net present value to determine whether the three strategies' costs would be profitable compared to the baseline or

“without the adaptation” or “alternative intervention”. NPV is the Present Value of the stream of future cash flows from a project minus the project’s net investment. Building on works by Myers, *et al.*, (2005) the cash flows were discounted at the market rate as appropriate cost of capital as follows:

$$NPV = CF_0 + \frac{CF_1}{(1+K)^1} + \frac{CF_2}{(1+K)^2} \dots + \frac{CF_n}{(1+K)^n}$$

Where NPV= *Net present value*

$CF_0, CF_1, CF_2 \dots CF_n$ , are the cash flows (*Monetary costs-Monetary benefits*) for periods  $t=0, 1, 2 \dots n$

$K$ =the discounting factor also known as the opportunity cost of capital.

NPV = Present Value of future cash flows – Investment

NPV Decision Rule: If  $NPV \geq 0$  then investment in a strategy is considered viable and acceptable

The study sought to unveil the costs and benefits from livestock feed enterprises, water pans and aloe crop and to relate them to the awareness level to the overall climate change adaptation. The following financial indicators were evaluated for the adaptation:

- i. Cash flow was used as a measure of the balance between revenues and costs, with appropriate accounting for depreciation and liabilities. The discount rate used was 15% being the prevailing interest rate in the financial markets which rates decline over time (Myers *et al.*, 2005);
- ii. Net present value (NPV) tool was used being the sum of revenues and costs over time, based on an assumed discount rate, referenced to the present (the first year);
- iii. Payback period factored in was 5 to 10 years being the period in which it is expected that the cash inflows will outgrow the recurrent costs and provide desirable returns for the investment.

## CHAPTER FOUR: RESULTS AND DISCUSSIONS

### 4.1 Preview

The results discussed in this chapter answer research questions that mirror the analysis of specific objectives of the study. The objectives were to analyse costs, benefits, whether costs exceeded benefits and suitability of water pans, Aloe crop and pasture as adaptation strategies. Data collection methods and instruments used were CBA with NPV as indicator of viability, contingency valuation, historic and climate models data tools were used too. To appreciate the socio-economic environment in the area, this section presents the results in the following manner: socio-economic characteristics of the respondents, descriptive statistics for various adaptation strategies, climate change perceptions and variations, and contribution of the respondent's awareness of the cost of adaptations to the climate change debate and rural development. It ends with a model estimation and description of the economic costs.

### 4.2 Study Results

#### 4.2.1 *Vulnerability, Risk Assessment and Identification of Strategies*

To identify adaptation strategies in a participatory manner, a rapid vulnerability assessment was conducted followed by adaptation options selection at the pre-field phase of the study (see Annex B, C and I). The assessment aimed to establish household vulnerability levels resulting from climate change and variability and what adaptation strategies best suited the scenario. Household vulnerability assessment was conducted using questionnaires and focus discussions tools. Farmers in the three project sites concurred on the following; 1) rainfall had declined and become more erratic both in intensity and spatial 2) temperature was on positive trend, frequent and prolonged droughts threatened agriculture livestock productivity 3) wind direction was increasingly unpredictable and affected rainfall distribution or its failure altogether (Table 4.1). Identification of water harvesting pans, pasture and aloe crop as adaptation options were finalized in a participatory manner based on the vulnerability assessment results. Other considerations included the economic study timelines, viability of the identified options as well as costs and benefits.

**Table 4. 1: Summary Climate Related Impacts Factors as Felt in Ijara**

Location	Climate related impacts								
	Rainfall Reduction	Erratic Rainfall	Increased rainfall intensity	Sporadic but slightly increased rainfall amounts	Temperature increase	Drought	Prolonged drought incidences after the El-nino events	Floods/ sea water intrusion inland	Unpredictable wind direction
Bothai, Handaro			●		●	●			●
Sangole-Ijara, Kotile			●		●	●			●

As results on Table 4.1 show, rainfall was of greatest concern in all the sites due to its reduction, increased intensity and sporadic but slightly increased precipitation. The unpredictable rainfall pattern occasioned flooding and drought that impacted adversely on Ijara ecosystems issuing in decimation of crop and livestock. Similarly the results show unpredictable wind direction which explained *inter alia* erratic rainfall scenario.

### 4.3 Socio-Economic Characteristics

Farmers’ responses were solicited using a questionnaire in which their socio-economic profile was sought. It was necessary to assess aspects of the socioeconomic background of the farmer given it influences reaction to impacts of climate change and farm productivity levels (Helena *et al.*, 2014). Consequently, it was vital to understand their socio-economic characteristics and the inter-play across them in relation to costs and benefits of adaptation. The variables assessed were gender, household size, length of stay, relationship of the respondents to the household heads and source of livelihoods. A brief discussion on each follows:

#### 4.3.1 Socio-Economic Variables Influence on Adaptation

The findings indicated that 46% of the respondents were male whereas 54% were female. Among them 57% headed the households interviewed. Overall male-headed households

were 63% and child-headed household was 1%. Up to 75.54% farmers had lived in the area for more than 30 years which was useful to the study as it indicated majority understood local weather pattern and adaptation measures being measured comparatively well (Table 4.2). On average household size were 5 members. These demographics were considered vital as impacts of climate change and variability affect household members fairly differently e.g. women and girls traditionally walked 15-20 km to fetch water. In this case, the more the number of women and girls, the better the output from chores.

Table 4. 2: Respondent Gender and Duration of Stay in Study Area

During population lived in Ijara		Gender of respondents	
Duration lived in area (Years)	Population percentage	Male	%
0-5	20.96	✓	46.0
6-10	19.21	Female	
11-15	11.35	✓	54.0
16-20	15.28	Total	100
21-25	7.86		
26-30	12.23		
31-35	6.11		
36-40	5.24		
40 and above	1.32		

Equally critical was understanding gender of respondent and relationship to household head given the varied traditional gender reaction to extreme weather events (Table 4.3). For instance drought periodically pushed men household heads to migrate livestock to far-flung greener areas along the Indian Ocean.

Table 4. 3: Gender of Respondent and Relationship to HH Head

<b>Gender of HH and relationship to HH head</b>			
Relationship to HH head	Population percentage	Gender	
HH head	57.0	Male	%
Spouse 1	39.0	✓	62.28
Spouse 2	0.9	Female	
Child	0.9	✓	36.72
Grand child	1.8	Child	1.0
Parents	0.4	Total	100
Total	100		

#### **4.3.2 Source of Livelihoods in Ijara sub-county**

Within that period of stay in the area effects of climate variability had necessitated changes in occupation besides the traditional pastoralism to included crop farming, business, remittances and wage incomes (Table 4.4). Also 4.4, 48.35% of the households engaged in livestock farming as a livelihood strategy whereas 30% engaged in pasture and other crops. Apart from provision of food to the community from sales, pastures generated income, and in turn became alternative livelihoods that build community's resilience to effects of climate variability. However, the challenge in this sector was poor marketing infrastructure. The area has no standard livestock market and relies on markets from neighbouring sub-counties. This is due to inhibition of livestock trade by veterinary regulations, poor animal health and body conditions, and diseases and partly due to overgrazing- all of which raise costs of production. Similarly, there has been lack of capital assets in the area limiting the trading volume among the livestock traders, with frequent extreme events, mainly drought and floods compounding the situation (Table 4.5).

Other significant livelihood sources were remittances from outside the sub-county at 9.92% and salaried incomes 1.45% (Table 4.4). Forty-one per cent farmers had engaged in the climate change adaptation strategies under discussion for the past ten years implying that the adaptation strategies have gained prominence in the last one decade. Crop farming itself was found to be a fairly new undertaking in the study area. The

findings show that communities that traditionally relied on pastoralism have increasingly been conditioned to incorporate crop farming by extreme weather events and variability.

Table 4. 4: Percentage Livelihood sources in Ijara

Livelihood	Frequency	Per cent (%)
Livestock farming	234	48.35
Shop business	48	9.92
Pasture and other crop farming	147	30.37
Remittances from outside the area	48	9.92
Employment income	7	1.45

#### 4.4 Climate prediction and costs benefits effects

CORDEX models and climatic data prediction from Kenya Met Services (KMS) indicated that the changing climate and variability impacted significantly on costs and benefits of adaptation. Whereas traditional precipitation trend (Figure 3.6) show a steady decline, the curvature looks up as from 2030 indicating increased precipitation in the coastal belt to include Ijara. However, the positive traditional temperature trend (Figure 3.6 continues. Interestingly 32.08% households were of the view that there is noticeable temperature rise in the last ten years while 67.56% indicated rainfall intensity flood, frequency and geographical spread for the last ten years-albeit unpredictable Table 4.5). The prevailing climate trend shows a steady temperature rise whereas rainfall is unpredictable with tendency to flood when it occurs. Table 4.5 show the extreme weather events in the last years

Table 4. 5: Effects of extreme weather events in Study Area

Extreme event/Shock	Frequency	Per cent%
Increased temperature	162	32.08
Unpredictable rainfall intensity pattern and flood	75	67.56
Wind gusts	1	0.42
Total	240	100

#### 4.4.1 Noticeable Changes in Weather Pattern in Ijara

Of concern to 91.2% farmers, and the most noticeable weather pattern change was rainfall intensity, frequency and geographical spread in the last 30 years. Other changes in precipitation were that rains came earlier 59% and heavier 25%. These rainfall changes concerned farmers due to ensuing high costs of pasture. Also migration for greener pasture far away from home, often championed by men had direct and indirect socio-economic costs.

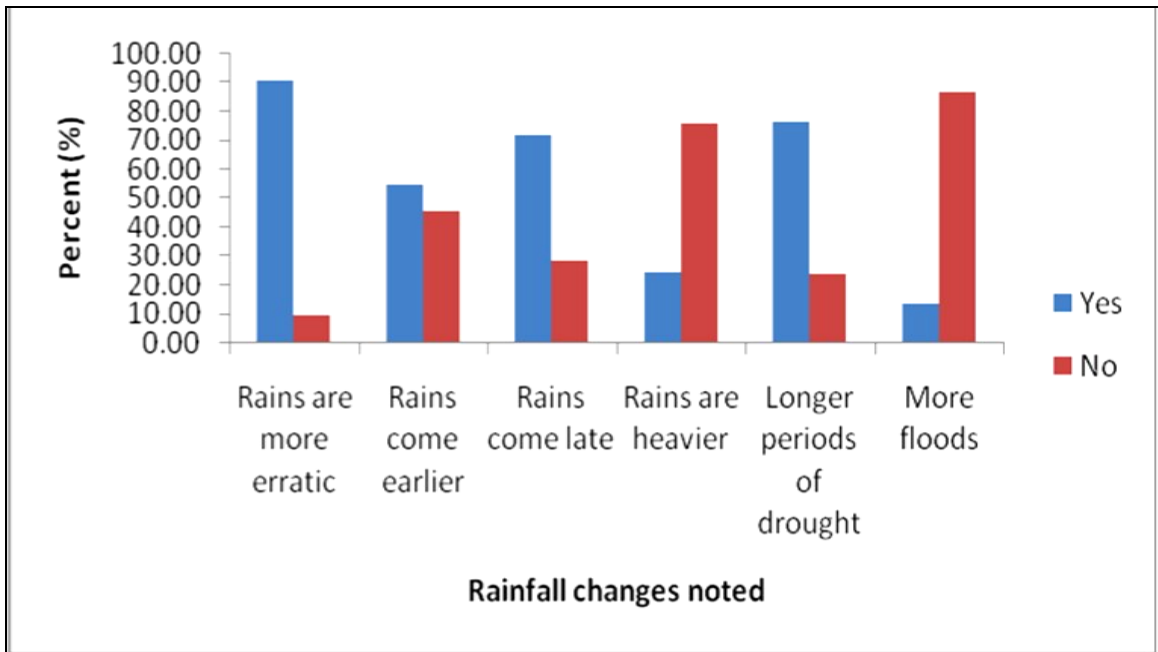


Figure 4. 1: Percentage Noticeable rainfall changes in Ijara

As Table 4.6 show, 52.9% pastoralists believed climate change was caused by deforestation, 69% by the will of God (*Shauri ya Mungu*) whereas 32.08% blamed burning fossil fuels. Further, the study specified that drought was the single most significant extreme weather event in the study area. Other challenges and climate variability related shocks were decimation of pasture 13.45%, diseases 7.96% and lack of water 12.03% (Table 4.17). The shocks worry local community who admit to the resultant diminishing quality of life (Mwaura *et al.*, 2013) and its attendant costs such as forced migration to Boni forest and Kipini areas along the Indian Ocean.

Table 4. 6: Causes of Climate Change in Study Area

S/N	Causes	Frequency
1.	Burning of fossil fuels e.g. coal, oil, gas, petrol	6
2.	Deforestation- slash and burn	77
3.	Horticulture, livestock production activities	113
4.	Will of God	127
5.	Lack of Humanity	2
6.	Increased population	10
7.	Don't know	4
	<b>Total</b>	<b>340</b>

Based on the results, adaptation is desirable not just because it increases resilience, but for the co-benefits it offers in form of agricultural productivity and emissions reduction and apt socio-economic development. In addition, subsequent discussions with key informants established that other observed shocks are erratic rainfall (traditionally started in April for the short rains October for the long rains but turned erratic (Table 4.1). Others are increased human and livestock diseases incidences and type. This high response portends both despondency and good hope for preferred adaptation strategies as stakeholders are ready to opt out of the unsavoury situation occasioned by climate change and variability. Also it is an opportunity for synergistic partnerships and appropriate networking among local, national and international stakeholders.

Table 4. 7: Livelihood Challenges Existing Before Strategies Intervention

Livelihood Problems before intervention	Frequency	%
Animal diseases	76	13.45
Pasture land decimated	45	7.96
Drought	201	35.57
Livestock attack from predators	65	11.50
Shortage of food	18	3.18
Water shortage	68	12.03
Time wasted trekking for water	32	5.66
Animal dying due to thirst	29	5.13
High prices of food	31	5.48
Total	565	100

#### 4.5 Coping with Extreme Weather Event in Ijara

In the event of diminished adaptation capacity the households would willingly persist on planting trees and nurturing pasture in own land 40.83%, retaining only manageable livestock numbers and right breed 20.83%, harvesting rain water and using soil control structures 16.25%, in that order of preference. Of these options, adjusting livestock numbers and nurturing and conserving pasture were the most preferred; naturally because livestock remains the dominant livelihoods in the area (Table 4.8).

Table 4. 8: Adaptation Strategies preferred in Study Area

S/N	Adaptation Strategies	Frequency
1	Must plant trees/ bushes on our lands	46
2	Ought to nurture, conserve pasture	12
3	Plant more trees than we cut	40
4	Keep number of livestock that my land can provide for	23
5	Diversifying agricultural crops e.g. aloe	4
6	What to do in the event storm or severe drought strikes	5
7	Adopt improved livestock breeds	27
8	Harvest rain water and use soil control structures	39
9	Importance of harvesting rain/storm water	2
10	Avoid building houses on slope, unprotected land	10
11	Cooperate with others, adaptation is responsibility for all	6
12	Nothing	6
13	Other	4
	<b>Total</b>	<b>240</b>

As Mwaura *et al.* (2013) affirms 85% of agro pastoralists and pastoralists in ASALs are aware of climate change and the effect from the ensuing impacts necessitating adaptation. Adaptation is a matter of the present, often requiring immediate intervention and it is important that it enjoins other development planning, programs and projects (FAO, 2009; World Bank, 2008). The main extreme events in the area were drought and floods whose adverse impacts included decimation of pasture, loss of assets and income, decline in

crop yield, livestock death, loss of entire crop and food insecurity (Figure 4.2). Conversely, investments in coping measures caused emission from agriculture practices and so the intervention needed limitation to carefully select cost-effective climate-smart options (CCAFS, 2009).

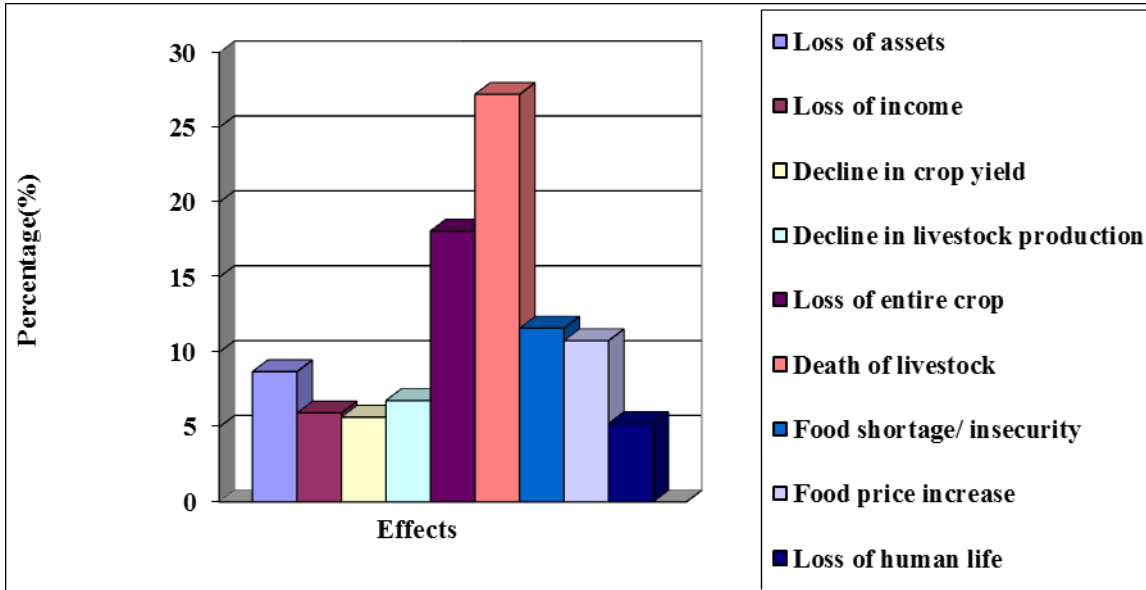


Figure 4.2: Effects of the extreme climate events on livelihoods in Ijara

A key lesson here is that to maximize on benefits from adaptation, it is imperative to factor-in that adaptation responses may have negative consequences for food security, and that some farmers were privy to this knowledge. For instance 37.5% farmers were apprehensive that slash and burn agriculture and livestock production approaches were responsible for emissions (Table 4.6). It is noteworthy that the view on emission from farmers echoed conclusions in GoK (2013). The concurrence was that other than sequestering carbon, agriculture activities contributed to emission through livestock-paddies enteric fermentation and fertilizers. Agricultural activities reviewed were tomatoes, onions, natural pasture, water melon, on-farm grasses, and livestock production. Aloe crop was singled out as most climate-smart (Table 4.8). Up to 33.23% agro-pastoralists specified that livestock and horticulture production contributed the most to emission-arguably attributable to the array of chemicals used in production (Table 4.16).

#### 4.5.1 Costs of Adaptation to Extreme Weather Events in Ijara

Costs limitations to adaptation against the snowballing frequency of extreme weather events, mainly drought were lack of finances 48.12%, no skills 39.85% and lack of climate change know-how 12.03% in that order of priority (Figure 4.3).

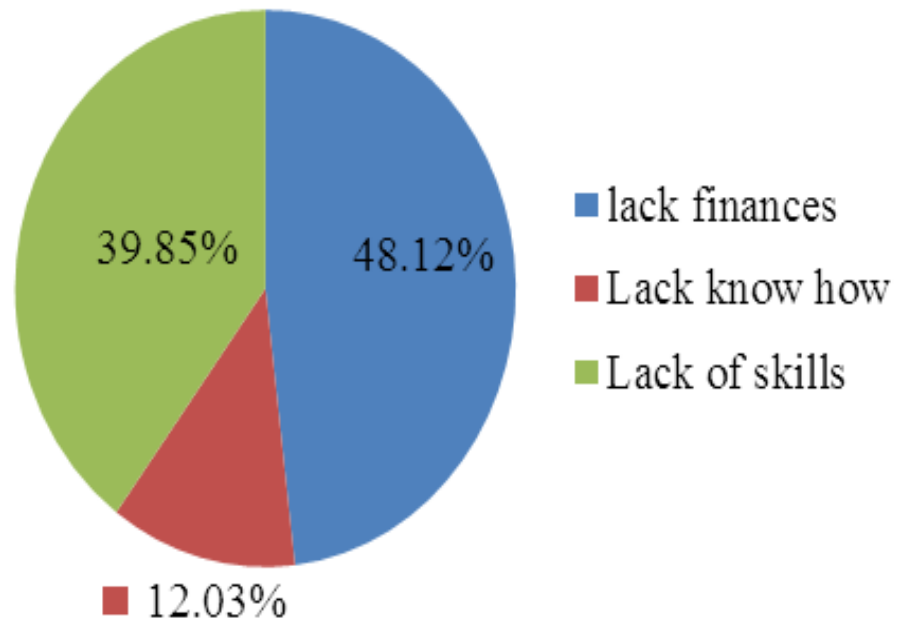


Figure 4.3: Limitation to adaptation to Impacts of climate change in Ijara

The limitations indicate pastoralists' despondency in that whereas they are aware and are affected by impacts of climate change, they nevertheless lack the wherewithal to tackle the adverse effects. This deficit raises costs of adaptation even higher as the negative impacts of changing climate and variability range on against farmers' lack of finances and pertinent skills. This is an opportunity to invest in soft adaptation through capacity building awareness creation as well as linkages with relevant *Shaaria*-compliant farmer-friendly insurance arrangements

#### 4.6 Change of Farming Systems for Optimal Benefits

Prompted by adverse impacts from climate variability 57.07% farmers invested in changed farming systems to incorporate on-farm livestock feed so as to raise benefits from farming practices. But 42.93% retained traditional systems (Figure 4.4)

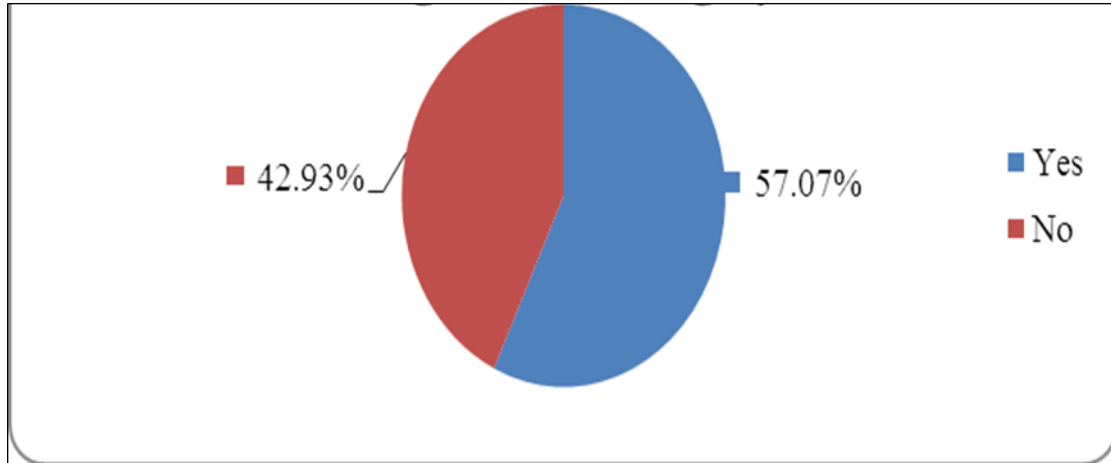


Figure 4.4: Adoption of Changed farming systems in Ijara

As indicated in (Table 4.9), the main challenge for ‘no change’ on new farming systems in Ijara was limited understanding of the impacts and opportunities of climate change as indicated by 46.27%. Other reasons were no access to capital 15%, lack of suitable market 11 % and shortage of labour (Table 4.9).

Table 4. 9: Reasons for Non Adoption of sustainable Farming Systems in Ijara

Reason	Per cent (%)	Frequency
No access to money	14.60	47
No access to credit	4.66	15
No access to land	9.01	29
No inputs	2.17	7
No access to market	11.18	36
Shortage of labour	10.87	35
Partial knowhow of climate change impacts, opportunities	46.27	149
Unaware of climate change and appropriate adaptation	1.24	4
<b>Total</b>	<b>100.00</b>	<b>322</b>

Given the limited skills on impacts and opportunities presented by climate change, possible key policy message include creation of requisite awareness and pertinent implementation support for effective adaptation, going forward. Due to environmental reasons, diversification into extensive crop agriculture demand cautious application. However, if augmenting cost-effective pastoralism was preferred, carefully selected strategies need to be considered such as livestock banks, community insurance schemes, livestock disease control and land ownership that gives user more permanent rights. Having now discussed status of farming systems the next section discuss farming activities that farmers spontaneously turned to as adaptation strategies namely livestock feed enterprises, water pans and Aloe.

#### 4.7 Significance of Pasture as Adaptation Strategy

As shown on Table 4.10, Ijara sub-county livestock population were 606,212 which is 12.81% of the total 4,731,579 in Garissa County.

Table 4. 10: Population of Livestock in Garissa County 2014

Livestock statistics in Garissa, Dadaab, Ijara, Fafi, Lagdera, Hulugho and Balambala sub-counties								
	Garissa	Dadaab	Ijara	Fafi	Lagdera	Hulugho	Balambala	Totals
<b>Camel</b>	47,000	132,000	0	45,590	28,000	0	122,900	375,490
<b>Dairy cattle</b>	121	70	0	0	0	0	0	191
<b>Beef Cattle</b>	198,440	220,000	170,324	95,100	45,000	187,320	188,000	1,104,184
<b>Goats</b>	588,000	270,000	174,340	180,500	112,000	162,323	460,000	1,947,163
<b>Dairy goats</b>	67	70	0	10		0	0	147
<b>Donkeys</b>	23,165	19,000	4,048	12,000	33,000	3,300	25,000	119,513
<b>Sheep</b>	283,000	80,000	200,000	95,600	88,270	143,000	200,000	1,089,870
<b>Indigenous</b>	45,000	30,000	57,500	8,500	9,200	18,421	26,400	195,021
<b>Poultry</b>								
<b>Total</b>								4,731,579

Source: State Ministry of Livestock, Garissa County, 2014

With a rating 47.5%, drought that decimated livestock feed was cited as the threat of concern in animal production as shown in (Figure 4.5)

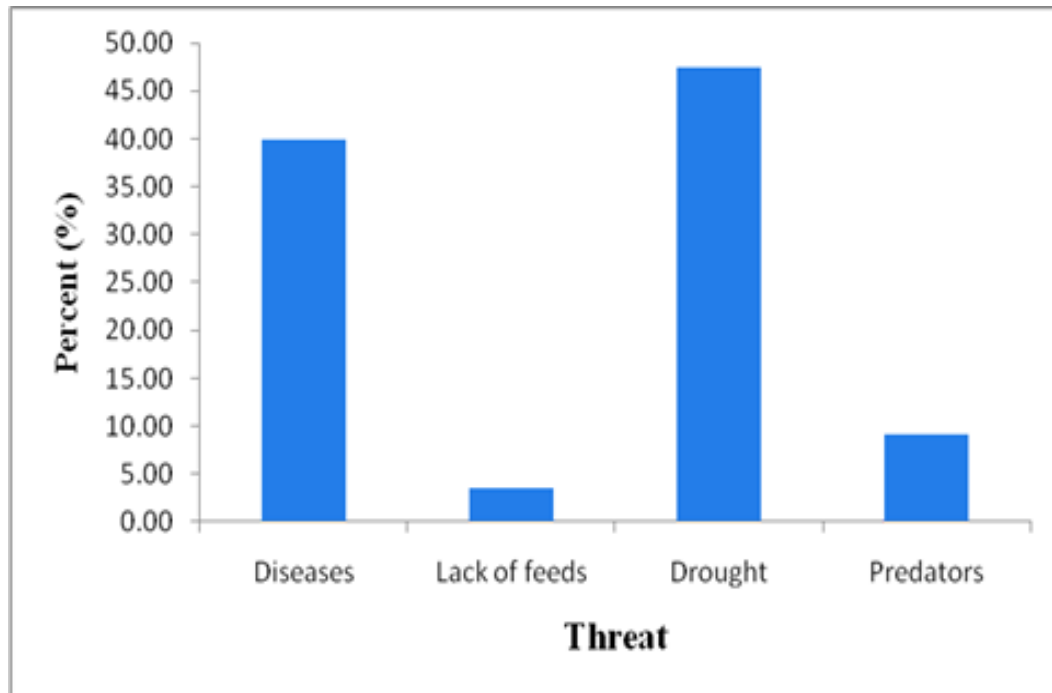


Figure 4.5: Threats to livestock production

Farmers' views were solicited on what costs and benefits were for purchasing and feeding one calf to maturity under scarce-feed scenario. To determine whether there was significant difference between costs and benefits of enterprises along livestock nurture continuum, a paired 't' - test was used (Table 4.11). The results indicated significant difference between monetary costs and monetary benefits on labour at Kshs 1350.25 with benefits being higher. Also costs of purchasing calf for feed-test were outwitted by benefits at Kshs 1254.39. A comparison between costs of treatment and benefits posted Kshs -91860 which was balanced by benefits in other activities' returns. Table 4.11

Table 4. 11: T-Test of Costs aand Benefits on Livestock Feed Enterprise in Ijara

Monetary costs ( <i>minus</i> ) Benefits	Mean	95% confidence interval of difference	T
		Lower	
Costs of calf - Benefits	1254.39	-519.86	1.393
Costs of pest control- Benefits	-68.07	-1422.42	-0.100
Costs of labour - Benefits	1350.25	161.94	2.241
Costs of treatment- Benefits	-918.60	-2391.62	-1.231
Costs of feed buying-Benefits	8587.24	5151.40	4.937
Total costs – Total benefits	17149.2	10731.69	5.265

#### 4.7.1 Impacts of Diminishing Grazing Lands over time in Ijara

The current standing pasture was insufficient for most of the seasons and as indicated in Figure 4.4.6, 86.26% farmers indicated pasture size was small and inadequate. Most of the pastures are natural.

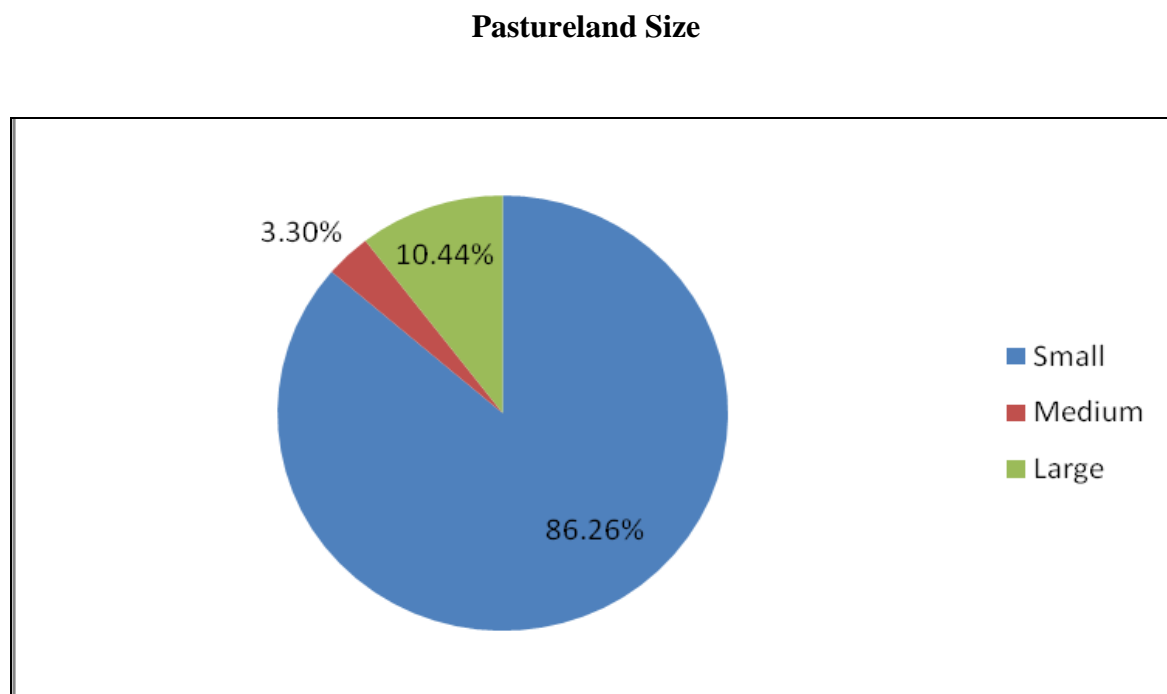


Figure 4.6: Accessible pastureland in the Study Area

#### 4.7.2 Types of Pasture Lands in the study area

Types of pasture in the area, shrubs occupy 58.33%, grasses to include rain-fed on farm Sudan grass 27.08% while others occupied 14.58% of the pastureland (Table 4.12)

Table 4. 12: Pasture types in Ijara

Type	Frequency	Per cent %
Shrubs	140	58.33
Others	35	14.58
Grasses including Sudan grass	65	27.08
Total	240	100.0

#### **4.7.3 Economic Analysis of Livestock Feeds and Threats to Production**

Pasture and as adaptation strategy is critical given the economic livelihood of the Ijara inhabitants is livestock keeping with 90% of the population directly engaged in it either solely or alongside other enterprises ( GoK, 2008). To lower costs of production and cope with changing climate and variability, pastoralists have in the past spontaneously taken to adaptation options such as livestock types to include indigenous cattle, sheep and goats, Boran Galla goats, black-head Somali sheep (District Development Plan, Ijara, 2008-2012). However, only a paltry 22% indicated that they store livestock feed (Table 4.13). The gap created by failure to store feed is attributable partly to the close proximity of the community to the expansive Boni forest which acts as feed reserve but also fails to lower costs of production as it has high infestation with tsetse fly (Gure Sadiq, personal communication, 2013).

Table 4. 13: Storage of animal feed

<b>Response</b>	<b>Frequency</b>	<b>Per cent</b>	<b>Per cent</b>
Yes	49	20.4	22.3
No	171	71.3	77.7
Total	220	91.7	100.0
Missing System	20	8.3	
Total	240	100.0	

The infestation alludes to the necessity to produce and conserve pasture for local consumption and for sale as adaptation strategy. A key threat to the free range grazing is that pasture costs ends up increased as it is denuded with little consideration for ecosystem's carrying capacity (Tserendash, 2006).

#### **4.7.4 Economic analysis Vis a Vis Pasture carrying capacity**

Pasture carrying capacity (PCC) consideration is critical in livestock sector chiefly because it denotes the maximum number of animals that can graze on particular pasture throughout the season without decimating it or denying posterity (GoK, 2007). Failure to

factor-in PCC raises costs of adaptation in the medium and long term as it fails to ensure sufficient residual feed for re-growth for subsequent year. A key benefit from being PCC compliant is that residual feed conserves soil erosion thereby increasing yield per unit area by improving stand vigour, moisture and nutrient re-cycling. (Tserendash, 2006) Tserendash (2006) developed a formula to aid understanding of the relationship between benefits of being PCC compliant discussed as follows:

$$\text{Carrying Capacity} = \frac{\text{Annual Seasonal Forage Production} \times \text{Utilization Rate}}{\text{Average Daily} \times \text{Length of Intake Grazing Season}}$$

Although it was beyond the study ambit to apply the pasture carrying capacity formula, its application is useful in teasing out stock rates versus available pasture. Consideration of PCC mitigate for threats that increase costs of adaptation as indicated in the study to include diseases, lack of feeds, drought and predators (Table 4.14). Of these four, 45.83% of the households felt that drought raises costs production the most, followed by lack of feeds 30.41% and diseases 20.41% in that order. The shocks echo the need for increased pasture enterprises as adaptation strategies as it does lower costs of livestock production and increase multiple benefits from incomes and livestock products.

Table 4. 14: Threats to livestock feed production in Ijara

<b>Threat</b>	<b>Frequency</b>	<b>Per cent</b>
Diseases	49	20.41
Lack of feeds	73	30.41
Drought	110	45.83
Predators	8	3.33
Total	240	100.0

#### **4.7.5 Economic Analysis of Alternative Livelihood Options**

As Figure 4.7 indicates, livestock forms the basic livelihood of the study population. The other alternative livelihoods are, crop farming, honey and small and medium enterprises. A comparison between costs and benefits of the livelihoods 10 and 5 years ago and

present indicated a steady decline of benefits from them all but for small medium businesses. The decline implied that the sunken costs on spontaneously implemented coping measures, chiefly, livestock and convention crops are not easily recoverable. This underscores the necessity of strategies in this study in form of enhanced water harvesting pans, aloe crop and pasture, all done differently. Otherwise, the trend would increase costs of adaptation that issue in undesirable effects particularly in a dry area where communities have traditionally relied on livestock.

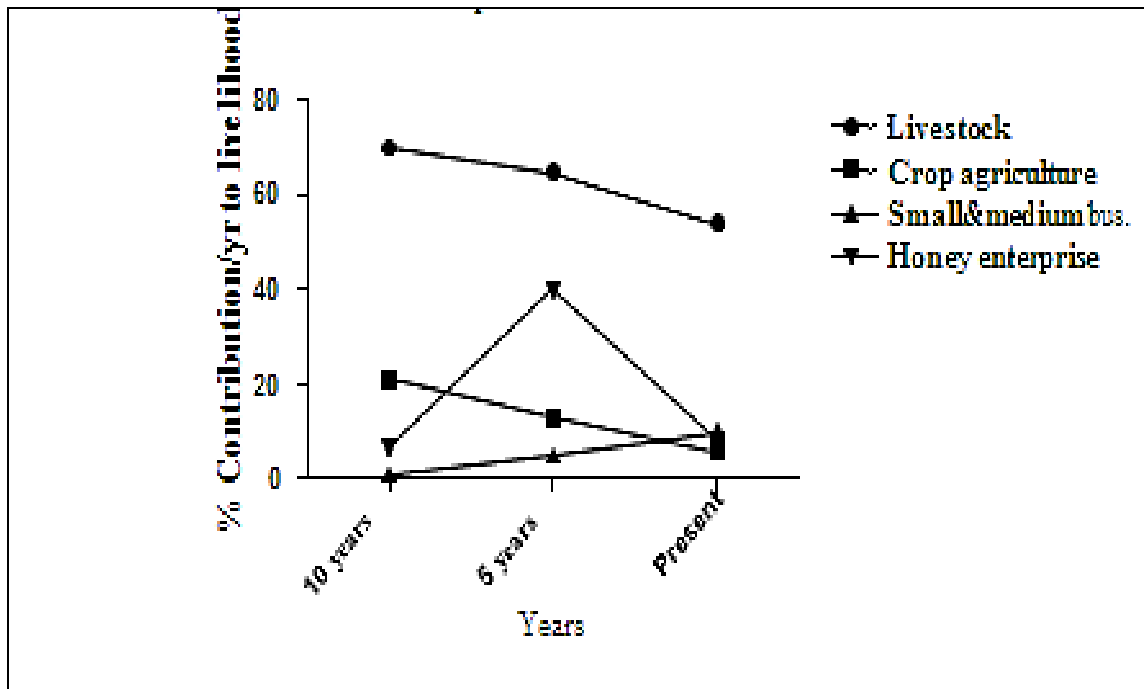


Figure 4. 7: Contribution from alternative sources of livelihoods

#### 4.7.6 Economic Analysis of Pasture Production Costs

Up to 51.67% agro-pastoralists produced fodder whereas 48.33% depended on fodder sourced from outside the region for their livestock (Table 4.15). In view of the high costs discussed earlier, this response indicates dire need for the pasture enterprise as adaptation strategy to cushion almost half the farmer population from the high costs. As Annex J indicates, and further specified in Figure 4.8, the study specified that benefits worth Kshs 1,925,091, 4,069,234.55 and 6,103,851.83 per hectare from one, two and three seasons

respectively of pasture production per year is attainable and to be preferred. The pasture is mainly rain-fed Sudan grass grown on-farm locally.

As indicated on (Figure 4.8) the present value of the pastures in three production seasons rise steeply from Kshs 109,526.00 which represents the initial capital outlay and peaks at year two before gently reducing exponentially to the tenth year. The curve change represent the time value of money, i.e. a shilling received today is more than a shilling received later. Time value of money is captured by interest rates which are the cost of capital i.e. maximum benefit or value is realized at year two when the costs outlay is balanced by an equally appealing cash inflow

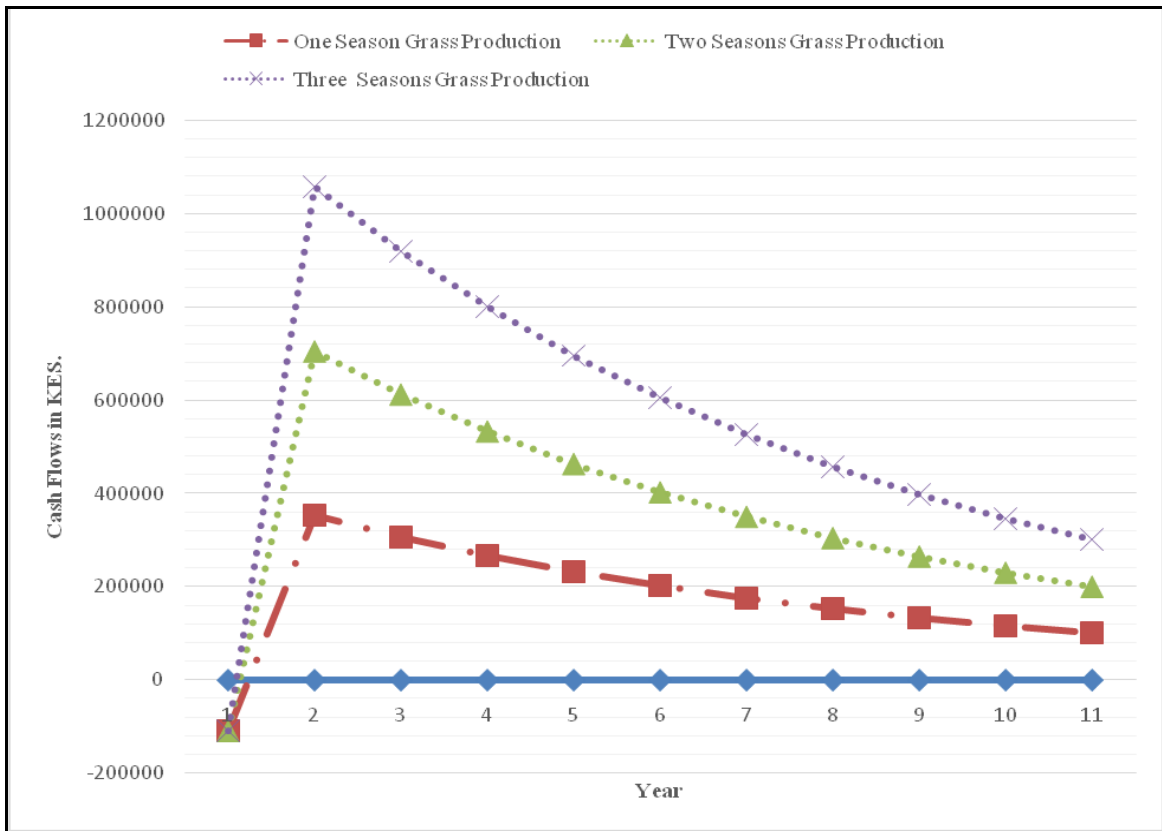


Figure 4.8: Ten-year cash flow under three pasture seasons

Beyond year two, the pasture revenue streams, though equal in nominal values to earlier streams, are reduced in value through the discounting factor and reduce in real value thus the gentle slope observed in the graph. Despite the initial steep capital costs that tapers

off in the second year onwards, pasture enterprise was found economically viable and an apt adaptation strategy

Table 4. 15: Households engaged in fodder production

<b>Response</b>	<b>Frequency</b>	<b>Per cent</b>
Yes, produced fodder	124	51.67
No, didn't produce fodder	116	48.33
Total	240	100

Data obtained from the Ministry of Agriculture and livestock, Ijara indicate that to process and store fodder entail construction of hay processing and storage shed (unit used is Kshs) 200,000, procurement of simple mechanical hay bale 50,000, capacity building 50,000. As indicated on Table 4.16, the costs of nurturing one calf bought at 8,161 and analysed in this study is 53,399. Other costs incurred in raising the calf are pest control 7,119, labour 7,202 and treatment Kshs 5,787.

Table 4. 16: Livestock production costs per unit

Costs	N	Mean	Std.Deviation
Purchasing a calf	235	13940.9	8160.9
Pest control	123	7119.5	7119.2
Labour	211	7440.3	7202.1
Treatment	199	7167.8	5787.4
Pasture buying	185	17252.4	21870.5
Fencing	193	5887.6	8975.9
Total monetary cost	238	53398.7	46341.9

Apart from capital costs, feed costs were overall high indicating that the pasture enterprise is the timely adaptation strategy as it saves livestock farmers from exorbitant costs. Also the strategy cushions the farmers from gaps in fodder supply that occur during drought. The prevailing fodder prices on the local market were used in the analysis. The stream of costs in the rain-fed on-farm Sudan grass included land preparation, fencing, seed and seeding, plough and data collation whereas benefits values analysed were

increased incomes and livelihoods both monetary and non-monetary. Moreover, the ‘without strategy’ scenario is that costs of fodder exceeded benefits, again demonstrating invaluableness of pasture strategy to ameliorate the high costs. Despite the initial high capital costs that tapers off in the second year onwards, pasture enterprise was found economically viable and an apt adaptation strategy.

Table 4. 17: Livestock feed enterprise cash flows.

Cost and benefits structure	Description	Discent rate	Total cost (nominal)	Nominal Cash flows in (Kshs.)					
				Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Monetary Costs									
Initial investment (capital costs)	Procurement of fodder processing equipment, construction of hay baling and storage shed	15%	300,000	300,000	-	-	-	-	-
Annual operational/Main tenance costs	Land preparation for pasture , procurement of farm inputs, field management Harvesting, processing inputs, transport and labour	15%	214,626.7	-	42,925	42,925	42,925	42,925	42,925
ther costs	Capacity building	15%	200,000	200,000	-	-	-	-	-
total			714,626.7	600,000	42,925.3	42,925.35	42,925.35	42,925.35	42,925.3
Non-monetary costs/Avoided damage costs									
Livestock death of pasture deficit		15%							
Monetary Benefits									
Income from sale of hay bales i.e. Pasture/ha 9227kgs@ 50 KES/kg		15%	142,080.35		28,416.07	28,416.07	28,416.07	28,416.07	28,416.07
Livestock sale and livestock products		15%	750,000		150,000	150,000	150,000	150,000	150,000
Non-monetary Benefits from healthy livestock: Status symbol, manure for crop, mobile bank, carrier, security, dowry									

Costs benefits structure factored-in capital costs (initial costs, annual operational/maintenance costs and livestock death and pasture deficits. Benefits included income from sale of hay bales and livestock and livestock products sales. The total (nominal) costs were incurred on land preparation for pasture , procurement of farm inputs, field management harvesting, processing inputs, transport and labour Kshs 214,627 Procurement of fodder processing equipment, construction of hay baling and

storage shed Kshs 300,000 and capacity building Kshs 200,000. All these were discounted at the prevailing financial markets rates of 15%. As probable in discounted rates, the curve on these initial costs (capital costs) dipped significantly after the first year and in turn benefits steadily rose from year one progressively (Figure 4.8). But as NPV (present value of future cash flow) below show, due to dipping of the future net value of the shilling, the benefits normalized after the initial rise. Non-monetary benefits included healthy livestock: Status symbol, manure for crop, mobile bank, carrier, security and dowry

Given the feed can last for five years under good maintenance in order to supply the same level of economic benefits, the analysis considered the cash flows for a five year period - applying the NPV formulae:

$$NPV = CF_0 + \frac{CF_1}{(1 + K)^1} + \frac{CF_2}{(1 + K)^2} \dots + \frac{CF_n}{(1 + K)^n}$$

Where *NPV*= Net present value of investment

*CF<sub>0</sub>, CF<sub>1</sub>, CF<sub>2</sub>... CF<sub>n</sub>*, are the cash flows (Monetary costs-Monetary benefits) for periods *t=0, 1, 2... n*

*K*=the discounting factor also known as the opportunity cost of capital.

Unit of Analysis=Kshs

NPV Decision Rule: If  $NPV \geq 0$  then the adaptation investment is economically viable.

Table 4. 18: Ten-year present value of future cash flow on pasture

Year	Discounting rate (@15%)	Cash inflow	Cash outflow	Present value
0*	1.000	0	50,00000	-500,000.00
1	0.870	1,300,000	108,222.80	117879.2
1	0.870			117879.2
2	0.756			102433
3	0.658			89154.62
4	0.572			77502.2
5	0.497			67340.19

6	0.432			58533.13
7	0.376			50945.5
8	0.327			44306.33
9	0.284			38480.11
10	0.247			33466.86

NPV=180,041.1 In this case the NPV is greater than 0 implying that benefits from the livestock feed enterprises exceed costs, making the investment worthwhile as adaptation strategy. Cash inflow was Kshs 1,300,000 whereas cash outflow was Kshs 108,222.80.

Table 4.18 show discounting rate application, cash in-flow and out-flow and resulting net present value of the pasture investment. The study quantified costs and benefits of livestock pasture enterprises considering a 5-year period for cash flow, being the period in which the feeds can last under good maintenance in order to supply the same level of economic benefits. Also it was clear that the strategy takes place under harsh extreme weather condition, chiefly drought. But persuasion to tackle the problem was that production of livestock feed, particularly the budding on-farm grasses will be much more feasible once costs and benefits are clear. Feed production and management aim to cushion the vulnerable communities from exorbitant costs which exceed the sum total of outside-sourced feedstock. From the study it was clear that the high costs of production, not only affect competitiveness of Kenya's livestock products particularly at the international market, but also makes it difficult for the community to plan and manage scarce resources in a bid to adapt. But livestock feed enterprises emerged economically viable within the framework of external support given the high capital involved. The strategy is functionally inter-linked with water provision.

#### **4.8 Aloe Crop Adaptation Strategy**

With over 80 Aloe species and 80% of them existing in ASALs, Kenya has the greatest Aloe diversity among the East African countries, growing naturally in the wild (Wabuye *et al.*, 2006; Njuguna, 2005). The crop is effective for climate change adaptation in drought prone areas where other plants dry up (Senelwa, 2009). Their cultivation and industrialization in these areas serve as a sustainable cash income in places of food insecurity, improve environmental conservation and improve household

health and wellbeing. *Aloe secundiflora* has the widest distribution in Kenya and contributes to over 90% of commercial aloe gum exploited in the country (MMMB, 2014). It is the most adaptable for growing in semi-arid lands as it can be grown without fertilizer or manure application, has a high leaf area index or growth measure of (P 6 0.05) (Kathuli, *et al.*, 2010). Also, both *Aloe secundiflora* and *Aloe Vera barbadensis* have a better survival proportion of 96% and 92% respectively after the first year of growth with minimal changes subsequently (*ibid.*). The preferred climatic conditions include rainfall 250-750 mm, well drained soils, rocky and nitrogen contents of 0.4-0.5%, pH between 4.5-7.0 and temperature 15-39<sup>0</sup>C and 10-170 metres above sea level, which Ijara ecosystems typify (Obanyi *et al.*, 2010).

The start of Aloe farming in Ijara was reactive adaptation measure against impacts of the ravaging extreme weather events, diminishing natural capital and decimation of the traditionally-relied-upon livestock industry. The farming provided an alternative livelihood option and was supported by Arid Lands Project in conjunction with Ministry of Agriculture in 2009. To this end and to diversify risks, aloe production commenced on-farm and a processing plant set up in Kotile, which processes shampoos, soap and body lotions. Since then about 100 agro-pastoralists have maintained plots of about half hectare each around their homesteads. Such plots are easily accessible around town centres to include Sangailu, Ijara, Masalani, Korissa and Kotile. In Sangailu and Ijara some producers operate manual processors at home whereas Korisa's Jirole Aloe Producers operate both manual and automated processors (see Plate 2). Aloe processing typically involves creating gel or bitters that is then sold to consumers. Aloe harvesting is done arbitrarily, and in the process products are of low quality as saps from different species are mixed up. The study measured the economic viability of the strategy to inform policy and better management.

Aloe is globally recognized for its role in environment conservation and human health care products (Mukonyi, *et al.*, 2008). The latter use makes for good business particularly if the business assumed unique niche, capitalizing on market need so as to compete favorably. Also such approach should develop business model capable of success in the

current unregulated Aloe business. These business concerns guide the discussion that follows subsequently with market access featuring prominently at the tail end of conclusions and recommendations. Also costs of production are important to consider and as Table 4.19 indicates, costs of planting material are the highest among farm costs. This is because land is communally owned and is made available at minimal costs.

#### **4.8.1 Regulations and Quality Assurance**

Prior to the Wildlife (Conservation and Management) Aloe Species Regulations, 2007 published in Legal Notice No 403, Kenya lacked adequate regulations and mechanisms to oversee or regulate the protection, conservation and management of aloes, outside protected areas. The unclear provisions for regulation of utilization within the wildlife legislation framework triggered the unchecked harvesting of aloes in the wild in the 1980s resulting in over exploitation and wanton destruction (KWS, 2008). The study clarified that with exception of Aloe Vera and its derivatives, trade in other aloes are listed in Appendix II of CITES and a few rarer species in Appendix I of Kenya Wildlife Service which manage CITES assisted by national museums of Kenya as the scientific authority. It was noted that globally, quality assurance was done by the international Aloe Science Council Certification whose process requirements included site visit and full audit. These regulatory measures check decimation of aloe as the 1997 IUCN *Red List of Threatened Plants* registered 22 species of Aloe as being rare or threatened in particular *Aloe ballyi* (IUCN, 2002). The unregulated harvesting not only degraded the ecosystems biodiversity but also threatened Aloe farming (Mukonyi *et al.*, 2008)

#### **4.8.2 Aloe Production Costs per Hectare**

Production costs per ha with cultivars planted 1m x 1m spacing equals Kshs 192,500. Costs items are land preparation, fencing, planting, monitoring, evaluation, harvesting and post-harvest handling (Table 4.19)

Table 4. 19: Production costs of Aloe/ha

Item type	Sub-item	Quantity	Unit cost (Kshs)	Amount (Kshs)
Fencing (use twigs)		1 ha	15,000	15,000
Land preparation	Ploughing	1 ha	10,000	10,000
	Harrowing	1 ha	10,000	10,000
	Planting	1 ha	10,000	10,000
Cost of planting material	Cultivars (1m x 1m)	12,250 cultivars	10	122500
Field management	Weeding	1 ha	10,000	10,000
	Manure application	1 ha	4000	5000
Harvesting		1 ha	5,000	5000
Transport		Lump sum	5,000	5,000
<b>Total cost</b>				<b>192,500</b>

Data source: Ministry of Agriculture and livestock, Ijara

As indicated in (Figure 4.9), land preparation was done in May and January, cultivars planted in April, weeding in May harvesting in July and September whereas marketing occurred mainly in December. Prices were highest in November and December

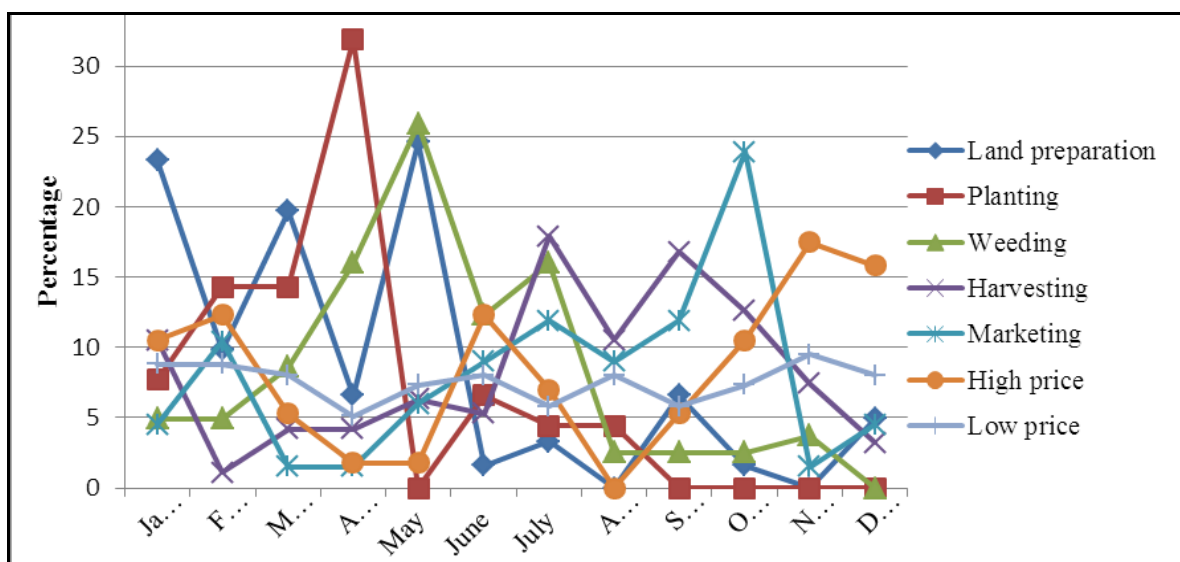


Figure 4.9: Annual Aloe enterprise calendar

The fresh leaf sap yield per plant was 50 ml. which translated to (12250 plants per ha x50ml per plant/1000); which netted 612.50 Liters/ha. Some producers opted to boil the fresh sap. Four litres of aloe sap when boiled for three hours and then allowed to cool and dry in an open container in the shade for 30 minutes produces one kilogram of crude aloe gum (KEFRI, 2008). This implies that 600 litres per acre produce  $(600/4) = 150$  kg of crude aloe gum. This is worth  $(150\text{kg} @ \text{Kshs } 250) = \text{Kshs } 37,500$  per season; which is a significant benefit that makes Aloe economically viable as an adaptation strategy. The benefits compared favorably with investment of Kshs 192,500 (Table 4.19) given some capital costs such as fencing are one-off investments. These benefits and would spill over with increased acreage which in addition catapult cost effectiveness (Mukonyi,2008). Increased acreage does not only ensure continued supply it also curtails unsustainable harvesting of wild aloes which poses many threats to biodiversity and ecosystem balance. Expanded acreage not only forges sustainable supply of raw materials to the industry but ensures good returns from the investment.

As indicated in Figure 4.10, the benefits from aloe farm sales are more than costs incurred, barring capital investment. The figure also indicates sources of cultivars, actors in the enterprise, preferred products and markets, showing percentage for each. Cultivars are sourced from the wild and from individual aloe farms. The actors in the enterprise (with percentage they represent in the business) are producers 21%, transporters 17%, processors 17%, brokers 4%, and extension service providers 2%. The most preferred products are soaps 42.9% and fresh leaves 41.7%.

Utilization of Aloe leaves is rated the highest due to the ease with which therapeutic and beauty products are manually processed locally. Markets for the products are local centers, Korissa, with Garissa town, Mombasa and Nairobi as sale outposts. Significant challenges in aloe production process rears up at marketing given farmers often find themselves at the mercies of brokers.

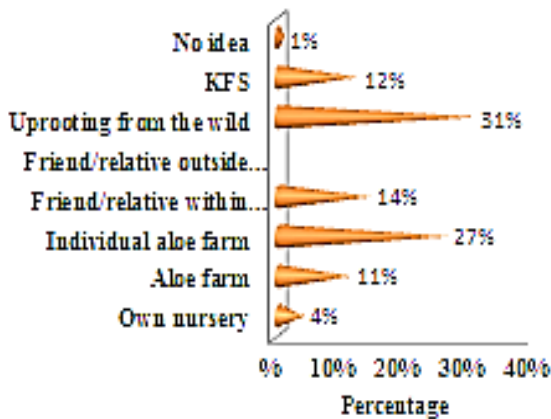


Figure 4.10 a : Sources of cultivars

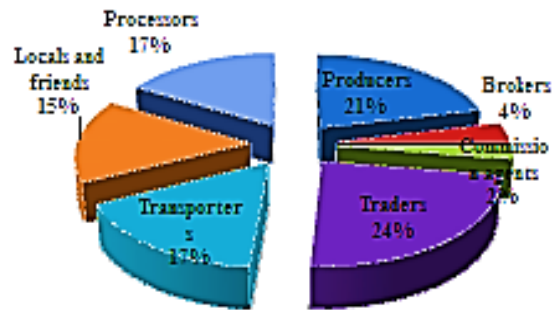


Figure 4.10 b : Actors in Aloe enterprise

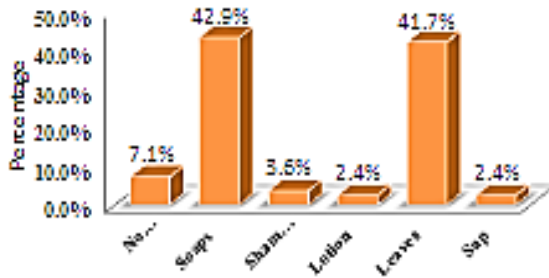


Figure 4.10 c : Aloe products buyers prefer

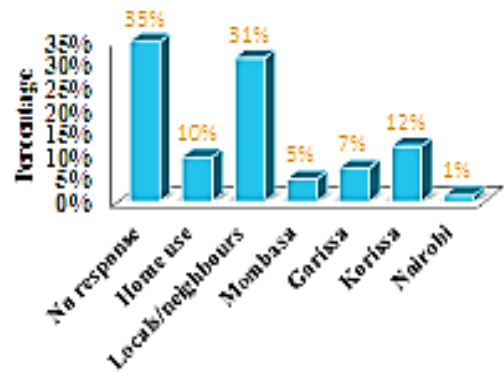


Figure 4.10 d : Markets for Aloe products

Figure 4.10: Aloe Enterprise Chain

The study established that Ijara aloe farmers search market for the produce only after processing Aloe products. This approach subjects the producers to accepting low pricing as at that stage they find themselves stuck with products when they actually need revenue. To increase benefits, information on market should be sought early; best at planting so as to know what commodity would fetch more and not to wait as most farmers do until harvest to negotiate price. This is even more essential as Aloe products are clearly on high demand both locally and globally. But the crop offers good grace period as once mature; a crop can last for five years successfully yielding significant harvest. Despite the grace period, the negotiations must be done way before harvest. Better still, negotiate way before planting. It is better to start small and with what is doable and then move on.

To enhance accessibility to market, it is crucial to bolster capacities human, institutional and capital. Doubtless, this will not be panacea to development given land in the region is communally owned among other challenges indicated in the study. But the way forward really is to enhance farmers' collective bargain, create effective business hubs as well as expand the crop acreage. These hubs would collectively access market, bargain for better commodity price while guaranteeing consistency in supply and quality. Presently farmers approach market individually but end up frustrated from the exploitation they are exposed to from middle men whom they often have to work with.

To develop Aloe industry to gainful levels benefits, the study recommend carrying out capacity enhancement programmes led by extension and other technical support using a negotiated peer and facilitated learning processes. The process could be expedited through multi-stakeholder workshops, seminars held among target community in the sub-county given the interest on the crop were rated high. The focus of the capacity building to be on wider issues of social and community development to include legal / legislative frameworks, rights and obligations of individuals, community dynamics, local governance, the role of the private sector and linkage to markets. Also it is important to empower focal community persons to include women and youth leaders by acquisition of requisite skills on production of market-certifiable products.

This collective bargain and access to suitable market can be gainfully achieved by first bolstering institutional arrangement. The study indicated that institutions are weak or altogether non-existent in Handaro and Sangole-Ijara, which gap calls for immediate attention.

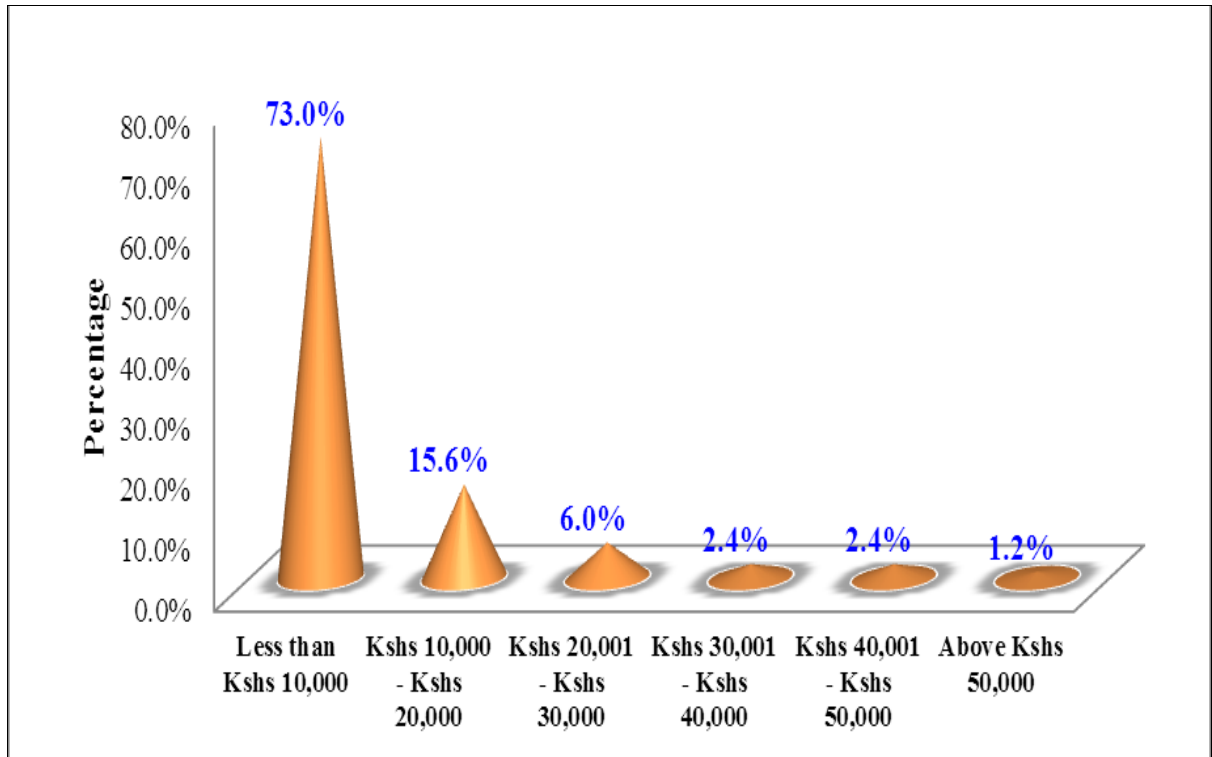


Figure 4.11: Benefits from Aloe

As indicated on Figure 4.1.11, 73% earn up to Kshs 10,000 per hectare per annual season whereas 1.2% net in over Kshs 50,000. Up to 66% of the respondents indicated they transported the aloe to the market/processing plant on their backs, 13% of the respondents used trucks, 8% of the respondents used donkeys and 2% of the respondents used bicycles (Figure 4.12)

#### 4.8.3 Transportation mode of Aloe to market/processing plant

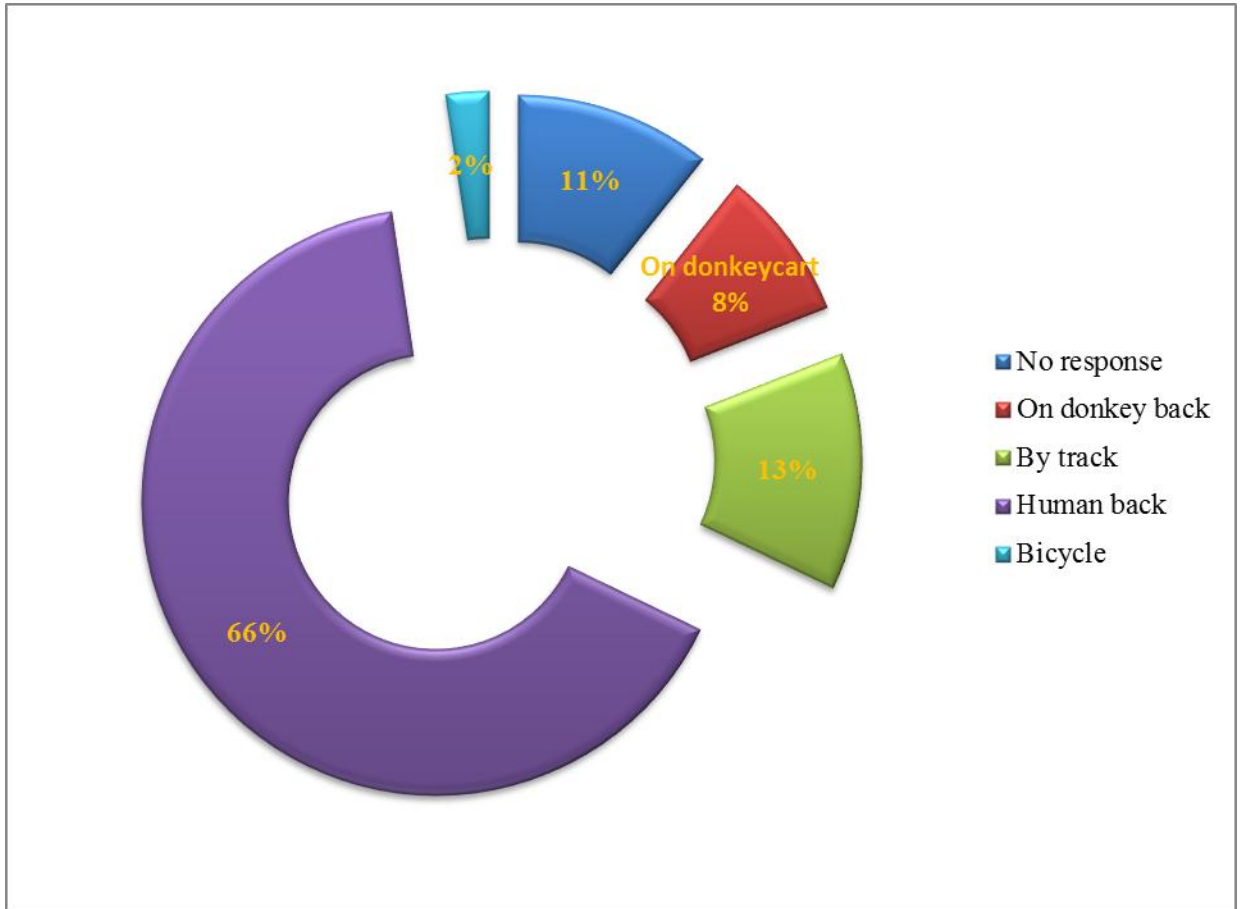


Figure 4.12: Transport mode

Supported by various stakeholders the farmers have moved on to sap extraction and processing to make the products discussed. However most processors do it manually and only Kotile sites have automated processor as shown on Plate 2. The study indicated that it was cumbersome to process Aloe manually. To process raw Aloe to economically viable standard farmers need access to conventional processing equipment. Currently farmers who are unable to process export raw Aloe gel thereby losing much-needed revenue to reduce poverty and to adapt to impacts from extreme weather.



Plate 2 (a): Manual value addition



Plate 2(b): Automated value addition



Plate 2 (c): Aloe farm, Kotile-Ijara



Plate 2 (d): Aloe products, Ijara

Plate 2 a-d: Ijara Aloe value addition, manual and automated

#### **4.8.4 Post-Harvest Handling**

Equal to 38% of the producers retained Aloe on-farm and harvested it when needed, 32% kept the aloe in sacks after harvest and 30% spread the aloe on floor in house after harvest. The post-harvest handling portends loss in benefits as fresh aloe leaves requires processing within three hours of harvesting otherwise sap chemical formulation changes (Mukonyi *et al.*, 2008).

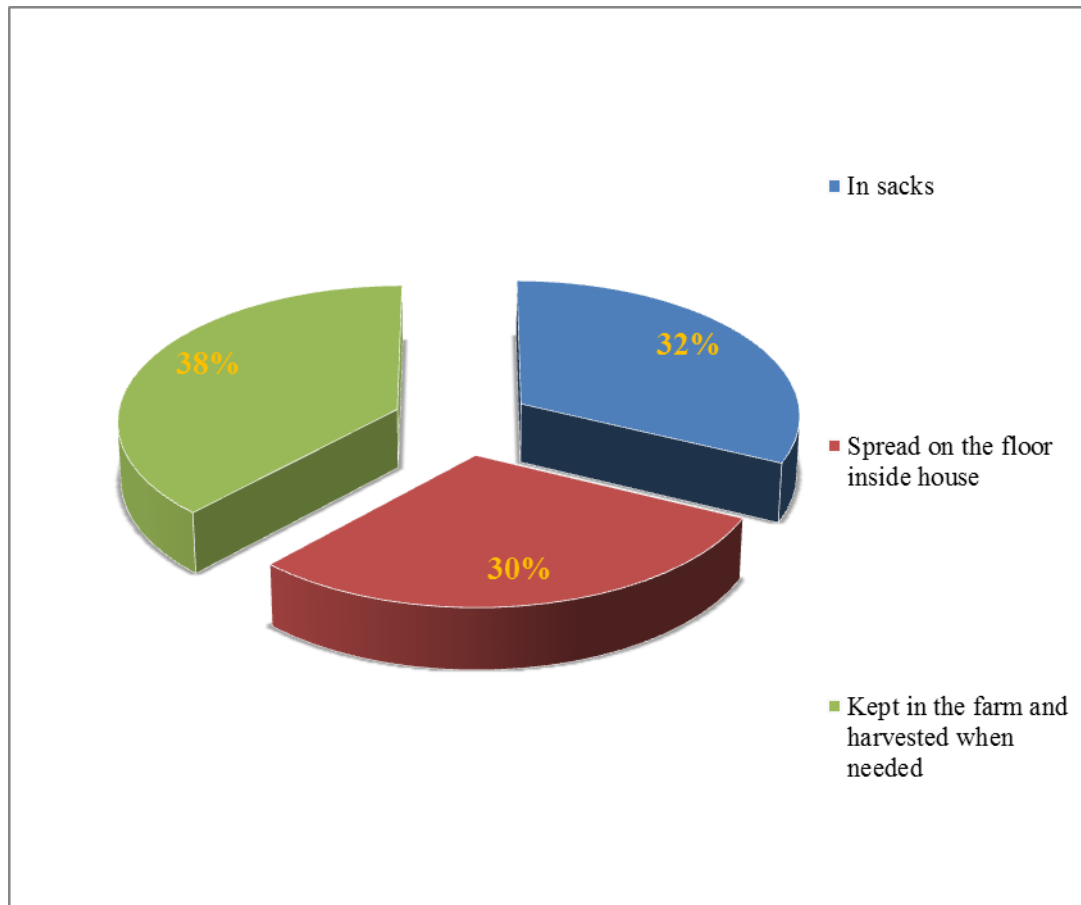


Figure 4.13: Storage of Aloe after harvest

#### **4.8.5 Percentage Aloe Loss after Harvest**

As specified in Figure 4.14, 34% producers lost less than 10% of the aloe after harvest and before sale, 17% made losses of between 10% to 20% of aloe harvested, 15% lost between 21% to 30% of the harvest, 11% lost between 31% to 40% expected benefits, 10% lost between 41% to 50%, 8% lost between 51% to 60% and 5% lost above 60% of the aloe between harvest and sale points. The post-harvest losses are significant and apart from fomenting a cycle of poverty, they increase vulnerability against impacts of climate change and variability.

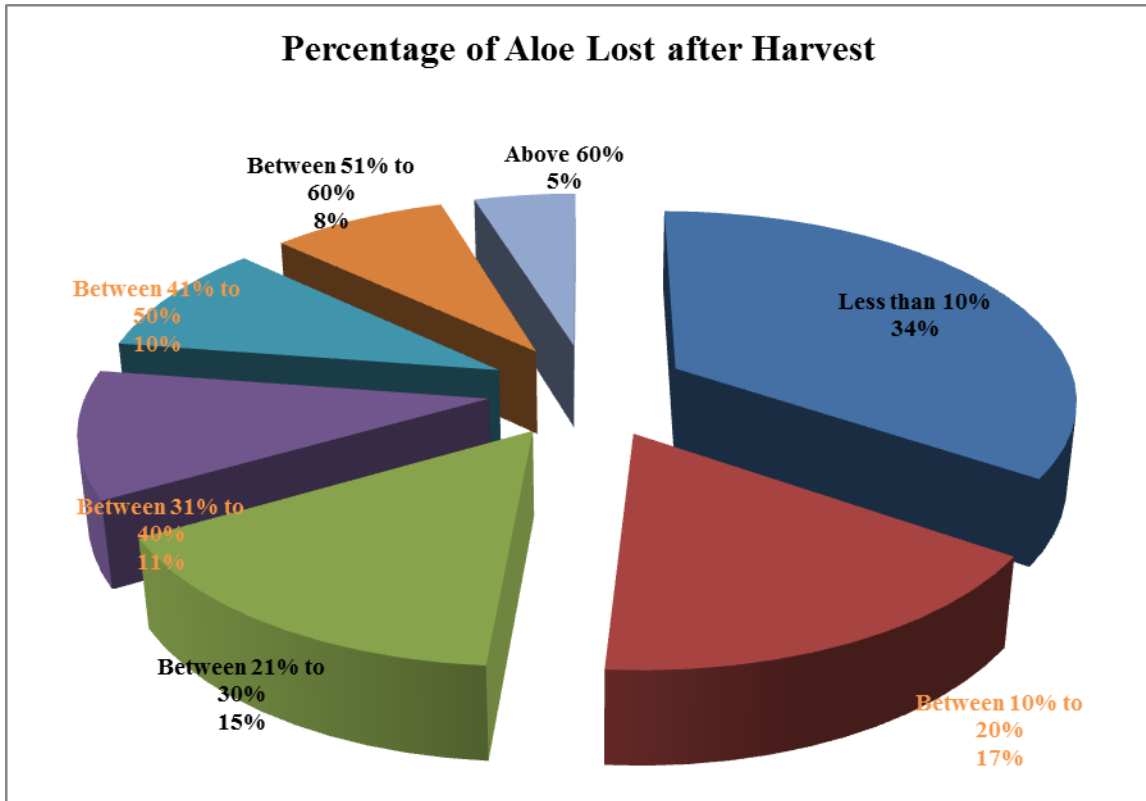


Figure 4.14: Percentage Aloe loss after harvest

Student “t” statistical analysis was used to compare the arithmetic means and statistical importance of the cost of production and annual benefits. In this regard total cost of benefits from Aloe adaptation strategy were subtracted from costs involved

Table 4. 20: The t –test results of cost and benefits of Aloe

	Paired Differences				T	Df
	Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference		
<b>Total costs of farming Aloe (minus) benefits of farming Aloe</b>	22551.71	40278.454	3089.22	Lower 16453.28 Upper 28650.13	7.300	169

The results indicate that there was significant difference between the costs incurred and the benefit received while using Aloe crop farming as an adaptation strategy (Table 4.20). Specifically, the results indicate that, the higher investments costs attracted equally high benefits.

Table 4. 21: Aloe processing, marketing costs and benefits

CAPITAL COSTS	
ITEM TYPE	AMOUNT KES
Procurement of processing machinery	1,000,000
Transport of machinery (from supplier)	80,000
Construction of aloe processing shed	495,757
<b>PROCESSING INPUTS COSTS</b>	
Soap making raw materials	93,000
Cream making raw materials	58,214
Lotion making raw materials	96,600
Shampoo making raw materials	93,300
<b>OTHER COSTS</b>	
Kenya Bureau Standard (KBS) standardisation	50,000
Labour costs	50,000
Sales and marketing	50,000
Administrative costs	50,000
<b>INCOME FROM SALE OF ALOE PROCESSED PRODUCTS</b>	
Product sales    Amount (Kshs.)	
Annual income from sale of soap	400,000
Annual income from sale of cream	300,000
Annual income from sale of lotion	300,000
Annual income from sale of shampoo	300,000
Total benefits	1,300,000

**Data source:** National Drought Management Authority, Ijara sub-county (2013)

Table 4.21 shows summarized costs of undertaking aloe sap extraction, processing and marketing as obtained from key informants particularly National Drought Management Authority, Ijara sub-county and focus group discussions. The costs indicate capital investment that required external support before year two of produce, when benefits pick up as shown in Table 4.22)

Table 4. 22: Aloe production cash flow (Kshs)

Water pan cost and benefits structure	Description	Discounting rate	Total cost (Nominal)	Nominal Cash flows in (US\$.)					
				Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
<b>Monetary Costs</b>									
<b>Initial investment (capital costs)</b>	Procurement of aloe processing equipment, processing shed and	15%	18538	18538	-	-	-	-	-
<b>Annual operational/Maintenance costs</b>	Land preparation, procurement of farm inputs, field management Harvesting, processing inputs, transport and labour	15%	6366		1273	1273	1273	1273	1273
<b>Other costs</b>	Capacity building	15%	1765	1765	0	0	0	0	0
<b>-total</b>									
<b>Non-monetary costs/Avoided damage costs</b>									
<b>Avoided Crop failure</b>									
<b>Environmental conservation</b>									
<b>Monetary Benefits</b>									
<b>Income from sale of aloe processed products</b>		15%	76470		15294	15294	15294	15294	15294
<b>Non-monetary Benefits</b>									
<b>Treatment of minor ailments at home</b>									
<b>Manure from crushed aloe leaves</b>									

The aloe productivity can last for twenty years under good field management practices in order to supply the same level of economic benefits. But the analysis considered the cash flows for a ten year period Table 4.23 Aloe cash flow in production, processing and marketing - costs and benefits (Kshs). Applying the NPV formulae:

$$NPV = CF_0 + \frac{CF_1}{(1 + K)^1} + \frac{CF_2}{(1 + K)^2} \dots + \frac{CF_n}{(1 + K)^n}$$

Where  $NPV =$  Net present value

$CF_0, CF_1, CF_2 \dots CF_n$ , are the cash flows (Monetary costs-Monetary benefits) for periods  $t=0, 1, 2 \dots n$

$K$ =the discounting factor also known as the opportunity cost of capital.

Unit of Analysis= Kshs. NPV = Present Value of future cash flows – Investment

NPV Decision Rule: If  $NPV \geq 0$  then the adaptation is worthwhile.

Table 4. 23: Net present Value of Aloe 10-year cash flow

Year	Discont Rate (@15%)	Cash inflow	Cash outflow	Present value
<b>0*</b>	1.000	0	1,725,757	-1,725,757
<b>1</b>	0.87	1,300,000	108,222.80	1,036,846.16
<b>2</b>	0.756			900983.56
<b>3</b>	0.658			784189.40
<b>4</b>	0.572			681,696.56
<b>5</b>	0.497			592,313.27
<b>6</b>	0.432			514,847.75
<b>7</b>	0.376			448,108.23
<b>8</b>	0.327			389,711.14
<b>9</b>	0.284			338,464.72
<b>10</b>	0.247			294,368.97

**NPV=Kshs 4,255,773 –**

Cash in-flow for the 10-year period was Kshs 1,300,000 whereas cash out-flow was Kshs 108,222.80. The aloe cash flow based on 15% discounting rate indicated that the net present value is Kshs 4,255,773, meaning the strategy is viable. This is in spite of initial capital outlay required which experience gradual decline with increased acreage, utilization and stable market base.

#### ***4.8.7 Way Forward for Aloe Strategy***

As way forward, it is critical to ensure commercial certification of Ijara Aloe value chain and businesses with KWS as per 2007 Conservation and Management Act, which, as noted, lacks. This way Aloe products trade would legally and with ease access both national and international markets thereby sourcing desirable revenue. Ijara Aloe enterprise immediate opportunities include purchasing bulk, adding value and selling to traders and consumers in Garissa, Nairobi and Mombasa. In the medium term, it is important to enhance value addition and curtailing sale of raw material. Additionally, it is imperative to strengthen linkages along the value chain continuum from production to consumer and up to disposal stage. As an adaptation strategy, Aloe farming was found economically viable despite the initial capital costs that taper off with increased utilization and widening of market. The study clarified that ASALs can produce enough gum from the crop for both local and foreign markets if farmers were given proper incentives. Currently most farmers are discouraged from years of exploitation from middle level actors. Other challenges include lack of suitable equipment, non-supportive legislative framework, and insufficient acreage, lack of consistent investment in the industry, capital hurdle, lack of suitable market and high import taxes on equipment.

#### **4.9 Economic Analysis of Water Pan Adaptation Strategy**

Water pans in Ijara serve the major proportion of the sub-county and are key influencers on population distribution, schools, health facilities and administration posts- mainly as check against insecurity (GoK, 2008). Only 15% of the total population has portable water (Ijara district strategic development plan 2002-2008). Besides River Tana, Lakes Jerrei and Hadhi, Ijara has 20 water pans. Water availability tackles farmer-pastoralist conflicts which in turn curtails ecosystem degradation due to unplanned watering points. Other water challenges include, siltation, degradation of water pans resultant to poor management (GOK, 2008). The water pan presented impacts costs to include acquisition of land, steep capital outlay, attracting informal settlement around it and possible emissions from the many livestock and wild game that congregate around it daily. These are some of the benefits and costs that the study assessed to ascertain economic viability of the adaptation strategies in use. Although water needs in Ijara are acute specifically for

livestock, domestic and crop farming, the study explored broader economic water values as uses are inter-linked. As indicated on Figure 4.15, the values are generally classified as use and non-use values:

<b>TOTAL ECONOMIC WATER VALUE</b>	<b>Value</b>	Distant use value
		Indirect use value
	<b>Non-Use Value</b>	Existence value
		Bequest value
		Philanthropic value
		Option value
		Quasi-option value

Source: Modified from Kerry, T. *et al.*, 2004

Figure 4.15: Economic Value of Water

Figure 4.15 present two main categories of water use namely, use values and non-use values. Within use values, there are direct (consumptive e.g. irrigation) or (non-consumptive e.g. water for aesthetic). Non-use values (existence, bequest, philanthropic) are of ethical concerns and altruistic preferences stemming from self-interest and non-direct use values (Kerry, *et al* 2004). Non-use value is not applicable in Ijara. Of great interest in Ijara is consumptive water use value as water is scarce and in high demand for livestock, domestic and subsistence crop farming. Currently that demand is met by 20 water pans constructed over the years largely through external aid complemented by labour and goodwill from local community. The study focused on Handaro water pan constructed in 2009 by the Ministry of Agriculture through NALEP programme with Handaro community contributing labour, but remained largely unclear about the costs of implementing the pan and benefits that accrued thereof (see Plate 1).

Handaro water harvesting pan is in *Bulla* Handaro in Sangailu division of Ijara sub-county. The area covers 2470 km<sup>2</sup>, a population 12,534 persons who are served by the water pan. As shown in Annex H, the pan capacity is 30,000 m<sup>3</sup>: top (90x120m<sup>2</sup>, bottom 80x100m<sup>2</sup> depth 3m, side slopes 1:2, and cost Kshs 9,741,150,000 to construct (Ijara

Strategic Plan 2005-2010; Ministry of Water and Irrigation, 2009). Estimated water loss through evaporation was 7.5 m<sup>3</sup>, with the same amount earmarked for domestic, livestock and irrigation (Table 4.24). The sizeable water source was constructed to mitigate for the 3-4 years cyclic drought experienced in the area affecting the community lifestyle and settlements as they were forced to migrate in search of water and pasture and sustenance (GOK, 2008). Also the facility construction factored in both crop and livestock whereas other water pans in the area focus on livestock. Given the water stress, women and girls bore the blunt as they were culturally bound to fetch water, 20-30 kilometers away. Based on the dual initial expectations on the pan, and the numerous livestock and crop agricultural activity it supported, the economic analysis focused on it.

Table 4. 24: Handaro Water Pan Capacities

<b>Usage</b>	<b>Quantity M<sup>3</sup></b>
Domestic, livestock and irrigation	7.5
Estimated evaporation loss	15
Estimated seepage loss	7.5
Required storage capacity of Handaro Pan	30

Data source: Ministry of Water and Irrigation, Ijara

Major problems experienced before the water pan was constructed were acute water shortage, as indicated by 36.66% of the households, food shortage 24.16%, socio-economically valuable time wasted trekking for water 9.16%, livestock diseases and deaths 8.33% and 12.08% respectively.

Table 4. 25: Challenges encountered before water pan

Challenges	Freq	%
Animal diseases	20	8.33
Attacks from wild animals	23	9.58
Shortage of food	8	24.16
Water shortage stress	88	36.66
Wasted time trekking for water	22	9.16
Livestock deaths	29	12.08
Total	240	100

These constraints are of concern particularly in the face of prediction of higher temperature of 4<sup>0</sup> C by 2100 (IPCC, 2007). Adapting to the warmer climate through implementation of strategies such as Handaro water pans is costly but adapting is imperative as costs of not doing it will be much more. What these costs mean for ASALs such as Ijara is that adaptation is a must and must be done now, approaching it via tackling roots of poverty through development projects which are to be done differently, not business as usual way. In this resilience enhancing interventions land is a central factor of production and maximizing land use will catalyst poverty reduction as well as support desired adaptation, barring stringent tenure system. As an ASAL, land in Ijara is communally owned and governed by customary land law that accords rights to every community member but lacks incentives and sanctions for efficient utilization and management (GoK, 2004)

All the households reported that water pans were constructed in their areas as a response to adverse effects of climate change on their lives and livestock. However, the number of water pans differed in that some areas had only one water pans while others more. Out of the total number of household 98.3% were aware that ownership rested with the community (Table 4.26). The high rate of awareness portended well for sustainability given water pans requires regular management to include periodic de-siltation.

Table 4. 26: Ownership of water pans

Owner	Frequency	Per cent
Community	236	98.3
Other systems	4	1.7
Total	240	100

As for Water pan excavation 92% household were aware that it was by mechanical means and only complemented by 4% manual excavation (Table 4.27).

Table 4. 27: Method of excavation of water pan

Excavation method	Frequency	Per cent
Manual	18	7.5
Mechanical	222	92.5
Total	240	100

Ninety-five per cent of the households appreciated that water pan costs of maintenance were firmly in the hands of respective community (Table 4.28).

Table 4. 28: Maintenance of water pan

Responsibility	Frequency	Per cent
Community	230	95.83
Government	10	4.16
Total	240	100

Up to 84% local communities appreciated that that if the water pans were not maintained, they would remain useful only for 1 year.

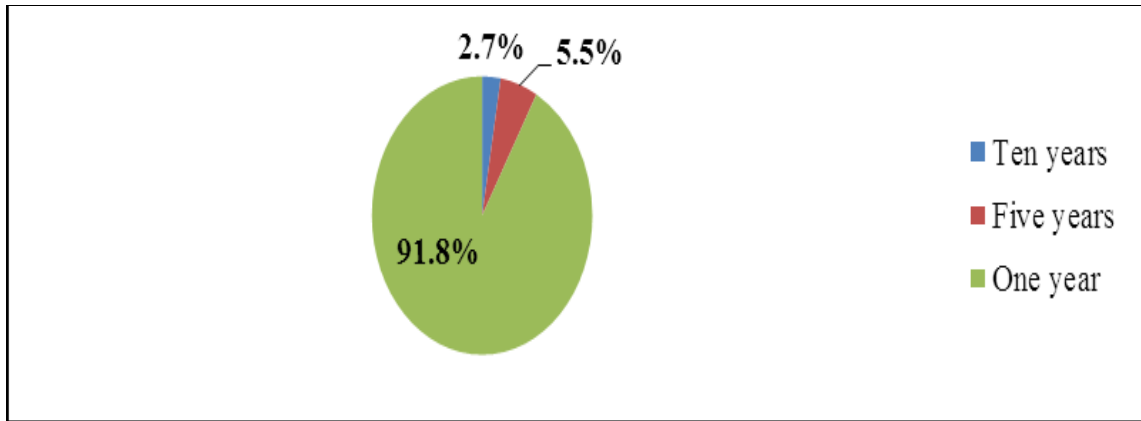


Figure 4.16: Usefulness without maintenance

This result indication is critical as it does flash grave consequences in the event of non-maintenance as is the case for most water pans in Ijara sub-county. The study focused on Handaro water pan mainly because of current usability and potential to support continued adaptation. It was excavated by Ministry of Agriculture through NALEP program in 2009.

Table 4. 28: Number of Livestock Kept Before and After Pan

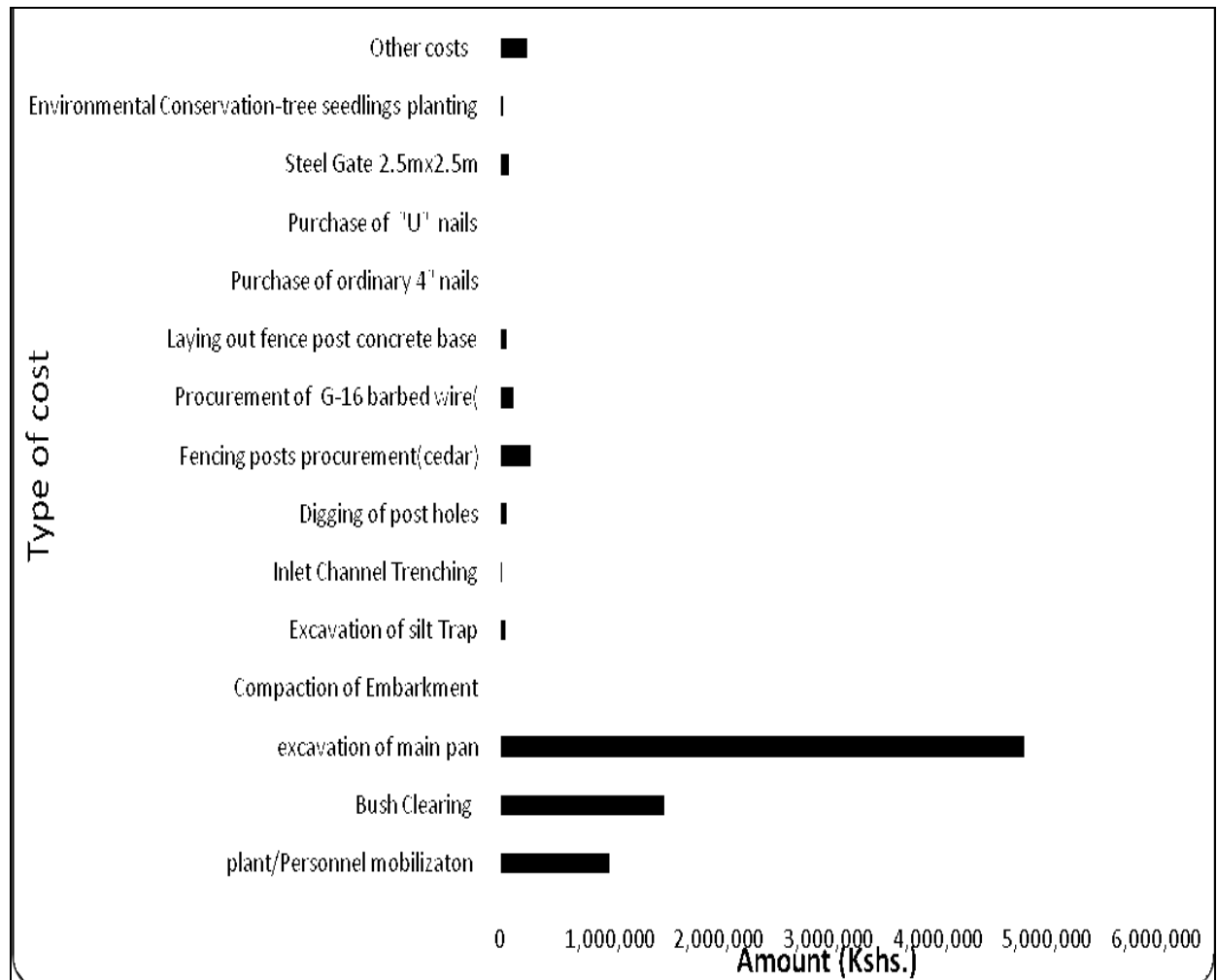
Livestock before and after pan	Mean	N	Std. Deviation	Std. Error Mean
Cattle before pan	7.25	209	8.47	0.59
Cattle after pan	11.29	209	10.69	0.74
Sheep before pan	8.86	207	7.98	0.55
Sheep after pan	13.38	207	11.44	0.80
Goat before pan	9.76	206	8.82	0.61
Goat after pan	15.44	206	13.46	0.94
Chicken before pan	3.06	119	2.91	0.27
Chicken after pan	3322.74	119	9040.67	828.76
Camel before pan	3.36	153	40.42	3.27
Camel after pan	0.19	153	1.24	0.10

Key socio-economic benefit from water pan was the increase in cattle per household at the rate of 3 heads after water pan was available; the number of sheep rose by 4 heads while goats increased by 5 heads (Table 4.29). The increase represents increased incomes in livestock which is welcome input from water pan strategy.

#### 4.9.1 Costs and Benefits of Handaro Water Pan Use

Figure 4.17 specify the breakdown of costs as obtained from key informants from the Ministry of Water and irrigation, Ijara and Garissa for Handaro Water pan.

Figure 4.17: Costs of implementing water pan adaptation strategy



Data Source: Figure generated based on costs from the Ministry of Water and Irrigation, Ijara sub-county

Figure 4.17: Costs of Implementing Water Pan Adaptation Strategy

Key cost streams in water pan construction are excavation, bush clearing, fencing, and labour. As Figure 4.17 shows, excavation for Handaro was clearly high capital outlay costs but benefits exceeded costs as from year two on based on revenue netted from agri-business activities it supported. Before construction of the water pan households had to walk 15-30 Km daily in search of water for domestic and livestock use but the pan has

reduced the distance to less than 4 km for most households. Also the study clarified that the typical water pan holds water for a mean period of 10 months. This translates to a total value of water impounded to an average Kshs. 1, 776,633 for that period of time. The figure of Kshs. 1,776,633 was arrived at by asking the respondents how much it would cost them to obtain the same amount of water from water trucking services available in the sub-county. This is a welcome saving as recent costing of Emergence Water Trucking showed that the cost of 1m<sup>3</sup> of water after being trucked to a location 65 km away from the water source was 160% times more than the same amount of water at the source. However not many households in the area were aware of these costs least of all the excavation costs as 15% specified they were aware but 81.66% indicated unawareness.

Table 4. 29: Awareness to cost of excavation

<b>Response</b>	<b>Frequency</b>	<b>Per cent</b>
<b>No</b>	196	81.66
<b>Yes</b>	36	15
<b>Total</b>	232	96.66
<b>Others</b>	8	3.34
	240	100

Further, Kshs.1, 717,909.2 was the total sum respondents would be willing to pay for the same volume of water if they were to purchase it in terms of jerry cans to irrigate their crops, water their animals and for household consumption. The sum total of such expenditure yielded monetary benefits derived from the use of the water pan. This was the response derived from the direct question put to the respondents in terms of how much they would pay (Table 4.31) in which 78.26% were willing to pay.

Table 4. 30: Willingness to Pay for water

<b>Response</b>	<b>Frequency</b>	<b>Per cent</b>
<b>No</b>	50	21.74
<b>Yes</b>	180	78.26
<b>Others</b>	10	
<b>Total</b>	240	100

Additionally, as shown on Table 4.33, the water pan has generated monetary benefits drawn from household savings from labour, sales of crops around water pan, domestic water use and income from other economic activities through time saved.

Table 4. 31: Water use on Irrigation

Responses	Frequency	Percent
Yes	41	17.08
No	191	79.58
Total	232	96.66
System	8	3.34
Total	240	100

Equal to 79.58% households indicated water was not used for irrigation while 17.08% differed (Table 4.32). The implication here is that, crop farming was not a major activity and was comparatively a recent innovation.

Table 4. 32: Monetary benefits of water pan strategy

MONETARY BENEFITS FROM:	N	MEAN	STD. DEVIATION
Labour saved from fetching water far off, to engage other income generating activities, monthly	238	6210.71	10908.32
Monthly labour saved in watering livestock far off sources (time saved to generate incomes)	234	9331.20	31306.40
Income from sale of crops watered from the dam monthly	230	8901.57	27626.54
Savings from household water consumption, monthly	226	2693.58	4614.61
Time saved to do other chores, monthly	220	3074.09	5885.17
Total income from water pan, monthly	236	28631.8	62474.83
Valid N (list wise)	211		

#### 4.9.2 The Cash flow of costs and benefits

The following are the Water pan costs and benefits for Handaro water pan mechanically excavated (30,000m<sup>3</sup>). The 5-10 year period is the interlude in which the water pan can last under good maintenance in order to supply the same level of economic benefits.

Table 4. 33 Water pan cash flow-present value analysis

Water pan cost and benefits structure	Description	Discounting Rate	Total cost	Cash flows in (KSHS.)					
				Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
<b>Monetary Costs</b>									
<b>Initial investment (capital costs)</b>	Include costs for feasibility study. Environmental and Impact assessment , Topographical surveys and structural designs, mobilization of equipment and personnel, main pan excavation works, silt traps, inlet channel and embankments, fencing and environmental conservation	15%	9,741,150	9,741,150	-	-	-	-	-
<b>Rehabilitation /Maintenance costs</b>	Repair of silt traps and embankments, fence and desilting	15%	1,270,000	-	254,000	254,000	254,000	254,000	254,000
<b>Other costs</b>	Project Administrative and supervision and 16% VAT	15%	1,500,000	1,500,000	-	-	-	-	-
<b>Non-monetary costs</b>									
Environmental degradation									
Human- wildlife conflicts									
Loss of grazing land									
<b>Monetary Benefits</b>									
Total direct income from water pan*			1,717,909.2	-	343,581.84	343,581.84	343,581.84	343,581.84	343,581.84
<b>Non-monetary Benefits</b>									
Reduced incidence of water borne diseases									
Improved environment as a result of tree planting									

The water pan can last for twenty years under good maintenance in order to supply the same level of economic benefits. The analysis considered the cash flows for a ten year period. Applying the NPV formulae:

$$NPV = CF_0 + \frac{CF_1}{(1+K)^1} + \frac{CF_2}{(1+K)^2} \dots + \frac{CF_n}{(1+K)^n}$$

Where  $NPV =$  Net present value

$CF_0, CF_1, CF_2 \dots CF_n$ , are the cash flows (Monetary costs-Monetary benefits) for periods  $t=0, 1, 2 \dots n$

$K$ =the discounting factor also known as the opportunity cost of capital.

NPV = Present Value of future cash flows – Investment

NPV Decision Rule: If  $NPV \geq 0$  then the adaptation is economically feasible.

Table 4. 34: Net present value 10-year Aloe cash flow

Year	Discounting Rate (@15%)	Cash Inflow	Cash Outflow	Present Value
0	1		11,241,150.00	-11,241,150.00
1	0.87	343,581.84	254,000.00	77936.2008
2	0.756	343,581.84	254,000.00	67723.87104
3	0.658	343,581.84	254,000.00	58944.85072
4	0.572	343,581.84	254,000.00	51240.81248
5	0.497	343,581.84	254,000.00	44522.17448
6	0.432	343,581.84	254,000.00	38699.35488
7	0.376	343,581.84	254,000.00	33682.77184
8	0.327	343,581.84	254,000.00	29293.26168
9	0.284	343,581.84	254,000.00	25441.24256
10	0.247	343,581.84	254,000.00	84864.71448

Net PV=512,349.255

Net Present Value of 512349.255, is greater than zero, meaning water pan as adaptation strategy is economically viable.

#### **4.9.5 Economic Effects Of Human –Wildlife-Livestock Conflicts**

The cost of adaptation in Ijara is increased by human-wildlife-livestock conflicts as 94% of the households indicated that the menace was a huge problem in the area (Table 4.36). The problem typifies escalated costs through resource conflicts as humans and livestock compete with the wild animals for water from the water pans especially during drought. Resultants to the conflicts costs rise as water level dip, attacks and deaths occurring with that of livestock being a common phenomenon due to marauding lions and other canines.

Table 4. 35: Human-wildlife-livestock conflicts vs. water pan

Response	Frequency	Per cent
<b>Yes</b>	226	94.17
<b>No</b>	5	2.08
<b>Total</b>	231	96.25
	9	3.75
<b>Total</b>	240	100

On comparing scenario before and after pan, it is clear that the losses through attacks particularly of livestock increased after water pan was constructed. The increase in conflicts is attributable to the congregating of livestock and wild animals at the common watering point which is common in Ijara.

#### **4.9.6 Economic Impact of Water Pan on Crop Production**

Water pan provide much-needed benefits reprieve from drought ravages and ensuing high costs of crop production in the area. Up to 89.3% of agro-pastoralists indicated that the water pan was economically viable (Figure 4.37). This view is supported by positive cash flow on bumper yield from on-farm pasture of 9227kgs per ha retailing at Kshs 50 (see Table 4.17: Livestock feed enterprise cash flows.)

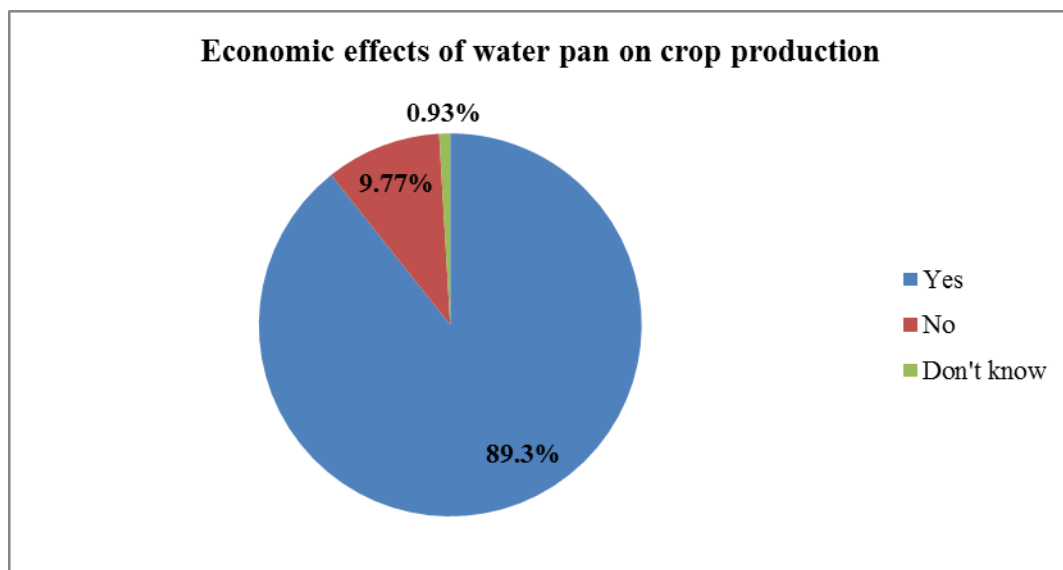


Figure 4. 36: Economic effects of water pan on crop

Most farming in Ijara is rain-fed, but due to worsening climatic conditions farmers have to adapt to irrigated farming using existing technologies such as water harvesting pans. But, even then, the study indicated that only paltry 5% do irrigation, sourcing from nearby water pan as the pans cannot sustain intensive irrigation due to high costs stemming from the rising demand for water that is shared between wildlife, domestic and livestock. However, 56% of farmers preferred water pan to resorting to appealing to the international community for emergency assistance when a drought occurs as it has resulted in dependency syndrome with higher costs on life.

An alternative to water pan in the area is Emergency Water Trucking (EWT) which is increasingly becoming a common method for delivering water in response to drought emergency. EWT is not necessarily cheaper; as recent costing in Mandera by stands for Rural Agency for Community Development and Assistance (RACIDA) showed that the cost of 1m<sup>3</sup> of water after being trucked to a location 65 km away from water source was 160% times more than the same amount of water at the source (FAO, 2009). Also the costing indicated that the main drivers of emergency water trucking in the ASALs include drought, poor settlement patterns propelled by political interests, creation of new districts even in locations without reliable sources of water, commercial interests of businessmen; and lack of long term strategies for investing in reliable and adequate water sources in the ASALs (FAO, 2009).

## **CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 Summary**

The chapter presents summary, conclusions and recommendations made based on the study results. Propositions for area that require further research are provided towards the end of the chapter. Chapter One introduced the background of the study and set out the objectives and questions. The chapter also presented the conceptual framework. Chapter Two reviewed literature and isolated gaps requiring further research. Chapter Three provided the background of the study area and the study design. It described the methods and instruments of data collection, analysis and presentation. Chapter Four reported the analysed data and discussed findings.

### **5.2 Conclusions**

From the study, it is clear that economic development initiatives are central part of adaptation requiring mainstreaming climate data into development through different approaches, not business as usual. Also, it is critical to invest in human capital and competent institutions that focus on enhancing resilience and tackling roots of poverty starting with low regret options. There is need to invest in weather risks that already stress people and ecosystems such as drought by investing in enhanced strategic water harvesting and poverty reduction technologies for if not, climate change will compound drought risks, raising costs even higher. And while at it, consider hard adaptation (undertaking actual options) and soft adaptation e.g. awareness creation as one entity given the two complement each other and should spread concurrently. The conclusions are vital for the study area now that the three adaptation strategies under study namely water pan, Aloe crop and livestock feed enterprises were found economically viable but required home-grown capital-generating initiatives, done differently. Overall, the findings clarified that ASALs are water stressed and Ijara epitomize this stress more readily in form of incessant drought which in turn increases vulnerability to drought in an endless vicious cycle. But as results indicate, adaptation reduces vulnerability and increases resilience. Consequently, investing in proven economically viable adaptation

makes strong economic sense, even in unpredictable ecosystem conditions and climate change. In order to be able to create lasting impact for drought-affected communities, it is imperative that actors work in concert to build long term resilience and in line with National Climate Change Response Strategy and Kenya's Vision 2030's disaster preparedness and capacity development. This is especially important because onset of drought only comes to exacerbate existing development weakness in the area. The results become a handy tool for policy formulation guided by the clarity on costs and benefits established in the study as briefly discussed below:

**a) Costs and Benefits**

i) **Pasture Enterprise**

The study established that investments in pasture enterprise, paid off and that accruing benefits exceeded costs. The Kshs 120,000/ha/season input costs on on-farm Sudan grass yielded up to 1.8 tons/ha of dry matter seasonally. The prevailing market Ten-year cash-flow on the fodder across three rain-fed seasons netted Kshs 1,925,091, 4,069,234.55 and 6,103,851.83 per hectare from one, two and three seasons respectively. The three seasons arose from MAM and OND rain seasons and an additional one based on water pan usage. The study specified that pastoralists indistinctly stick to keeping livestock despite the feed deficits arising from either economical or climatic factors which compromise quality, quantity and market prices. But the strategy cushions the farmers from gaps in fodder supply that occur during drought. Prevailing market prices were used on the analysis and showed increased incomes and livelihoods both monetary and non-monetary.

ii) *Water Pan*

A key conclusion from the study was that with NPV of Kshs 512,349.255 (Table 4.11), Handaro water pan was economically viable as adaptation strategy, despite the initial steep costs that taper off after year two of usage. Before construction of the water pan households trekked 15-30 Km daily in search of water for domestic and livestock use but the pan has reduced the distance to less than 4 km for 70% of the households. The study established that the water pan impounds water for 10 months annually which translates to

an average Kshs. 1, 776,633 for that period of time. The value Kshs. 1,776,633 was arrived at by comparing costs of obtaining the same amount of water from water trucking services available in the sub-county. This was welcome benefit as recent costing of Emergence Water Trucking showed that the cost of 1m<sup>3</sup> of water after being trucked to a location 65 km away from the water source was 160% times more than the same amount of water at the source. Further, Kshs.1, 717,909.2 was the total sum respondents would be willing to pay for the same volume of water if they were to purchase it in terms of jerry cans to irrigate their crops, water their animals and for household consumption.

*iii) Aloe crop*

The study established that Aloe cash flow based on 15% discounting rate translated to net present value Kshs 4,255,773. The key benefits from Aloe revenue derived from medicinal and beauty products. The products on high demand were soap, body lotions and shampoo products. The target group who utilized the products the most were youth and women, with peak demand being July-August and December –January. The main costs in Aloe production were cultivars planting material, land preparation, field management, harvesting and transport. Other costs were initial investment (capital costs) Kshs 18538 and annual operational and maintenance costs Kshs 6366.

*iv) Strategies Benefits vs. costs*

The study clarified that benefits from the three strategies exceeded costs incurred. For instance a cropping season of Aloe crop netted Kshs 37,500/Ha, with inputs Kshs 125,000/ha, which is significant benefit given some capital costs such as fencing is one-off expenditure. Also water pan net costs were exceeded by benefits as livestock asset value were improved, time wasted previously trekking in search of water was saved to engage other income generating activities. Additionally, the pan water was used in irrigation and supported pasture growth. Other benefits that outwitted costs were environmental benefits to include micro-climate, carbon sink, cropping whose co-benefits include green fertilisers, crop residue, manure, green cover and soil enrichment. Water pan cash flow per year was Kshs 512,349.25.

## **b) Viability of the strategies for adaptation**

Despite the initial high capital costs that tapers off in the second year onwards, pasture enterprise was found economically viable and an apt adaptation strategy. The study indicated that water pans, livestock feed enterprises and Aloe crop are economically viable as adaptation strategies. Viability in this context frames the vulnerability scenario in which the community lives – mainly because of the high poverty indices (63%). The analysis placed integral focus on what interventions are viable to the community rather than who finances the interventions that bolster their resilience to the adverse impacts of climate variability. While it may seem that ‘viability under the framework of community support from development partners’ downplays the viability indicator, it is worth noting that projects of such mechanisms can cost effectively exist on partnerships support. However, benefits from utilization by the local communities of such adaptation strategies have proved viable hence the overall project sustainability is assured.

The study indicated that implementing cost-effective water pan, Aloe crop and pasture enterprises are key pathway to manage costs arising from extreme weather events, drought in particular. For long now drought and floods have seemed natural to life in Ijara, like other ASALs of Kenya as attested to by the five devastating droughts in the last decade; 2001, 2003, 2006, 2009 and 2011 and major floods in 2006 and 2010 (Fitzgibbon, 2012). These extreme weather events deal significant blow to the economy as was the case with the 1998/99 *El Nino* floods that stagnated ASAL economy. Given the persistence of the extreme events, economic costs of the impacts on market and non-market sectors will be a disconcerting 3% of Kenya’s GDP per annum by 2030 with potential to rise to above 5% of GDP per year by 2050 (SEI,2009). And yet managing drought is an exorbitant venture as indicated by government’s expenditure of over Kshs 10.5 billion on food relief excluding contribution from development partners. Other expenditure on the same around same time was UN and GoK joint appeal in May 2000, USD 121,029,702; and an additional USD 122,650,146 spent in February 2001 (GoK, 2004). Some of the adaptation measures instinctively put up then to bear the blunt of

these shocks were water harvesting pans, such as Handaro, Aloe crop and pasture enterprise and have been found viable investment in the study

### **5.3 Recommendations**

#### *a) Pasture enterprises*

The study recommends promotion of livestock feed at farm level to demonstrate that pastures can be established at the level among pastoral communities either for domestic use or commercial purposes and preferably both. This will *inter alia* trigger a paradigm shift among the pastoralists who believe that the responsibility to grow manage pasture rests with *Allah*. But the reality on the ground demands that communities especially in the region do a lot to adapt and improve their lives to enhance their survival by innovatively managing and utilizing the natural resources around them. Further, to ensure enhanced cost effectiveness, availability, optimal utilization of pasture as well as control of environmental degradation, the study recommends grazing management to be reorganized. The proposed change includes paddocking so that some paddocks are grazed on while others are reserved for use at other times. Also it is recommended to promote pasture production by providing seeds, training farmers and buying the pasture from farmers for storage in strategic feed reserves.

More specifically, Garissa county government need to formulate livestock improvement policy guidelines that should at least cover the following areas; revitalizing the traditional grazing management practices, organizing the marketing infrastructure and investing in on-farm fodder production technologies. Clearly, there exists an opportunity for the adoption of on-farm rain fed Sudan grass production both as a short-term and long-term adaptation strategy for adequate pastures availability all-year round. Estimated Sudan grass yields were 1.8 tons of dry matter per hectare, whose market price was Kshs 50/kg. The harvest not only avail much-needed feed, it also boost resilience through incomes particularly because it can be grown twice a year using prevailing MAM and OND rains 250-700mm and additional six times annually using water pan as it takes 40-50 days to mature. Additionally, the county government will be better off creating strategic feed reserves by promoting increased fodder production at household level and absorbing the

surplus in readiness for dry season. Also there is need for adequate post-harvest handling systems, creation of strategically located markets, accessibility and awareness. A major hindrance to increased fodder production is the communal land tenure system in the county which begs for revision to allow for permanent individual ownership rights. The land review would enable individual farmers to invest in long term sustainable land-use management systems whose propensity it is to increase productivity

*b) Aloe crop*

The study established that Aloe crop is globally recognized for its role in environment conservation and human health care products and these benefits are experienced in Ijara. The study recommends special focus on enhancing production value chain of Aloe health and beauty products as they make for good business. To address the challenges farmers currently face in particular, capital, it is recommended to carry out feasibility study, capacity building, and institutional development, increase aloe acreage as well as acquiring suitable processing equipment. This will also enhance efficacy in Aloe production and market access. The focus should factor-in women and youth as the target group who utilize the products the most factoring in high demand season which is July-August and December –January.

The study clarified that market for aloe products were mainly local (Ijara and Garissa), with Nairobi and Mombasa currently absorbing minimal products. Aloe products processed locally were limited to soaps and shampoo with high incidences of consumption at Aloe leaf level. Based on the results, it is recommended to carry out a broad value chain study to establish Aloe crop markets, actors to include producers, processors, transporters, traders and consumers, in and outside the county. A detailed study is vital to collectively review economics affecting each of the enterprises along the value chain and way forward galvanizing the chain strategies' target markets.

*c) Water harvesting pan*

The study established that water pan increase benefits by accelerating economic activities and incomes around them well enough to complement livestock products. For sustainability of this complementary role, the study recommends that farmers be exposed

to hard (actual implementation) and soft (awareness creation) adaptation all at the same time as the two approaches complement each other. Also, incentives will be in order given that farmers in this area are largely new to crop farming and because cropping has the co-benefits in form of crop residue, soil enrichment, green cover, livestock feed, manure and carbon sink. Additionally it is recommended that farmers be supported with high-breed seeds (tolerant to drought and fast growing and high yielders) and subsidized agricultural inputs. Also it is recommended that media outreach through radio be enhanced so that more farmers are informed about climate change, its causes, consequences, mitigation and adaptive measures- all as co-benefits.

As for water resource-based conflicts, there is need to invest in robust research to establish way forward and mitigating measures against water resource-based conflict. The study has shown that water pan have offered an oasis of life for humans, wildlife and livestock. However, the watering points have increasingly become sites for perpetual conflicts among users. Other ecosystem health-related conflicts have arisen from settlements that mush-room around water pans.

*d) Establishment of community management institutions*

The study indicated that institutions are weak or altogether non-existent in Handaro and Sangole-Ijara, which gap calls for immediate attention. The study recommends this all-important institutional development to include galvanizing farmers around their home-grown marketing SACCOs to increase benefits and to cushion them against undue extortion from brokers. Also, it is recommended to train women and youth in core processing and business skills to enable the local enterprises to gradually increase benefits through upped production and marketing of basic aloe products.

*e) Costs and Benefits Vs. climate Data Application*

Given the declining livestock feed vulnerability occasioned by drought and floods, and based on constraints outlined earlier, the study recommends provision of enhanced downscaled weather information. Such data will inform water harvesting, protection of natural capital, special livestock insurance schemes; breeding of animals that adapt well

to climatic vagaries; regular vaccination campaigns; promotion of economic livelihood diversification, construction and de-silting of water pans, water re-cycling, and awareness campaign to promote water efficiency measures.

Further, there is need for Garissa county government to invest in weather stations and to train farmers on monitoring and collection of weather data so as to better inform farming and livestock management decisions for food security and upped resilience. Notably, the predicted increased rainfall year 2030 onwards and high temperature means high evaporation and increased surface run-off both of which requires innovative water harvesting technologies and enhanced soil stabilization approaches such as multi-benefits crops e.g. Aloe.

Having analysed CORDEX models and climatic data prediction from Kenya Met Services (KMS) with regard to climate prediction and costs benefits effects, the study established that the changing climate and variability will change significantly by 2030. The predicted rise in both precipitation and temperature will impact markedly on costs and benefits of adaptation. The costs rise because of possible infrastructure to check off floods, new adaptive livestock crop breed; new diseases that follow increased temperature in a wet landscape. The benefits increase because arid conditions will dip giving way to increased crop and livestock production as long as new adaptive technologies and disease control are implemented.

#### f) *Adaptation Benefits in Relation to Gender*

The study specified that adaptation costs and benefits contrast gender-wise as climate change impacts on gender differ markedly and also coping strategies in response to climate variability differ too. For instance it was clear that women's and men's perceptions of and responses to impacts of extreme weather events, as well as their access to resources and support, vary fundamentally (Figure 4.1). Furthermore, gender disparity; social and economic roles of women also lessen their economic status, therefore making them more vulnerable to the impacts of climatic change. The study indicated that the economic status of such women is low due to their reliance on meagre job opportunities that are dependent on natural resources and ecosystem. Based on this view, the study

recommends an improved system of dissemination of climate, crop and rainfall information that is gender sensitive and accessible to a wider social spectrum. The system should be applicable without biases due to gender, property ownership, age or religion. This will enhance emergence of new creative solutions and new resilience both at the institutional and household level as the gradual breakdown of barriers to gender empowerment. Institutional support and policies should focus on recognizing and sustaining these new approaches.

*g) Adaptation in relation to Land tenure systems*

The study recommends reviewing current communal land tenure system in the region to allow for more permanent ownership rights to individuals. The change may provide level ground for more market-oriented approaches and incentives for apt resource management and to maximize available resources so as to clinch value-for-money economy. Additionally the study recommends that county government offer incentives for pertinent emerging livestock and awareness campaigns among pastoralists to underscore the importance of balancing stocking rates with the available land resources as a way of ensuring sustainable pastoralism access to market.

#### **5.4 Areas for further Research**

The scope of the study excluded research on market and monitoring of livestock growth as well as application of the pasture carrying capacity formula to ascertain sustainability of pasture. The study recommends that area highlighted below be isolated for further research:

*i) Cost-effectiveness:* Cost-effective strategic livestock feed reserves to promote pasture production and marketing in the county

Pasture-carrying capacity: Pasture-carrying capacity to be assessed to ascertain balance between livestock population to pasture availability. This will inform resilience and sustainability of livestock production

*ii) Quantifying impacts of pasture on livestock health:* Monitoring livestock health and body weight to ascertain impacts of pasture on livestock population in Ijara as well as quantifying emissions

*iii) Impacts of land tenure system:* Strategic review of the communal land tenure system to promote fodder and improved livestock production

IV) *Grazing management:* There is need to carry out survey to inform climate-smart paddocking. This will inform enhancement of sustainable and economically viable utilization of grazing resources and control of environmental degradation.

v) *Cost-effective climatic monitoring:* It is imperative to research further on what equipment and capacity enhancement is cost-effective enough. Establishment of strategically positioned cost-effective weather infrastructure/stations will support collection of sufficient and reliable climate data to inform strategic management

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## APPENDICES

### Appendix I: Household Survey Questionnaire

*Introduction: This survey aims at obtaining information that will be used for economic analysis of water pans, pasture enterprise and aloe crop as adaptation strategies in Ijara Sub-county, Garissa County. Data obtained will be used to quantify benefits and costs of the strategies for academic purposes to inform climate-smart policy development.*

1. To be completed before the interview		2. To be completed by Student Researcher	
0.1	Supervisor name: Supervisor ID       __ __	- Questionnaire Number:  __ __        __ __  Team      + Questionnaire code      Numbering	
0.2	Date of interview :  __ __  /  __ __  / 2013 Day      Month	0.13- Date  __ __  /  __ __  / 2013 Day      month	
0.3	County name:      County code:  __	Researchers      name	
0.4	Sub-County name:      Sub-county code:  __ __	0.14-Researcher      Code  __ __	
0.5	Ward name:      Ward code  __ __	Remarks	
0.6	Sub-location name      Sub-location code:  __ __		
0.7	Enumeration Area (EA) name:      Area code:  __ __		
0.8	Village/Town name:      Code  __ __		
0.9	Livelihood zone name:      Code:  __ __		
0.10	GPS Coordinates E  __ __ : __ __ __  W  __ __ : __ __ __	Signature of Researcher: _____	
0.11	Elevation: _____ Metres (above sea level)		
This Section to be completed by Interviewer in full		To be completed by data entry clerk:	
Name of interviewee:		First data entry Date:  __ __  /  __ __  / 2013 DayMonth Name of data entry clerk	
Telephone: Occupation: _____ Sex : _____		Remarks	
Name of interviewer:			
Telephone no:		- Second data entry Date:  __ __  /  __ __  / 2013 Day      Month Name of data entry clerk:	
Signature :		Remarks : Signature of second data entry clerk (to be put after the questionnaire is entered)	

**SECTION A: Household information--Members of Households, Education, and Employment**

1	Please state the relationship of the respondent to the head of the household ( <i>key</i> ):
1	How long has the household been involved in crop farming/livestock/water conservation/pan? ( <i>Please tick as appropriate</i> ) _____ ( <i>In number of years</i> )
2	Gender of household head: _____ ( <i>if household is female headed, don't ask 1.5</i> )
3	Household size:
4	How many wives does the head of household have?: _____ ( <i>note to enumerators: please include entire family, including other wives, below</i> )

**TABLE 1.5: HOUSEHOLD ROSTER**

No.	1.5.1 Name ( <i>ok if first name only</i> )	1.5.2 Relation to household head ( <i>key</i> )	1.5.3 Gender ( <i>key</i> )	1.5.4 Age ( <i>years</i> )	1.5.5 Marital status ( <i>key</i> )	1.5.6 Highest education level achieved—write	1.5.7 Religion
1							
2							
3							

<b>Key 1.5.2 Relationship of respondent to household head</b> 1: Head of household; 2: Spouse 1 3: Spouse 2 4: Spouse 3 5: Child; 6: Grandchild; 7: Parents; 8: Other family members (includes cousins, etc.) 9: Worker/other proxy for owner 10: Others, specify _____	<b>Key for 1.5.3 – Gender:</b> Male Female	<b>Key 1.5.6 -Highest Level of Education</b> None Primary Secondary College University Others – madrasa, adult education
	<b>Key for 1.5.5 Marital status</b> 1. Married 2. Married, but not living together 3. Married, more than 1 spouse 4. Widowed 5. Divorced 6. Never married	

1.6 Which year did your household settle here? (*Tick as applicable*)

Before 1960		1970		1980		1990		2000		2010	
-------------	--	------	--	------	--	------	--	------	--	------	--

<b>SECTION B: SOURCE OF LIVELIHOODS</b>			
2.1 What are the main sources of household livelihoods? ( <i>In order of priority. Use table 2.3 below</i> )			
2.2 Estimate the contribution of each of the sources in the household livelihood ( <i>Use table 2.3 below</i> )			
2.3 Estimate the contribution of these sources of livelihoods 5 and 10 years ago ( <i>Use table 2.3 below</i> )			
Table 2.3: Main Sources of Livelihoods			
Source of livelihood*	Current contribution in the household	Contribution in the household (5 years ago)	Contribution in the household (10 years ago)

N.B: source of livelihoods can be  
 i. Livestock farming  
 ii. Shop business

- iii. Crop farming
- iv. Remittances from outside the area
- v. employment income
- vi. others (specify)

**SECTION C: SHOCKS TO THE HOUSEHOLD**

3.1 Which extreme climate events significantly affected your household income during the last 10 years?

3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6
Type of shock (key)	When was the shock (year in last 10 years)	What did the shock result in? (Key)	What did you do? - Action? (Key)	How widespread was the shock? (Key)	Estimate the amount of loss to the household (KSH)

<p><b>Key for 3.1.1 - Type of climate event:</b></p> <p>Drought Flood Erratic rainfall pattern Hailstorm Lighting Wind gusts Other, specify _____</p> <p><b>Key for 3.1.3 - Outcome of climatic event:</b></p> <p>1. Loss of assets, 2. Loss of income, 3. Decline in crop yield; 4. Decline in livestock production 5. Loss of entire crop 6. Death of livestock; 7. Food shortage/insecurity 8. Food price increase 9. Loss of human life 10. Other, [specify _____]</p>	<p><b>Key for 3.1.4 Action</b></p> <p>Did nothing Sold livestock Sold crops Sold land/home Sold assets Seeking assistance from relatives or friends Borrowed from bank Borrowed from private money lenders Received food aid Participated in food for work HH head migrated to other areas HH plus others migrated to other areas Migrated to urban area Sought off-farm employment Bought food Ate less Ate different foods Kept children home from school Other [please specify _____]</p>	<p><b>Key for 3.1.6 – How widespread</b></p> <p>Only my household Some households in village Most households in the village All households in the village Many households in the district All households in the district</p>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

3.2. When was the last drought you experienced? _____ (year)	3.3. When was the last year you experienced above normal rainfall? _____ (year)
3.2.1. During the last large drought, did you change your farming practice (crop and livestock)? _____ (Yes: 1, No: 2)	3.3.1. During the last year with too much rain/floods, did you change your farming practice (crop and livestock)? _____ (Yes:1, No: 2)
3.2.2. If yes, what did you do? (key)	3.2.3. If yes, how? (key)
3.3.2. If yes, what did you do? (key)	3.3.3. If yes, how? (key)
3.3.4 Having experienced the climatic shock, did you change your farming practices (crop/ livestock)? <b>1. Yes 2. No (circle your answer)</b>	
3.4 If you did not change your crop farming and/or livestock practices in response to drought or above normal rainfall, what was the reason? (Use key)	

<p><b>Key for 3.4. Reasons why I did not change my farming/livestock practices?(please circle your response)</b></p> <p>No access to money No access to credit No access to land No inputs No access to markets Shortage of labor Limited understanding of the impacts and opportunities of climate change No information on climate change and appropriate adaptation options</p>
----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Other

**SECTION D: COSTS OF FARM EQUIPMENT, AND WAGES RATES**

**4. What type of farm tools and equipment do you use? (Circle the equipment in the key provided)**

1. Panga 2. Hand hoe 3. Spade 4. Pick ax 5. Winnowing 6. Plough and yoke for animals 7. Reaper 8. Manual sprayer 9. Plough-tip 10. Plough handle 11. Rake 12. Wheelbarrow 13. Carts (hauling) 14. Fork Jembe 15. Planting stick 16. Slasher 17. Hay balers 18. Crushers 19. Loading ramps 20. Syringes 21. Branding equipment 22. Milking equipment 23. Other light machinery, (please specify \_\_\_\_\_) 24. Tractor 25. Plough 26. Trolley/Trailers 27. Thresher 28. Fodder cutting machine 29. Generator/Diesel Pumps 30. Spraying machines (chemicals/fertilizer) 31. Harvester 32. Water pump 33. Other Heavy Machinery (please specify \_\_\_\_\_)

**4.1 What are the Costs of the Farm Tools and Equipment that you use in your farm? (Use table 4.1 below)**

**Table 4.1: Costs of Farm Equipment and Hiring Rates**

	Number	Cost per unit (own, purchase price)	Cost per unit (if hired, cost of hiring)
Farming tools type:			

1.

**4.2. LABOR COSTS FOR LIVESTOCK AND ALOE CROP FARMING**

4.2.1 Does your farm use hired labour? 1. Yes 2. No (circle response) \_\_\_\_\_

4.2.2 If yes, what are the labour costs for your farming and/or livestock rearing activities? (Use table 4.2 below)

4.2.3	Farm/Herding Wage Rates – labor costs	Hired Labor		If someone from the household works on someone else’s farm, wage received	
		Male	Female	Male	Female
4.2.4	Average wage/day (across various activities) for each type of worker	4.2.4 a	4.2.4 b	4.2.4 c	4.2.4 d
4.2.5	Total In kind payments* or benefits per day (across various activities) [quantity] [incl. housing, food, land, livestock, crops, education, health]	4.2.5a	4.2.5b	4.2.5c	4.2.5d
4.2.6	Average number of laborers working during last 12 months				
4.2.7	Maximum number of labor working during peak time last 12 months				

Table 4.2: Labour costs for livestock and crop farming

**NOTE:**

-Where “wage per day is not achievable apply a different denominator. To be worked out later on

-\*”in-kind payment”: could alternatively be: how much would it cost the worker need to pay to obtain the same items other than paying cash

**4.3 COSTS AND BENEFITS OF LIVESTOCK AS ADAPTATION STRATEGIES**

4.3.0 Do you produce fodder for your livestock? 1. Yes 2. No (if yes then answer 4.3.1, else go to 4.3.2)
4.3.1 What are the cost of production or purchase of fodder?.....Kshs./month
4.3.2 Do you own pasture land ? 1. Yes 2. No ( if yes 4.3.3, else 4.3.5)
4.3.3 What size of pasture land do you access?
4.3.4 Comment on the size of your pasture land?_
4.3.5 What size of pasture land do you control?
4.3.6 What types of pasture is available?
4.3.7 Is the pasture: 1. natural _____ 2.established? (Circle response)
4.3.8 Do you store any animal feed? 1. Yes 2. No (circle response)
4.3.8 What is the main threat to animal production?
4.3.9 Estimate the area (communal or individual) of farm under trees and shrubs _____%
4.3.10 what are the common tree species and shrubs in your land (communal land) by proportion during the following time periods (currently, 5 years ago, 10 years ago)

(Use the table below to indicate your response as well as the proportion vegetation cover on land)

Current tree species	Proportion of land covered
Species 5 years ago	
Species 10 years ago	
4.3.10 what are the livestock enterprises that you are involved in starting from the most to the least profitable? (Record response in the table below)	

Rank	Livestock enterprises
1	
2	
3	

(Livestock enterprises can be goat rearing, chicken rearing, livestock trade, bee-keeping and others)

4.3.11 Give estimates of the amount earned per month in each of the above enterprises from most to the least profitable:	
1.....	2..... 3..... 4..... 5.....

4.3.12. Indicate the source(s) of family income and the monthly income (Kshs.) from sources stated below:		
S/No	Source of income	Income (Kshs)
1	Livestock sale	
2	Milk sale	
3	Employment	
4	Sale of fodder	
5	livestock trade	
6	other (specify)	

4.3.13 Has the government or any other organization carried out livestock interventions in your area in response to climate change? 1. Yes 2. No (circle the response)
------------------------------------------------------------------------------------------------------------------------------------------------------------------------

4.3.14 If yes, what type of interventions were they and how much did they cost? (Use table below)
---------------------------------------------------------------------------------------------------

Intervention	Year	Cost of intervention (Kshs )	Amount
Dairy goat improvement			
Fodder establishment			
Strategic livestock trade			
Others-specify).....			

4.3.15 What are the benefits from the Livestock interventions? (Use the table below to capture response)
----------------------------------------------------------------------------------------------------------

Intervention	Activity	Amount in Kshs/month
Dairy goat improvement	Sale of dairy goats	
	Sale of milk from dairy goats	
Fodder establishment	Sale of fodder	
Strategic livestock trade		
Others (specify).....		

4.3 16 Is the intervention helping you produce more in a profitable way and self-sustaining? 1=Yes 2=No (circle the response)
-------------------------------------------------------------------------------------------------------------------------------

- 14.3.18 How does the community start livestock rearing?(circle the answer?)
- (a) Borrowing a cow to rear and get calves and returning the cow to its owner without the calves
  - (b) Acquiring a calf for rearing by purchasing
  - (c) Herding someone's animals and getting paid in kind (starter stock)

4.3.18 what are the monetary and non-monetary cost of starting a new livestock enterprise to its maturity? (Use table 4.3.1 below)
4.3.19 what are the benefits of engaging in livestock rearing? (Use the table below)
4.3.20 what are the avoided damage costs? (Use <b>the table below</b> )

**Table 4.3.18: Costs and benefits of livestock enterprise**

Activity undertaken	Costs ( KES)		Benefits		Avoided damage costs	
	Monetary	Non-monetary	Monetary( kshs.)	Non-monetary	Monetary( kshs.)	Non-monetary
Purchase a calf calf (<2yrs not allowed)	1.____	1.____	1____	1____	1____	1____
Pest control		2.____	2____	2____	2____	2____
Labor (2 years to milking)	2.____					
Treatment (2yrs to milking)		3.____	3____	3____	3____	3____
Pasture ( buying grain) 2 yrs.@ 2,000 per bag of maize)		4.____	4____	4____	4____	4____
Fencing (thorny twigs for 2 yrs.)		5.____	5____	5____	5____	5____
Care e.g. trimming hooves						
Watering						
<b>Total</b>						

**Note:**

Some non-monetized benefits/costs are invaluable e.g. cultural, environmental, aesthetics among others.

**4.4 COSTS AND BENEFITS OF ALOE CROP FARMING AS AN ADAPTATION STRATEGY (Unit: 1 acre)**

4.4.0 Is Aloe a preferred crop grown as adaptation strategy? 1. Yes 2. No

4.4.1 If yes, what are the benefits and costs of growing the crop? (Use the table below)

ACTIVITY	COST KSHS.	BENEFITS KSHS
Bush clearing		_____
Plough		_____
Ridging blocks		_____
Nursery management		_____
Transplanting		_____
Watering (equipment)		_____
Watering (labour)		_____
Pest control (labour)		_____
Pest control (chemicals)		_____
Seeds		_____
Weeding		_____
Harvesting		_____
Post harvesting ( processing, packaging, storage, transport)		_____
Market search by phone		
<b>Total</b>		

**4.5 COSTS AND BENEFITS OF COMMUNITY WATER PAN INTERVENTION AS AN ADAPTATION STRATEGY**

4.5.0 What interventions by government or other development partners have been implemented in your area as a response to climate change? (Tick in the check boxes and indicate number for each)

Construction of water pans...	<input type="text"/>	No.....
Drilling of bore holes	<input type="text"/>	No.....
Green house technologies...	<input type="text"/>	No.....
Others- (Please specify)		

**4.5.1** Provide the details of a water pan in your area (see table 4.5.1 below)

Table 4.5.1: Costs of a water pan

COSTS ESTIMATES OF WATER PAN INTERVENTIONS		4.5.1.2	Ownership
4.5.1.1	Name of water pan:.....		
	..... (indicate whether communal or individual)		
4.5.1.3	Household distance from Water pan .....	KM	
4.5.1.4	Method of excavation: 1. Manual** 2. Mechanical (Circle the response)		
4.5.1.5	Are you aware of how much the water pan cost to excavate? 1. Yes 2. No (if no proceed to question 4.1.1.7)		
4.5.1.6	If yes how much? Kshs.....		
4.5.1.7	When was the pan excavated ?..... (indicate year)		
4.5.1.8	How long does the pan hold water after a rainy season? .....		
4.5.1.9	How much would it cost to water truck a similar volume of water for the entire duration the water pan has water? Kshs.....		
4.5.1.9	Who maintains the pan? 1. Community 2. Government 3. Other (specify.....)		
4.5.1.10	how much would it cost to maintain the pan (de-silt and repair) in a year? Ksh.....		
4.5.1.11	How long would a water pan remain useful without maintenance works? 1. Twenty years 2. Ten years 3. Five years 4. one year (Circle your answer?)		

\*\*Manual is excavation using shovels, wheelbarrows, ox scoops, ploughs and carts in contrast to bulldozer hire

**4.5.2** How to the costs compare between a water pan excavated manually and that mechanized for a water pan of the same volume? (Circle the response)

- i. It costs more to excavate a water pan manually than mechanically
- ii. It costs more to excavate the pan mechanically
- iii. The costs are the same

**4.5.3** What are the benefits drawn from community water pan? (Use table 4.5.2 below)

Table 4.5.3: Water pan benefits

WATER PAN BENEFITS / ANNUM.		Benefits (KSHS.)
Labor saved on fetching water far off		
Labor saved on watering livestock in far off sources		
Income from sale of crops watered from the dam		
Savings from household consumption of crop produce from the dam		
Time saved to do other chores		
Other benefits		
<b>Total income from the water pan</b>		

4.5.4 How much does the household consume? (Liters per day) .....

4.5.5 Do you pay for water? 1. Yes 2. No

4.5.6 How much would it cost to water truck water to a household in a month? Kshs.....

Do you grow crops under irrigation? 1. Yes 2. No.

4.5.6 If Yes, then indicate the major crops and the irrigated area;(use table 4.5.8 below)

Table 4.5.8: major crops grown and irrigated area

S/No	Type of crop	Area grown (acres)	Yield (Kg)	Price per Kg
1				
2				
3				

4.5.7 What numbers of livestock did you keep before the pan and now? (table 4.5.9)

**Table 4.5.9: Number of livestock kept before and after water pan**

Livestock type	Before water pan (Kshs)				After Water pan (Kshs)			
	Number kept	Kshs.	Number preferred	Kshs	Number Kept	Kshs	Number preferred	Kshs
Cattle								
Sheep								
Goat								

Chicken								
Camel								
Others								

4.4.7.1 Would you say the increase or decrease in livestock population before and after the water pan was caused by the water pan intervention? 1. Yes 2. No

4.5.7.2 If yes explain \_\_\_\_\_

4.5.8 What were approximate prices of animals in local area before and after the pan?

**TABLE 4.5.10: ANIMAL PRICES BEFORE AND AFTER WATER PAN**

Before water pan (Kshs)	After Water pan (Kshs)
Bull	
Cow	
Heifer	
Calf	
Ram	
Female sheep	
He goat	
Female goat	
Cock	
Hen	
Donkey	

Comment here if cause of price increase or decrease for livestock was caused by a factor other than water pan intervention: \_\_\_\_\_

4.5.11 How has the pan affected the livestock farming in the area?

**TABLE 4.5.11: EFFECTS OF WATER PAN ON LIVESTOCK**

Effect	Yes	No	Don't know
Reduced predation			
Grazing needs			
Increased pasture			
Decreased pasture			
Same			
Access to water:			
Increased			
Decreased			
Same			
Number of livestock -Increased			
Increased			
Decreased			
same			

4.5.9 How much water do you use on your animals per day? Kshs.....

4.5.10 did you experience changes in animal diseases before and after the pan and what were the losses incurred? If no proceed to 4.5.14

4.5.11 If yes, then provide response in table 4.5.12

**Table 4.5.12: Animal Diseases Before and After Water Pan**

Disease type	Before water pan		After water pan	
	No. affected	No. died	No. affected	No. Died
Cattle diseases				
East coast fever				
Red water				
Anthrax				
FMD				
Nagana				
Tick-borne diseases				
Tsetse disease				

Sheep diseases				
Goat diseases				
Chicken diseases				
Others (specify)				

Comments: \_\_\_\_\_

4.5.9 Is wildlife a problem in the area? 1. Yes    
2.No

4.5.10 Has any member of your household experienced conflicts with wildlife before and after construction of the water pan? 1. Yes 2. No ( circle your response)

4.5.11 If yes what is the level of conflict (*Indicate in the table below*).

S/No	Before water pan			After water pan	
	Conflict	No.	Compensation (Kshs)	No.	Compensation (Kshs)
1	Killed				
2	Serious injury				
3	Minor injury				
4	Threatened				
5	Other				

4.5.12 What problems did you experience before the pan was constructed?

i).....  
ii.) .....  
iii)  
iv.)

4.5.13 How many of the problems still persist?

i)  
ii)  
iii)  
iv)

4.5.14 How has your awareness of the costs and benefits you have listed above facilitated your adaptation to climate change?

#### 4.6 FUNDING SOURCES

4.6.0 What financing mechanism is used for climate change adaptations?

4.6.1 Who is paying for the initiatives?

4.6.2 Are those who benefit from the interventions involved in the financing (e.g. charges)? 1. **Yes** 2. **No** (*Circle the response*)

4.6.3 If yes, how much \_\_\_\_\_ Kshs

4.6.4 Is this amount a fixed percentage of the total intervention cost? 1. Yes 2. No

#### SECTION E: VULNERABILITY

5.0 What vulnerabilities shocks have greatly impacted your livelihoods?

5.1 What perceived problem or vulnerability made you opt for the adaptation measure? Water pan/fodder/improved livestock/crop. *Please mark (x) in table 5.1 below and comment (optional).*

Table 5.1: vulnerability context

Vulnerability/Shock	Water pan	Fodder	Livestock	Crop	Comments

Increased risk of droughts					
Increased incidences of drought					
Decreased precipitation					
Increased variability in precipitation					
Declining surface water quantity					
Increased risk of floods					
Others please specify:					

**SECTION F: CAPACITY BUILDING AND INFORMATION**

6.0 Do you or any of your household members belong to any community based, outside community groups/ or associations? (They can be formally organized groups or informal groups that people meet regularly to talk or do an activity).  
1=Yes 0=No (circle the response)

6.1 If Yes, what is the nature of the groups/associations? (Mark x)

1. CBO	
2 Faith based	
3.NGO	
4.Trade and business	
5. Farmer group 6. Religious	
7. Livestock societies	
8. Political/movement	
9.Social welfare	
10. Merry go round/savings	
11.Others(specify) _____	

6.2 Are there (or have you benefited from) support from institutions such as NGOs, CBO among others? 1 yes 2 No (Circle the response)  
6.3 If yes, name the institutions .....

6.4 What services did this institutions give?

Institution	Services offered

6.5 Do you have access to financial credit services for agricultural activities? Yes=1 No=0(circle response)

6.6 If yes, state the activities credit is applied \_\_\_\_\_

6.7 Do you have access to crop insurance services? Yes=1 0=No (circle response)

**SECTION G: ASSETS OWNERSHIP AND COSTS**

7.0 What is your nature of your land tenure system **1.Communal 2.Private (circle response)**

7.1 If you own private land, what is the size of your household land in Ha? \_\_\_\_\_

7.2 If your land is communal, comment on the size of the communal land \_\_\_\_\_

7.0 7.3 Please indicate the asset type ,other than livestock and other assets your household owns (use 7.3 table below)

Table 7.3: livelihood assets

Asset type	Number in your household	Breed	Estimated costs for each
Radio			
Television			
Bicycle			
Motor vehicle			
Landline phone			
Mobile phone			

Wheel barrow			
Electricity in house?	1=Yes 0=No		
Others(Specify)			

**7.0.1 Investments on Farming Inputs**

7.0.2	What varieties were grown in the last season?
7.0.3	How many seasons per year is this crop planted?
7.0.4	What quantities of inputs are applied (see table 7.4.3 below)

Table 7.4.3: farm inputs usage

Crop	Variety	No. of seasons	Farming inputs				Total harvest/yield in kg		Proportions of produce	
			Manure	In organic fertilizer (kg)	Top dressing fertilizer (kg)	Pesticide 1 – yes 2 – No	Seed		Home consumption	Sale

7.4.4	What yield were obtained (convert into kg)
7.0.4.1	Estimate the proportions of the quantities of the crops produced, consumed at home and marketed by household %
7.0.4.2	Estimate the amount of yield conveyed to the market%
7.0.4.3	How accessible is the nearest market? 1. Highly 2. Not accessible
7.0.4.4	Do you access market via broker? 1. Yes 2. No If yes, are brokers service satisfactory? 1. Yes 2. No
7.0.5	7.4.5 What is the main threat to crop production?

**SECTION H: PERCEPTIONS ON CLIMATE CHANGE AND ADAPTATION STRATEGIES**

**8.0 Have you noticed any long-term changes in the average temperature over the last 10 years?**

(If too difficult: Have you noticed a change in the number of hot days over the last 10 years?)

**Key:** 1. Increased, 2. Decreased, 3. Stayed the same, 4. Don't know

**8.1 Have you noticed any long term changes in rainfall variability over the last 10 years?**

(If too difficult: Have you noticed a change in the rains over the last 10 years?)

**Key:** 1 - Yes; 2 - No; 3 - Don't Know

**8.2 If yes, what changes have you noticed?** (Check change(s) that apply)

1.	Rains have become more erratic	<input type="checkbox"/>
2.	Rains come earlier	<input type="checkbox"/>
3.	Rains come later	<input type="checkbox"/>
4.	Rains are heavier	<input type="checkbox"/>
5.	Longer periods of drought	<input type="checkbox"/>
6.	More floods	<input type="checkbox"/>
7.	Other, specify:	

**8.3 Have you noticed any other changes in climate over the last 10 years, \_\_\_\_\_ (1 = Yes, 2 = No) if yes, please specify**

**8.4 Have you seen any changes in disease incidences (human, livestock, and crops) over the last 10 years? 1 - Yes.... 2 - No.....Explain...**

**8.5 Are you aware that agricultural practices (crop or livestock) contribute to climate change? (1=Yes, 2=No)**

**8.6 If yes, which agricultural practices (crop or livestock) can help adaptation to impacts of climate change? (Mark x in the table 8.6 below)**

Table 8.6: Agricultural practices

Agricultural practice	
1. Tomatoes	
2. Onions	
3 Water melon	

4. Management of natural pasture	
5. On-farm production of grasses (Cenchrus/Sudan grasses. Others...)	
6. Boran breed cattle	
7. White-coated shoats	
8. Camel	
Others (please specify.....)	

**SECTION I: CAUSES OF CLIMATE CHANGE**

**9.0 What do you think are the causes of climate change? (Do not show answers)**

Burning fossil fuels e.g. coal, oil, gas, petrol
deforestation i.e. cutting down forests and burning off
don't know
Will of god (amri yamwenyemizungu)
other (Please note all ideas)*
A. _____ B. _____ C. _____ D. _____

**9.1 Have you already planned to do any of these things in the FUTURE i.e. next 5 years to adapt to climate change? (Use key and mark x in the empty columns)**

plant trees on own/community land	
plant trees and bushes along boundaries and road reserves	
stop indiscriminate cutting down trees	
nurture natural pasture	
adopt improved cattle/camel breed	
adopt drought tolerant crops	
stop indiscriminate sand harvesting	
install rain water tank	
conserve available water	
nothing	
Other (please specify):	

**9.3 In the event your adaptation capacity diminished, what would be your options: yourself, your family and livestock? MARK X**

[1] move to a place further away from the more degraded ecosystem	
[2] shift to another part in the district	
[3] re-locate to another place outside the district	
[4] no, will stay put	
[5] not sure	

**9.4 Do you have limitations/ constraints to adapt to climate change? 1. YES 2.NO**

**11.5 If yes, what are your limitation/constraints?**

- [1] \_\_\_\_\_
- [2] \_\_\_\_\_
- [3] \_\_\_\_\_
- [4] \_\_\_\_\_

**9.5 What did you do as a result of the last extreme event? Mark x**

[1] stayed put (i.e. where you are)	
[2] dismantled dwelling and migrated out	
[3] planted more trees	
[4] reduced/increased number of livestock	
[5] engaged in water harvesting	
[6] nothing	
[7] other (please specify):	

9.6 Please indicate what your outlook is for the future in terms of further actions pertaining to climate change and if relevant, adaptation measures \_\_\_\_\_



0.7	Enumeration Area (EA) name: _____	Area code:  _ _	Signature of Coordinator: _____  <b>To be completed by data entry clerk:</b>  <b>First data entry</b> Date:  _ _  /  _ _  / 2013 Day                      Month Name of data entry clerk _____  <b>Remarks</b>   <b>– Second data entry</b> Date:  _ _  /  _ _  / 2013 Day                      Month Name of data entry clerk _____ Remarks : _____  <b>Signature of second data entry clerk (to be put after the questionnaire is entered)</b> _____
0.8	Village/Town name: _____	Village Code  _ _	
0.9	Livelihood zone name: _____	Livelihood Zone Code:  _ _	
0.10	GPS Coordinates E  _ _ : _ _   W  _ _ : _ _		
0.11	Elevation: _____ Metres (above sea level)		
Name of interviewee:  .....			
Telephone: _____			
Occupation: _____ Sex : _____			
Name of interviewer:			
Telephone no:			
Signature :			

What part of climate change adaptation are you or your organization involved in? (Circle)

1. Forestry 2. Agriculture 3. Water supply 4. Livestock Production 5. Veterinary Services  
Other, please specify: \_\_\_\_\_

**Part A VULNERABILITY**

<b>1.0 Have you noticed any long-term changes in the average temperature over the last 10 years?</b>
(If too difficult: Have you noticed a change in the number of hot days over the last 10 years?)
<b>Key:</b> 1. Increased, 2. Decreased, 3. Stayed the same, 4. don't know

<b>1.1 Have you noticed any long term changes in rainfall variability over the last 10 years?</b>
(If too difficult: Have you noticed a change in the rains over the last 10 years?)
<b>Key:</b> 1 - Yes; 2 - No; 3 - Don't Know

1.2 If yes, what changes have you noticed? (Check change(s) that apply)	
8. Rains have become more erratic	<input type="checkbox"/>
9. Rains come earlier	<input type="checkbox"/>
10. Rains come later	<input type="checkbox"/>

11. Rains are heavier	<input type="checkbox"/>
12. Longer periods of drought	<input type="checkbox"/>
13. More floods	<input type="checkbox"/>
14. Other, specify:	

**1.3 Have you noticed any other changes in climate over the last 10 years, \_\_\_\_\_ (1 = Yes, 2 = No) if yes, please specify \_\_\_\_\_**

**1.4 Have you seen any changes in disease incidences (human, livestock, and crops) over the last 10 years? 1 - Yes.... 2 - No..... Explain.....**

**1.5 What was the vulnerability/problem perceived that made you start investing in adaptation measures? Please circle in the list below and elaborate (optional).**

1. Increased precipitation
2. Decreased precipitation
3. Increased variability in precipitation
4. Decreased variability in precipitation
5. Increasing environmental degradation
6. Decreasing crop productivity
7. Decreasing livestock productivity
8. Decreasing quality and quantity of water for human consumption
9. Increasing incident of livestock diseases
10. Increased risk of drought
11. Increased risks of floods

**1.6. What informed your decisions on adaptation measure to intervene on?**

---

**1.7. Please briefly describe potential impacts of climate change-driven changes in on you or your organization (e.g. economic loss, decreasing economic viability of an activity, conflicts between water users, damage to property/infrastructure, health damage and loss of lives etc.)**

---

## **Part 2: ADAPTATION MEASURES**

**2.1. Where have the interventions take place? (Name the location[s])**

---

**2.2. When was the measure carried out? Please indicate time frame of the activity (start-finish)**  
 Activity \_\_\_\_\_ Time frame \_\_\_\_\_

**2.3. What was the role you or your organization played?**

---

**2.4. What other parties were involved? (Tick appropriately) 1. Public/private sector organizations 2. Communities 3. Individuals**

### **ADAPTATION MEASURES**

**2.5. Please give a brief description of the adaptation initiatives (objectives):**

---

### **Adaptation process**

**2.6.1 . What was the main type of adaptation? (Circle your response)**

- I. Capacity building (soft approach)
- II. Operational (physical implementation of adaptation measure)

**2.7. Is climate change adaptation the main objective (i.e. intentional) or an unplanned outcome of a different initiative?**

---

**2.8. What stimulated the adaptation initiative? Please tick 1. Weather event 2. Policy/legislation 3. Research results 4. Risk assessment 5. Costs benefits analysis 6. Other (specify)**

2.9. Who initiated it?

2.10 What financing mechanism is or was used?

2.11 Who paid for the initiative - were those who benefit from measures involved in the financing (e.g. charges)?

2.12. What are the estimated cost of planning and implementing the initiative?

Initiative	Planning cost (Kshs.)	Implementation cost (Kshs.)	Total cost( Kshs.)

**Section c: Sector specific interventions**

*(This section to be filled by an individual or organization that has implemented or participated in a water pan intervention as part of climate change adaptation)*

**3.0 COSTS AND BENEFITS OF WATER PAN (PLANNING, IMPLEMENTATION, STRUCTURAL, MAINTENANCE/IMPROVEMENT, AWARENESS**

3.1 Have you or your organization implemented a water pan project as part of climate change adaptation measure?

3.1.1 1. Yes 2. No (Circle your response.)

3.1.2 If yes provide the location and name of the water pan: Location: \_\_\_\_\_ Name of water pan: \_\_\_\_\_

3.1.3 How was the decision to use a water pan as an adaptation strategy reached?

3.2 What method was used to excavate the dam? 1. Manual 2. Mechanized.

3.2.1 If mechanized, who did it? \_\_\_\_\_

3.2.2 What are the dimensions of the pan? Top length \_\_\_\_\_ top width \_\_\_\_\_ side slope \_\_\_\_\_ bottom length \_\_\_\_\_

Bottom width \_\_\_\_\_

3.2.3 What is the volume of the pan in metres cubic?

3.2.4 What climatic challenge was the dam to help overcome?

3.2.5 How was this challenge identified?

4.0 How has the dam now solved the challenge? (Satisfactory, very satisfactory, most satisfactory)

4.1 Other than climate related challenge, what other problem has the dam helped solve? (Security of women and girls, incomes from the water others)

4.2 Was the community involved in the planning of the water pan? 1. Yes 2. No (circle response)

4.3 If yes, how were they involved?

4.4 Who in the community was involved?

4.5 How much did each of the following water project components cost? (Question to be answered by the individual or department directly involved)

i. Feasibility study Kshs.....

ii. Structural designs and drawings Kshs.....

iii. Environmental impact assessment Kshs.....

iv. Community mobilization Kshs.....

v. Equipment mobilization Kshs.....

vi. Excavation works Kshs.....

vii. Fencing Kshs.....

Any other cost: Kshs.....

(Specify)

4.6	What is the maintenance schedule if any? (please indicate type of works and the relevant costs in the SCHEDULE below)	
	<b>DATE</b>	<b>MAINTAINANCE WORKS</b>
		<b>COST (Kshs. /annum)</b>
	i).	
	ii).	
	iii).	
	iv).	

4.7 How do costs of the water pan compare to other alternative interventions such as water trucking?

COSTS OF WATER PAN	COSTS OF WATER TRUCKING	COSTS OF SINKING BORE HOLE

**BENEFITS AND COSTS OF PREFERRED CROP AS ADAPTATION (Unit: Half Hectare): to be administered to the agriculture department and any organization involved the crop farming sector)**

4.8 What is the preferred crop grown as adaptation strategy?  
 \_\_\_\_\_  
 \_\_\_\_\_

4.9 What are the benefits and costs of growing the Aloe vera crop? (Use table below)

ACTIVITY	COST KSHS.	BENEFITS KSHS
Bush clearing		
Plough		
Ridging blocks		9. _____
Nursery management		
Transplanting		10. _____
Watering (equipment)		
Watering (labour)		11. _____
Pest control (labour)		
Pest control (chemicals)		12. _____
Seeds		
Weeding		13. _____
Harvesting		14. _____
Post harvesting (drying, packaging, storage, transport)		15. _____
Costs of extractor equipment		16. _____
Total		

**BENEFITS AND COSTS OF IMPROVED LIVESTOCK (to be administered to the livestock department or veterinary department)**

4.10 What are the livestock intervention options for adaptation to climate change?  
 4.11 What are the costs both monetary and non-monetary of an adaptation intervention say acquiring new or local breed?  
 (Indicate in the table shown below).

Activity undertaken	Costs		Benefits		Monetary (KES)	Non-monetary
	Monetary (KES)	Non-monetary	Monetary (KES)	Non-monetary		
Acquire calf (>2yrs )						

Pest control						
Labor (2 years to milking)						
Chemical (2yrs to milking)						
Feed e.g. buying grain (2 yrs. to milking)						
Fencing (thorny twigs for 2 yrs.						
Care e.g. trimming hooves						
Watering per day / cow						
Total						

**Note:** Some non-monetary benefits/costs are more important

What, if any, are the criteria for measuring the success of adaptation?

Has adaptation been a success, partial success, failure, or is it too early to say? \_\_\_\_\_

### PART E: PERCEPTIONS ON CLIMATE CHANGE AND ADAPTATION STRATEGIES

**5.1 Are you aware that agricultural practices (crop or livestock) contribute to climate change?** \_\_\_\_\_  
(1=Yes, 2=No)

**5.2 If yes, which agricultural practices (crop or livestock) can help adaptation to impacts of climate change?**  
(Mark x in the table 5.2 below)

Table 5.2: Agricultural practices

Agricultural practice	
Tomatoes production	
Aloe Vera	
Onions production	
Water melon production	
Management of natural pasture	
On-farm production of grasses (Cenchrus/Sudan grasses. Others...)	
Boran breed cattle	
White-coated shoats	
Camel	
Others (please specify.....)	

### SECTION F: CAUSES OF CLIMATE CHANGE

**6.0 What do you think are the causes of climate change? (circle response)**

Burning fossil fuels e.g. coal, oil, gas, petrol
Deforestation i.e. cutting down forests and burning off
Don't know
Will of god ( <i>Amri ya Mwenyezi Mungu</i> )
Other (Please note all ideas)*

**6.1 What adaptation options are available for the community in the future i.e. next 5 years to adapt to climate change? (Use key and mark x in the empty columns)**

Plant trees on own/community land	
plant trees and bushes along boundaries and road reserves	
Stop indiscriminate cutting down trees	
Nurture natural pasture	

Adopt improved cattle/camel breed	
Adopt drought tolerant crops	
Stop indiscriminate sand harvesting	
Install rain water tank	
conserve available water	
Greenhouses	
Other (please specify):	

**6.3** In the event community adaptation capacity diminished, what would be their options: they, their family and livestock? **MARK X**

[a] move to a place further away from the more degraded ecosystem	
[b] shift to another part in the district	
[c] re-locate to another place outside the district	
[d] no, will stay put	
[e] not sure	

**6.4** Do you have limitations/ constraints to adapt to climate change as an organization or individual? 1. YES 2.NO

**6.5** If yes, what are your limitation/constraints?

[1] \_\_\_\_\_

[2] \_\_\_\_\_

**6.6** Please indicate what your outlook is for the future in terms of further actions pertaining to climate change and if relevant, adaptation measures. \_\_\_\_\_

**6.7** Please provide further information you consider relevant in the context of this survey, or indicate additional persons that you think should be contacted to enrich the study.

**6.8** Do you have any other written account of the work you been done on the adaptation measures?

**6.9** If so, could you provide references to documents? \_\_\_\_\_

*Thank you for sharing your valuable knowledge and experience.*

#### **Appendix IV: Bill of quantities for construction of Aloe shed**

SNO.	ITEM	QUANTITY	UNIT COST(KSH)	TOTALCOST(KES)
1	Iron sheets gauge 30-10ft	32	760	24320
2	Building stones	950	45	42750
3	Cement	75	750	56250
4	Ballast	4 tons	7000	28000
5	Sand	6 tons	3700	22200
6	Hard core	3 trips	6000	18000
7	Roofing nails	7 kg	200	1400
8	3'' nails	10 kg	120	1200
9	4'' nails	15 kg	120	1800
10	5'' nails	10 kg	120	1200
11	Wire mesh	6	600	3600
12	Timber 3x2	700ft	30	21000
13	Timber 2x2	400ft	20	8000
14	Timber 8x1	150ft	40	6000
15	Door and accessories	1	4000	4000
16	Wood preservative	20lts	100	2000
17	Wood iron	1	3500	3500
18	Y 12	18	850	15300
19	R 6	10	400	4000
20	Binding wire	5kg	150	750
21	Water			15000
22	Transport			25000
23	Construction cost			105487
24	Supervision( cost of fuel & allowances)			65000
	<b>TOTAL COST</b>			<b>495,757</b>

### Appendix V: Aloe Processing Costs

Activities	Units	Investment Cost	Recurrent Cost (Kshs)	Total Costs(Kshs)
Construction of aloe processing shed	1	495,757		495,757
Purchase processing machinery (electric)	4 units x250,0000	1,000,000		1,000,000
Transport of the machinery to Masalani	4X 20,000		80,000	80,000
Installation and maintenance of machinery	4		200,000	200,000
Capacity building	LSM		500,000	500,000
			<b>Total</b>	<b>2,275,757</b>
<b>SOAPMAKING RAW MATERIALS:</b>		<b>QTY.</b>	<b>COST</b>	
Caustic soda	Kgs	200	120	24,000
Coconut oil	Ltrs	200	120	24,000
Sodium silicate	Ltrs	100	150	10,000
Aloe sap	Ltrs	100	150	20,000
Perfume	R.S.	100	150	15,000
<b>Sub total</b>				<b>93,000</b>
<b>LOTION RAW MATERIALS</b>				
Stearic Acid	Kgs	25	560	14,000
GMS	Kgs	10	500	5,000
CSA	Kgs	10	480	4,800
Petroleum jelly	Kgs	5	480	2,400
Mineral oil	Kgs	10	750	7,500
Water	Ltrs	1000	20	20,000
Glycerine	Kgs	50	500	25,000
Tea	Kgs	10	1000	10,000
Aloe Vera	Ltrs	10	200	2,000
Formaline	Ltrs	10	240	2,400
Colour	Q.S.	10	200	2,000
Perfume	Q.S.	10	150	15,000
				<b>110,100</b>
<b>CREAM RAW MATERIALS</b>				
Stearic acid	Kgs	30	560	16,800
Mineral oil	Kgs	40	750	30,000
Petroleum jelly	Kgs	10	480	4,800
CSA	Kgs	2	480	960
Microcrystalline wax	Kgs	2	480	960
Tea	Kgs	1.78	1000	1,780
Preservative (formalin)	Q.S.	1	480	480
Perfume	Q.S.	1	150	150
Aloe jelly	Ltrs	5	200	1,000
Calycerine	Kgs	3	500	1,500
Water	Ltrs	29.22	20	584.40
Sub-total				<b>59,014.4</b>
<b>SHAMPOO: (100LITRES) MAKING</b>				
Urigeral	Kgs	12	560	6,720
CDE	Kgs	1	560	560
Salt	Kgs	2	50	100
Colour	Q.S.	1	200	200
Perfume	Q.S.	1	150	150
Formalin	0.1%	1	600	600

Aloe jelly/sap	Ltrs	5	200	1,000
Sub total				<b>9,330</b>
<b>KBS standardization</b>				<b>50000</b>
<b>Contingencies</b>				<b>100,000</b>

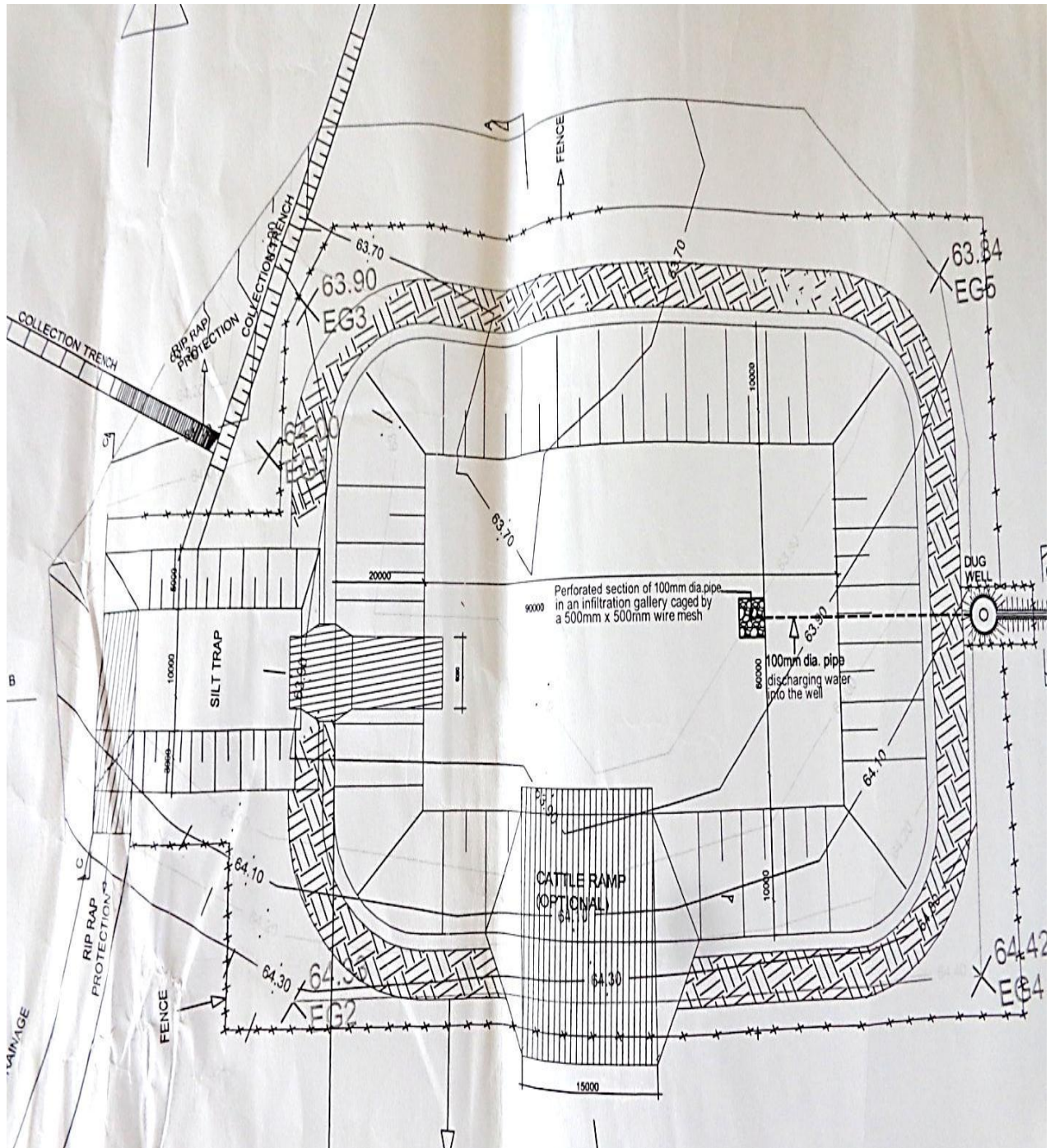
## Appendix VI: Research Matrix

Objective	Data Required	Source	Analytical Method/Approach	Expected outcome	Question no.
To quantify household-level costs of applying water pans, livestock feed and Aloe vera crop as adaptation strategies.	Costs of : -Inputs -Labor -Watering - excavation -Pests disease control -Market search - equipment -Planning -effects of climate	-Literature review -Household questionnaire -FGD -Key informants -farmers and extension	Cost Benefit Analysis (for known monetary values) and Contingent Valuation Method ( to elicit costs where no monetary value exist)	- Up adaptive capacity -Known costs on water pans, Aloe vera crop, livestock feed - Informed policy -data to aid reduction of vulnerability and enlarged body of knowledge -better management -sustainable use of resource	Q4, Q5 – all sub-questions
To measure household- level benefits of avoided damages resulting from adaptation strategies.	Benefits from: -labor saved on fetching water -labor saved on watering stock -income from crop sales around water pan - water pan induced food security savings from farm pan produce	-Key informants include women and girl child who fetch water - farmers and extension - Household questionnaire -FGD -Desk-top review	-Contingent Valuation Method particularly where monetary values on strategies are non-existent  -Cost Benefits Analysis	Avoided damages from: -enhanced adaptive capacity -saved labor to focus on other development initiatives -upped income -increased human and livestock health -increased food security	Q4.3, Q4.4.Q4.5.1,Q6 and Q7,Q8,9.

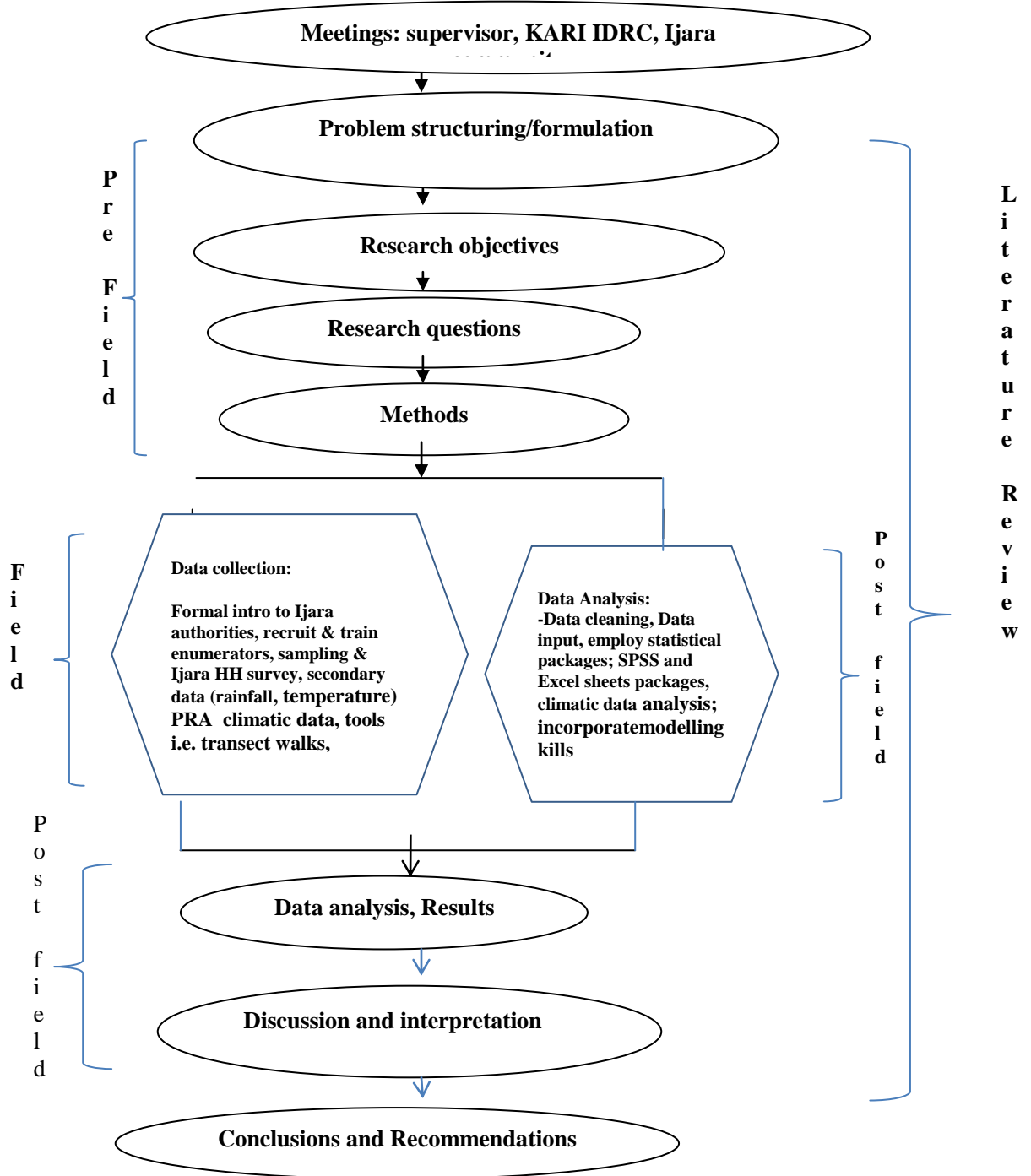
Appendix VII: Research Budget

Economic Analysis of Climate Change Adaptation Strategies at Community Farm Level Ijara Sub-County, Garissa, Kenya						
Activity	Location	MoV	Input	Unit	Unit cost	Total
Baseline survey	Ijara	Survey Report	DSA, travel cost, stationary, enumerators			97,550
Tool Pre-testing	Ijara	Report	Enumerators, stationary, travel costs, DSA			65,000
Household survey - Admin 240 questionnaires	Ijara	Survey Report	DSA, travel cost, communication, stationary			480,600
Data analysis		analysed data				80,000
Farm-level adaptation adoption	demo sites, Ijara	Report	demo sites	8	15,500	55,000
Monitoring and Evaluation	demo sites, Ijara	M&E report	demo sites	8	6,000	48,000
Design & Purchase of LandSat Images	Regional Centre for Mapping,	LandSat Images	Images	6	40,000	240,000
Travel - BioPhysicals maps	Nairobi		DSA 1RO Lunch	3	8,000	24000
			Transport	2	800	1600
<b>Grand Total</b>						<b>1,050,750</b>

Appendix VIII: Handaro Water Pan Blue Print (*Adopted from Ministry of Water and Irrigation, Ijara*)



## Appendix IX: Research Design- Phases



## Appendix X: Cash Flow- Pasture NPV Analysis for Three Seasons

### B. NPV ANALYSIS FOR ONE PASTURE CROPPING SEASON/ YEAR

Year	Discount Rate @ 15%	Cash Inflow	Cash Outflow	Net Cash Flow	Present Value
0	1.000	0	109,526	-109,526	KES 109,526.00
1	0.870	461,358	55,975.00	405,383	KES 352,683.21
2	0.756	461,358	55,975.00	405,383	KES 306,469.55
3	0.658	461,358	55,975.00	405,383	KES 266,742.01
4	0.572	461,358	55,975.00	405,383	KES 231,879.08
5	0.497	461,358	55,975.00	405,383	KES 201,475.35
6	0.432	461,358	55,975.00	405,383	KES 175,125.46
7	0.376	461,358	55,975.00	405,383	KES 152,424.01
8	0.327	461,358	55,975.00	405,383	KES 132,560.24
9	0.284	461,358	55,975.00	405,383	KES 115,128.77
10	0.247	461,358	55,975.00	405,383	KES 100,129.60
Total		3,944,304			KES 1,925,091

### B. NPV ANALYSIS FOR TWO PASTURE CROPPING SEASONS/ YEAR

Year	Discount Rate @ 15%	Cash Inflow	Cash Outflow	Net cash Flow	Present value
0	1.000	0	109526	-109526	KES 109,526.00
1	0.870	922,716	111,950.00	810766	KES 705,366.42
2	0.756	922,716	111,950.00	810766	KES 612,939.10
3	0.658	922,716	111,950.00	810766	KES 533,484.03
4	0.572	922,716	111,950.00	810766	KES 463,758.15
5	0.497	922,716	111,950.00	810766	KES 402,950.70
6	0.432	922,716	111,950.00	810766	KES 350,250.91
7	0.376	922,716	111,950.00	810766	KES 304,848.02
8	0.327	922,716	111,950.00	810766	KES 265,120.48
9	0.284	922,716	111,950.00	810766	KES 230,257.54
10	0.247	922,716	111,950.00	810766	KES 200,259.20
Total		7,998,134			KES 4,069,234.55

### C. NPV FOR THREE PASTURE CROPPING SEASONS/YEAR

Year	Discount Rate @ 15%	Cash Inflow	Cash Outflow	Net Cash Flow	Present Value
0	1.000	0	109,526	-109,526.0	KES 109,526.00
1	0.870	1,384,074	167,925.00	1,216,149.0	KES 1,058,049.63
2	0.756	1,384,074	167,925.00	1,216,149.0	KES 919,408.64
3	0.658	1,384,074	167,925.00	1,216,149.0	KES 800,226.04
4	0.572	1,384,074	167,925.00	1,216,149.0	KES 695,637.23
5	0.497	1,384,074	167,925.00	1,216,149.0	KES 604,426.05
6	0.432	1,384,074	167,925.00	1,216,149.0	KES 525,376.37
7	0.376	1,384,074	167,925.00	1,216,149.0	KES 457,272.02
8	0.327	1,384,074	167,925.00	1,216,149.0	KES 397,680.72
9	0.284	1,384,074	167,925.00	1,216,149.0	KES 345,386.32
10	0.247	1,384,074	167,925.00	1,216,149.0	KES 300,388.80
Total		12,051,964		KES 6,103,851.83	

### Appendix XI: Rainfall Data 1970-2008 from Masalani Police Post

(Adopted from Kenya Met Services)

Code	Station	Data	Yr	J	F	M	A	M	J	J	A	S	O	N	D	Total
	Masalani	Precipitation;	197	8.	2.5	99.	58.	33.	17.	24.	10	2.	7.7	80	77.	423
9140007	police post	daily total	0	4		5	9	1	6	8		4			8	
9140007	Masalani	Precipitation;	197	0	0	20.	36.	83.	103	5	2	9.	21.	18	107	407
	police post	daily total	1			9	2	7				9	1			
9140007	Masalani	Precipitation;	197	22	16	17.	56.	102	1.8	16.	25	55	86.	89	63.	553
	police post	daily total	2	.7		1	8			8		.2	9		8	
9140007	Masalani	Precipitation;	197	27	37	6.3	45.	18.	59.	2.2	16	6.	19.	11	13.	366
	police post	daily total	3	.3			1	7	7			1	4	5	5	
9140007	Masalani	Precipitation;	197	34	10.4	100	29.	46.	9.6	20.	2.6	0.	16.	11	15.	401
	police post	daily total	4	.9		.2	3	9		4		5	5	4	7	
9140007	Masalani	Precipitation;	197	6.	39.5	18.	10.	81.	31.	77.	2	3.	19	11	22.	431
	police post	daily total	5	4		2	9	1	6	5		6		8	4	
9140007	Masalani	Precipitation;	197	0	5.3	31.	72.	11.	5.2	21.	11	45	78.	50	103	436
	police post	daily total	6			1	2	8		4		.7	8			
9140007	Masalani	Precipitation;	197	0	19.5	26.	71.	24.	17.	3.9	102	9.	63.	12	129	592
	police post	daily total	7			3	3	9	4			3	6	6		
9140007	Masalani	Precipitation;	197	18	38.4	95	93.	169	12.	21.	19	3.	6.3	11	113	704
	police post	daily total	8	.2			3		6	5		8		5		
9140007	Masalani	Precipitation;	197	97	24.5	69.	172	194	57.	53.	4.3	11	3.6	11	171	972
	police post	daily total	9			5			9	5				3		
9140007	Masalani	Precipitation;	198	0	0	32.	59.	0.2	7.2	35.	9.9	2.	7.2	94	34.	283
	police post	daily total	0			2	9			3		7			6	
9140007	Masalani	Precipitation;	198	6.	0	149	98.	71.	9.3	20.	9.9	0	19	11	50.	447
	police post	daily total	1	5		.7	2	8		9					7	
9140007	Masalani	Precipitation;	198	6	0	31.	0	47	17.	0	0	28	139	11	87.	471
	police post	daily total	2			1			4			.4		5	5	
9140007	Masalani	Precipitation;	198	4.	16.1	42.	71.	110	60.	63.	22	44	1.3	10	35.	575
	police post	daily total	3	8		6	3		6	1		.2		3	3	
9140007	Masalani	Precipitation;	198	8.	0	9	68.	40.	0	37.	1.1	11	108	12	69.	475

	police post	daily total	4	5		3	5	2			2	9				
9140007	Masalani	Precipitation;	198	11	20	16.	75.	28.	17.	27.	43	25	63.	14	62.	531
	police post	daily total	5			2	4	1	4	5		.5	5	1	2	
9140007	Masalani	Precipitation;	198	2	0	31.	80	73.	0	2.5	25	0	92.	11	82.	506
	police post	daily total	6			1		5					6	7	9	
9140007	Masalani	Precipitation;	198	8.	6.5	39.	72.	46.	18.	23.	9.9	1.	19	16	9	417
	police post	daily total	7	9		7	7	2	1	1		3		3		
9140007	Masalani	Precipitation;	198	33	0	108	105	5	73	11.	9.4	24	7.7	12	66.	569
	police post	daily total	8	.3		.3				3		.1		5	9	
9140007	Masalani	Precipitation;	198	27	11	21.	89.	36.	17.	8.2	8.9	9.	115	12	263	732
	police post	daily total	9	.5		8	4	8	4			9		3		
9140007	Masalani	Precipitation;	199	37	53.5	135	170	77.	14	42	1.4	22	19	11	109	795
	police post	daily total	0			.7		3				.1		5		
9140007	Masalani	Precipitation;	199	0	0	31.	71.	47	17.	20.	9.9	9.	19.	22	66.	521
	police post	daily total	1			1	3		4	9		9	4	7	9	
9140007	Masalani	Precipitation;	199	8.	6.5	4	71.	47	17.	20.	9.9	9.	19.	11	66.	396
	police post	daily total	2	5			3		4	9		9	4	5	9	
9140007	Masalani	Precipitation;	199	3.	0	49	62.	74.	51	23.	49	35	11.	11	66.	541
	police post	daily total	9	2			5	8		7		.2	5	5	9	
9140007	Masalani	Precipitation;	200	8.	6.5	61.	38.	47.	17.	11.	9.9	9.	19.	11	66.	412
	police post	daily total	0	5		4	9	1	4	5		9	4	5	9	
9140007	Masalani	Precipitation;	200	8.	6.5	39.	71.	47	17.	20.	9.9	9.	19.	10	13	371
	police post	daily total	5	5		7	3		4	9		9	4	7		
9140007	Masalani	Precipitation;	200	33	0	31.	85.	46.	17.	21.	9.9	9.	19.	11	66.	457
	police post	daily total	6	.8		1	5	9	5	2		9	4	5	9	
9140007	Masalani	Precipitation;	200	8.	5.3	31.	69.	46.	17.	21.	10	9.	46.	16	55.	490
	police post	daily total	7	7		1	8	9	5	5		9	8	7	2	
9140007	Masalani	Precipitation;	200	50	6.8	28	71.	47	17.	21.	9.9	9.	19.	11	66.	463
	police post	daily total	8	.7			3		4	2		9	4	5	9	
9140007	Masalani	Precipitation;	200	9.	3.8	5.6	6.6	31.	25.	21.	9.9	9.	19.	11	66.	324
	police post	daily total	9	6				1	3	2		9	4	5	9	

## Appendix XII: Risk Value Table

Likelihood	Consequences			
	Minor	Moderate	major	severe
Unlikely	Low	Low	Low	Low
Likely	Low	Medium	Medium	High
Very likely	Low	Medium	High	High
Extremely likely	Low	Medium	High	Extreme

### Where:

<b>Low:</b> Impact risk that can be managed under existing conditions
<b>Medium:</b> Risk that should be closely monitored
<b>High:</b> Risk that should be incorporated into coping decisions
<b>Extreme:</b> Risk that is so high that demands new actions. For example, when a factor is ' <u>likely</u> ' to occur and have ' <u>severe</u> ' consequences, it is classified as ' <u>high</u> ' risk