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1 author:

Joseph Mwaura
Kenya Agricultural and Livestock Research Organization (KALRO)

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Mwaura J.[1] Koske J.[2] Kiprotich B. [2]
1.Kenya Agricultural and Livestock Research Organization P.O Box 230-70100 Garissa, Kenya
2.Kenyatta University, Departments of Agribusiness and Environment, P.O Box 43844-00100, Nairobi, Kenya

Abstract
To adapt to impacts of climate change and variability that outwit traditional coping mechanisms, communities in the semi-arid Ijara, spontaneously took to pasture enterprise strategy. The spontaneity translated into unclear costs and benefits that impeded management of the scarce resources. The study clarified costs and benefits by isolating them for analysis and measuring the strategies' viability for adaptation. The objective was to measure costs incurred and benefits gained from avoided damages through adoption of the strategy at community farm-level. 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. Fifty-seven per cent pastoralists had embraced agro-pastoralism to incorporate on-farm rain-fed Sudan grass, whose input costs were US$ 1333/ha/season with estimated yields of 1.8 tons/ha of dry matter. Cash flow across three rain-fed seasons netted US$21390, US$45214 and US$67820 per hectare from one, two and three seasons respectively. Overall net present value was US$ 2000p.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. Overall benefits from the strategy 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, supporting post-harvest feed reserves technologies, reviewing land tenure system and investing in local farmer-friendly weather data collection and application
Keywords: Adaptation strategy, benefits and costs, climate change, pasture enterprise

1. INTRODUCTION

Over Eighty per cent of employment and 30% of Africa GDP is supported by rain fed agriculture which exposes the continent particularly the ASALs to the risks of high seasonal rainfall variability (Calzadilla *et al*., 2010; Commission for Africa, 2005; Tumbo *et al*., 2012). A key challenge that ASALs in sub-Saharan Africa have to contend with is managing unreliable, highly variable, and scarce rainfall that decimate livestock feed and crop production (Cooper *et al*. 2011; Bhatt *et al*. 2006; Tol *et al.,* 1998). Consequently, it is imperative that pasture availability and management is enhanced as grazing influence soil carbon in that, rangelands with lesser livestock grazing intensity have higher soil carbon stocks and vice versa (Ritchie, 2014; Bulle *et al*., 2014). Given that 90% of emissions from agriculture emanate from enteric fermentation (GoK, 2012), pasture availability and management is in effect singularly the crux of the sector. The emissions global warming is essentially a green-house-like roof effect created by the excesses of the warming gases chiefly, carbon dioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O). As temperature and carbon dioxide levels change due to climate change, optimal growth rates for different species and composition changes with species altering their competition dynamics (Thornton *et al.,* 2007).

2. COSTS AND BENEFITS OF PASTURE 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. Generally the greenhouse roof-effect created by the excesses of the warming greenhouse gases increase uncertainty in pasture production and costs (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). 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.

The realization of the pasture costs uncertainty spawned by climatic shocks, meagre resources, diminishing natural capital, decimation of the traditionally-relied-upon livestock industry prompted Ijara communities to spontaneously take to pasture enterprise as adaptation strategy. But the costs incurred and the benefits gained, remained unclear; which the study expounded by assessing both. The objectives were to quantify household-level costs of pasture enterprise and to measure benefits of avoided damages consequential to adoption and implementation of the strategy. Using quantitative and qualitative methods, the study answered the questions on what the costs of pasture enterprise were, its benefits and whether these benefits exceeded the costs

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 catalyze 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 promotion of diversification of economic livelihood and awareness creation among pastoral communities and highlights 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 US$786,516,854, (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 US$3,460,674,157. 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, livestock industry 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. For instance 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 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.

2.1 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)

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 can be anticipatory or planned and autonomous as discussed briefly below:

2.3 Anticipatory, Planned and Autonomous 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

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

2.4 Assessing Adaptation Costs

Since pasture adaptation strategy in Ijara was spontaneously implemented costs remained indistinct, yearning for the economic assessment. Understanding the costs of adaptation 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 is difficult to estimate, because climate change measures is 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.

2.5 Adaptation Benefits

The benefits from pasture were contrasted with the associated costs, including the opportunity costs; the net benefits the difference between the costs and benefits. Generally, the most economically efficient measure is the one with the highest present value of net benefit (Turner, *et al.,* 2004). 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.

2.6 Assessing Impacts of Climate Change in Africa

Climate change and variability already have 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 gains that arise from predicted increase maybe thwarted by equally rising temperatures (ICPAC, 2013; Ng'ang'a, 2006). 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 spontaneous 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.

2.7 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. In turn the approach provided for authenticity in scientific data for meaningful conclusions to be drawn (Chambwera, *et al*., 2012; Nicholles *et al*., 2012).

3. CONCEPTUAL FRAMEWORK

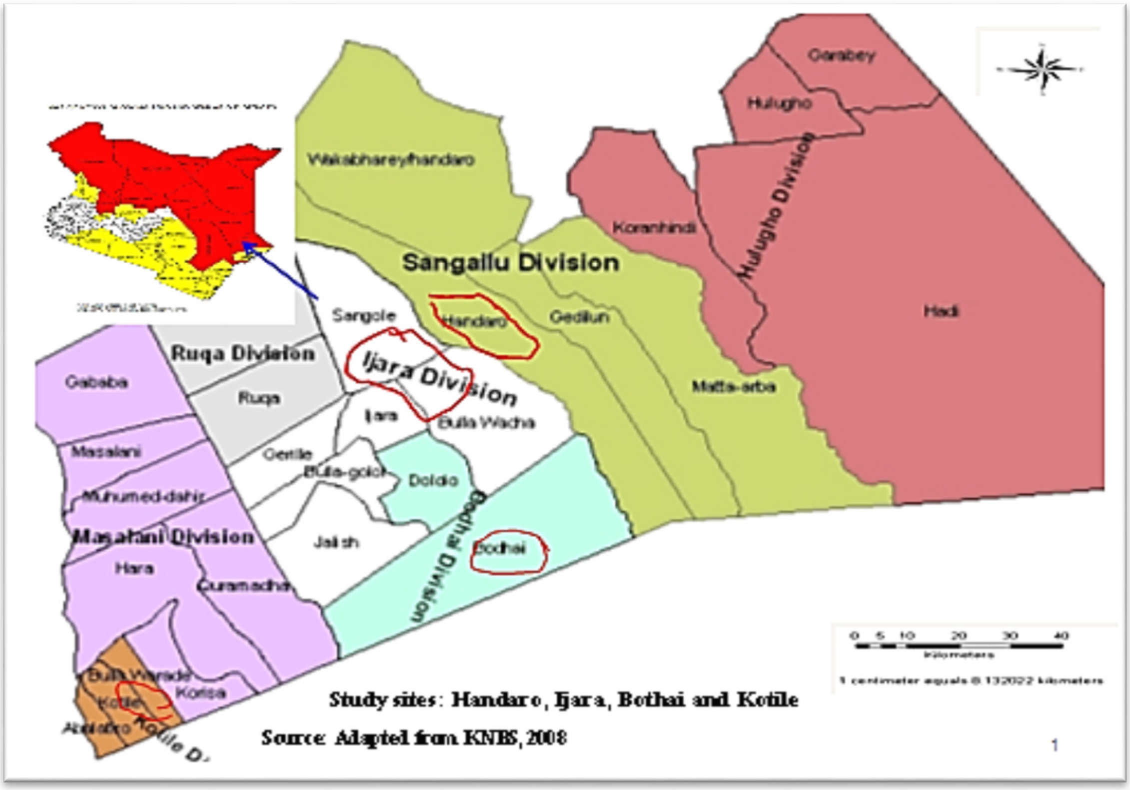
The study's conceptual framework outlines independent variables as costs and benefits that could be clear or indistinct, and adaptation that could be planned and therefore sustainable or autonomous/spontaneous which is reactive and unsustainable. Spontaneously implemented strategies whose costs remain indistinct issue in adaptation being compromised and short of desired outcome. The desired ultimate phenomenon (dependent variables) for the pasture cost benefit analysis 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.

Also it presents 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).

4. BACKGROUND INFORMATION

4.1 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 11,332km² 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. The sub-county 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 1: Map of Ijara and study sites

4.2 Biological and Physical Attributes in Ijara

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 characterized by low undulating plains that have low-lying altitude ranging between 0 and 90 meters 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 15ºC – 38ºC and the average relative humidity is 68%. It is estimated that up to 1000km^2 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.

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).

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. 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 analyzed using KMS data (40 years) period indicate a definite decline. Figure 2 below illustrates this decline graphically.

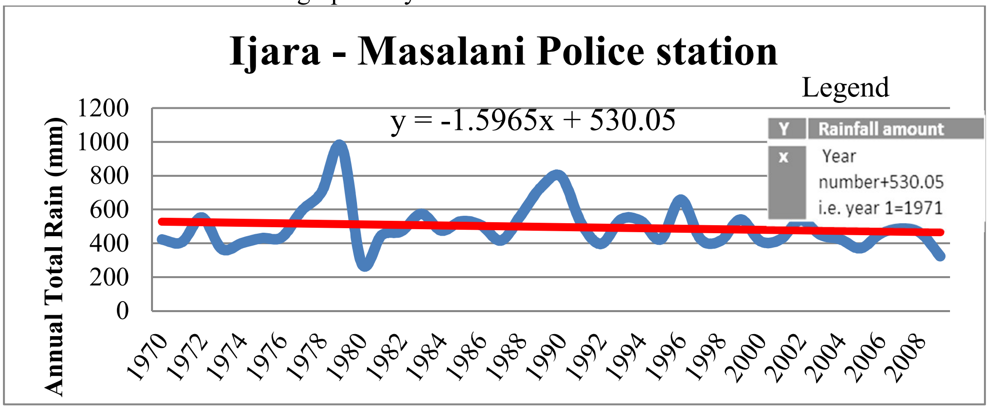


Figure 2: Rainfall trend 1970-2008; Ijara station

As Figure 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*12) +530.05=510.9 mm. However, predictions from across all models 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. 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 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. Recent study by IGAD Climate Prediction and Applications Centre (ICPAC) (2013) 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 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. 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. 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.

5. 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 as was the case in the study. 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.

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, contingence 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.

6. SAMPLING AND SAMPLE SIZE

A list of smallholder pasture farmers 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). 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:

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

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:

$$Size = \frac{2.71x9000x0.5(1-0.5)}{0.0523^2(9000-1)+2.71x0.5(1-0.5)}$$

$$= \frac{2.71x9000x0.5x0.5}{0.00274\,x8999+0.677}$$

$$= \frac{6097.5}{24.65726+0.677}$$

$$= \frac{6097.5}{25.33426}$$

$= 240$(Rounded to the nearest whole number)

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.

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. 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.

8. DATA PRESENTATION AND ANALYSIS

8.1 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 analyzed. Statistical package for social science (SPSS) and Excel software packages were used to analyzed the data. 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.

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". 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_o, CF_1, CF_2... CF n, 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.

NPV = Present Value of future cash flows – Investment

NPV Decision Rule: If NPV ≥ 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.

9. STUDY RESULTS

9.1 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. 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 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.

As results on Table 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.

Table 1: Summary Climate Related Impacts Factors in Ijara

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

9.2 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 (Onil, 2010). 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.

9.3 Significance of Pasture as Adaptation Strategy

As shown on Table xxx, Ijara sub-county livestock populations were 606,212 which are 12.81% of the total 4,731,579 in Garissa County. With a rating 47.5%, drought that decimated livestock feed was cited as the threat of concern in animal 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. The results indicated significant difference between monetary costs and monetary benefits on labour at US$ 16 with benefits being higher. Also costs of purchasing calf for feed-test were outwitted by benefits at US$14.

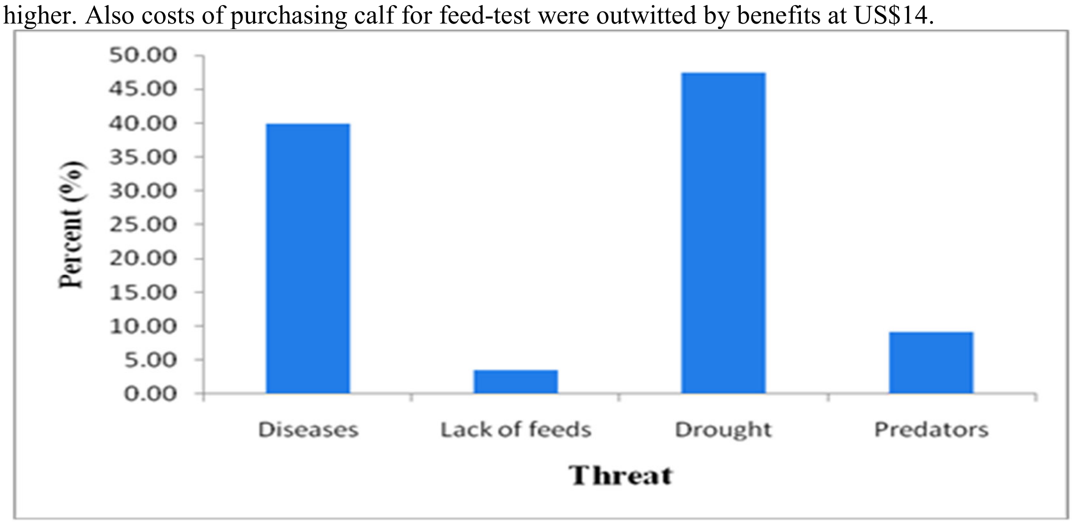


Figure 3: Threats to livestock production

A comparison between costs of treatment and benefits posted US$1020 which was balanced by benefits in other activities' returns.

Table 2: T-Test of Costs and Benefits on Livestock Feed Enterprise in Ijara

Monetary costs (*minus*) 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

9.4 Viability of Pasture

Pasture costs assessed 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). 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

9.5 Types of pasture and Impacts on their dwindle over time in Ijara

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 3). The current standing pasture was insufficient for most of the seasons and 86.26% farmers indicated pasture size was small and inadequate. Most of the pastures are natural.

Table 3: 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

9.6 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). 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: Storage of animal feed

Response	Frequency	Per cent	Per cent
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).

9.7 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:

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

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. 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 5: Threats to livestock feed production in Ijara

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

9.8 Economic Analysis of Alternative Livelihood Options

As Figure 4 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.

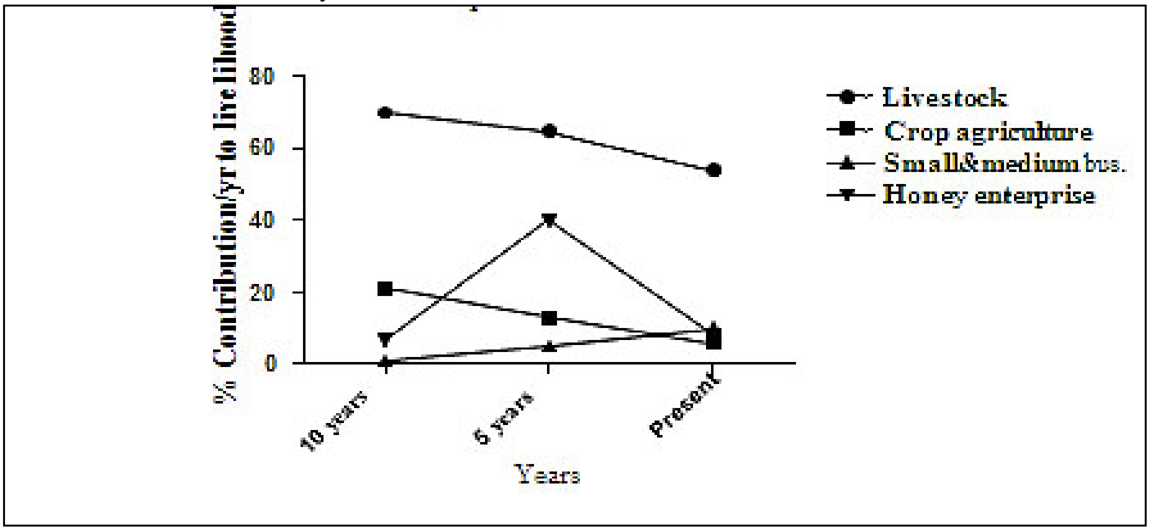


Figure 4: Contribution from alternative sources of livelihoods

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. 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. The study specified that benefits worth US$21390, US$45214 and US$67820 per hectare from one, two and three seasons respectively of pasture production per year is attainable and to be preferred. The pasture was mainly rain-fed Sudan grass grown on-farm locally. As indicated on (Figure 5) the present value of the pastures in three production seasons rise steeply from US$1216 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 was captured by interest rates which were the cost of capital i.e. maximum benefit or value was realized at year two when the costs outlay was balanced by an equally appealing cash inflow.

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.

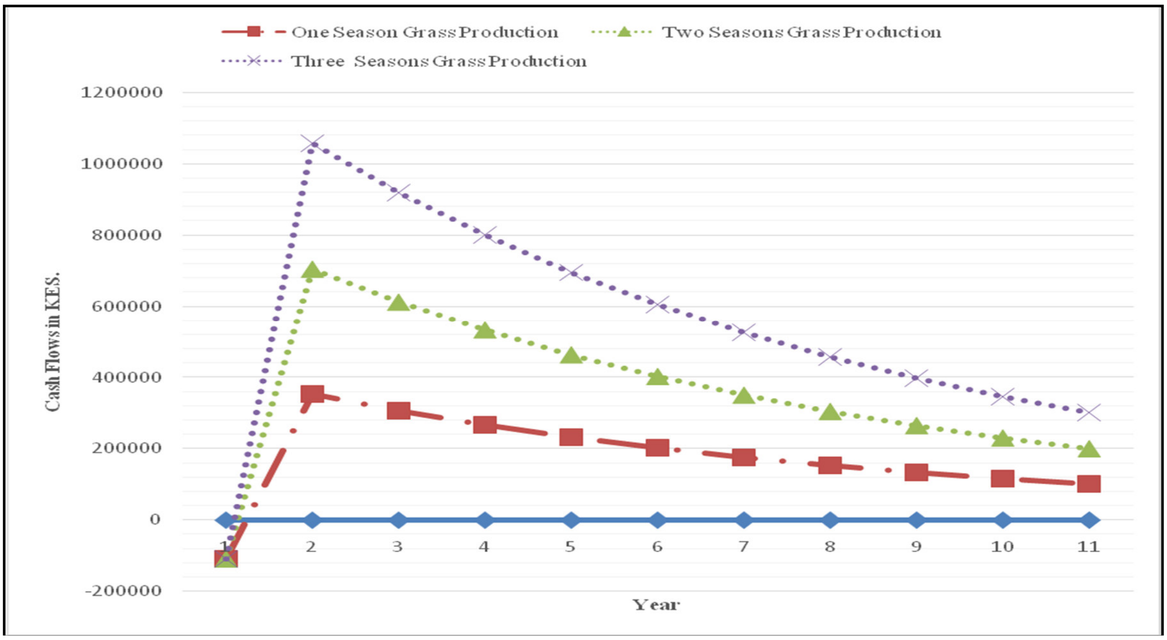


Figure 5: Ten-year cash flow under three pasture seasons

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 6: Households engaged in fodder production

Response	**Frequency**	**Per cent**
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 US$) 2222 procurement of simple mechanical hay bale 555, capacity building 555. As indicated on Table 7, the costs of nurturing one calf bought at 91 and analyzed in this study is 60. Other costs incurred in raising the calf are pest control 79 labour 80 and treatment Kshs 64.

Table 7: 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 analyzed 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.

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 US$ 2385 Procurement of fodder processing equipment, construction of hay baling and storage shed US$ 3333 and capacity building US$ 2222. 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. 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:

$$\mathrm{NPV} = \mathrm{CF}_0 + \frac{\mathrm{CF}_1}{(1+\mathrm{K})^1} + \frac{\mathrm{CF}_2}{(1+\mathrm{K})^2} \dots + \frac{\mathrm{CF}_n}{(1+\mathrm{K})^n}$$

Where *NPV= Net present value of investment*
CF_o, CF_1, $CF_{2\dots}$ CF_n, 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 ≥ 0 then the adaptation investment is economically viable.

Table 8: 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=US$2000 Table 8 show discounting rate application, cash in-flow and out-flow and resulting net present value of the pasture investment 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 US$14444 whereas cash outflow was US$ 1202.

DISCUSSION

The study quantified costs and benefits of livestock pasture enterprises considering a 5-10 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.

CONCLUSION

The study clarified that economic development initiatives are central part of adaptation requiring mainstreaming climate change data and practice 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. Equally vital is tackling 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 adaptation strategy was found economically viable but required home-grown capital-generating initiatives, done differently. Overall, the findings clarified that ASALs are water stressed and that 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 uncertainty. In order to create lasting impact for drought-affected communities, it is imperative that actors work in concert to build long term resilience, in line with National Climate Change Response Strategy and Kenya's Vision 2030's disaster preparedness and capacity development, dove-tailing into pertinent international protocols. This is especially important because onset of drought only comes to exacerbate existing development weakness. The study results become a handy tool for policy formulation guided by the clarity on costs and benefits established.

Specifically, pasture strategy was found economically viable for adaptation both in the current rain-fed 250-500mm conditions and beyond 2030 when precipitation may increase. For way forward value-for-money policy guidelines, the study implore county government to formulate livestock improvement guidelines towards: revitalizing traditional grazing management practices to tackle limited adaptation capacities, disease control and feed deficit costs. The preferable climate-smart approach requires investment in strategic value-chain linkages, viable markets acquisition and apt infrastructure. Also it is critical to promote strategic rain-fed and irrigated fodder production technologies using certified seeds and incorporating climate-smart water harvesting. Given the predicted increased precipitation in Ijara 2030 onwards, it is crucial to enrich soil stabilization by using multi-benefits crops such as Aloe and climate-adaptable pastures types as well as, supporting post-harvest/feed reserves technologies. To encourage the rising number of agro-pastoralists to sustainably invest in pasture farming, it is cost-effective to review land tenure system towards permanent ownership rights and to incorporate promotion of local farmer-friendly weather data collection and use.

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