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Evaluation of Mitigation Strategies for Climate Change Adaptation in Mandera County, Kenya

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ABSTRACT

The high vulnerability of Sub-Saharan Africa region to the impact of climate change results from over dependence on natural resources, poor infrastructure, pervasive poverty and the weak institutional capacity to respond and mitigate environmental disasters effectively. In Kenya, Mandera County is characterized by fragile and sensitive ecosystems with persistent droughts, floods, epidemics, livestock diseases and conflicts. The objective of this study was to evaluate strategic options for climate change adaptation and mitigation in Mandera County, Kenya. Sampling strategies included cluster random sampling, multistage sampling and simple random sampling. The study sample size was 384 household heads and the use of questionnaires, interview schedules, key informant questionnaires, focus group discussion and observation schedule were employed in data collection. Data analysis involved the use of Statistical Package for Social Scientists (SPSS) and Ms Excel. The results revealed that of the 384 household heads 13.3 % (51) embraced climate smart agriculture, 11.2 % (43) diversification of livelihood, 9.1 % (35) use of green clean energy resources, 8.3% (32) commercialization of livestock and livestock product while 3.4% (13) supported livestock banking respectively. The main internal (community based) measures included drilling of boreholes and wells 9.6% (37), planned grazing 8.1% (31), promotion of good governance, transparency and responsible leadership at the county level 7.8% (30) and construction of large scale dams 7.6% (29) respectively. External measures included provision of early warning system 12.5% (48), construction of viable high capacity dams 12% (46) and provision of subsidized animal feed by the County government 11.5% (44) respectively. Chi-square tests conducted on climate change adaptation mechanisms and key mitigation strategies against climate change showed that there was high significant ($P<0.01$) variation amongst the respondents. Coping strategies included; migration to areas with water and pasture 33.33% (128), praying for rainfall through special prayers i.e. *robdoon and hersi* 12.5% (48) and herd splitting (*hoga rac*) 10.2% (39) respectively. Indigenous knowledge mechanisms included observation of livestock behaviour 19.5% (75), observation of migration pattern of birds 16.4% (63) and signs of trees shading leaves 13.3% (51).

Keywords: Community livelihoods, pastoralist, early warning systems, climate smart agriculture

I. INTRODUCTION

Climate change is one of the biggest long-term challenges to global development. It is predicted that Africa will be the hardest hit region in terms of catastrophic natural disasters (IPCC, 2007). The high vulnerability of the continent to the negative impact of climate change results from the fact that Africa as a whole has a high dependence on natural resources, poor infrastructure, pervasive poverty and weak institutional capacity to respond and mitigate environmental disasters effectively. Climate change has not only become one of the most pressing global development challenges but is also increasingly recognized as a major human security issue for the 21st Century (UNDP, 2007; World Bank, 2010). Climate change undermines human security by reducing access to resources that are essential for sustaining livelihoods (Barnett and Adges, 2007; Kumsa and Jones, 2010) and may potentially exacerbate and reinforce the trend towards social instability that may already exist in some societies (Brown and Crawfold, 2009). The Sendai framework for disaster risk reduction 2015-2030 places much emphasis on four priority areas on Disaster Risk Reduction (DRR). The priority areas include understanding disaster risk, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction for resilience and enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction. Climate change and human security are very central to all the 17 Sustainable Development Goals which should be achieved by 2030. Specifically SDG No. 1, 2, 3, 6, 8, 13, 14, 15, and 16 are very critical in climate change and human security (UNISDR, 2015).

Climate Change is any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer. Climate change may be due to natural external forcing, such as changes in solar emission or slow changes in the earth's orbital elements; natural internal processes of the climate system; or anthropogenic forcing (IPCC, 2007). Climate Change is associated with a myriad of socioeconomic and biophysical shifts, but potential and projected changes in climate variability, including increases in extreme event frequency or intensity, is well recognized as a central societal concern. Global average temperature is one of the most-cited indicators of global climate change, and shows an increase of approximately 1.4°F since the early 20th Century (Houghton *et al.*, 2001).

There has been a general, but not global, tendency toward reduced Diurnal Temperature Range (DTR - the difference between daily high or maximum and daily low or minimum temperatures) over about 70% of the global land mass since the middle of the 20th century. However, for the period 1979–2005 the DTR shows no trend since the trend in both maximum and minimum temperatures for the same period are virtually identical; both showing a strong warming signal (Hansen *et al.*, 2012). A variety of factors likely contribute to this change in DTR, particularly on a regional and local basis, including changes in cloud cover, atmospheric water vapour, land use and urban effects. Indirect indicators of warming such as borehole temperatures, snow cover, and glacier recession data are in substantial agreement with the more direct indicators of recent warmth (Rahmstorf *et al*,. 2012). Evidence such as changes in glacial mass balance (the amount of snow and ice contained in a glacier) is useful since it not only provides qualitative

support for existing meteorological data, but glaciers often exist in places too remote to support meteorological stations.

Extreme and harsh weather is now a norm in Kenya (GoK, 2010). The pressures of climate change and climate variability make Kenya highly vulnerable to the impacts of climate change. This vulnerability is further aggravated by the fact that Kenya's economy is reliant on climate sensitive natural resources. Stern (2009) and Heinrich (2013) estimate that the central economic costs of climate change could be equivalent to 2.6% of GDP each year by 2030 for Kenya. Climate change has been identified as one of the greatest threats to humanity of all times, a threat to human security in addition to producing adverse environmental conditions. It is already challenging the realization of a broad range of internationally protected human rights (Ome & Casimir, 2015). Climate change and climate variability are projected to contribute to increased drought episodes, food insecurity, irreversible decline in herd sizes, and deepening poverty. The ASALs are inflicted by a major drought once in every 5 years resulting in widespread food insecurity, poverty, and irreversible decline in herd sizes. The constraints posed by climate change on agriculture range from pronounced seasonality of rainfall to severe and recurrent droughts (Omwoyo *et al.*, 2015). Mandera County is an arid area with sensitive ecological systems whose main economic activity is pastoralism. It is practiced in a sensitive and insecure environment characterized by highly spatial and temporal rainfall distribution, which often result in long, dry periods. The livelihoods of pastoralist communities largely depend on livestock. The County has experience recurrent droughts, human conflicts, terrorism, epidemics, human wildlife conflicts and animal disease whose impacts have increased immensely. Currently, climate change poses a threat to human development in terms of security and livelihood in Mandera as climate change and pastoralists' livelihood are interlinked processes making it one of the greatest and most complex challenges Kenya has to deal with today and in the years to come in order to achieve vision 2030. The United Nations International Strategy for Disaster Reduction (UNISDR) has identified understanding disaster risk and investing in disaster risk reduction for resilience as key priority areas to disaster risk reduction and sustainable development.

This study was found necessary due to the call by the International Strategy for Disaster Reduction through resolution 69/283 of 2015: Sendai Framework for Disaster Risk Reduction 2015–2030 for the need for improved understanding of disaster risk in all its dimensions of exposure, vulnerability and hazard characteristics; the strengthening of disaster risk governance, including national platforms; accountability for disaster risk management and preparedness to "Build Back Better. While various non-governmental organizations and governmental agencies have over the years carried out climate change risk awareness campaigns and poverty reduction programmes, climate change related disaster frequency and intensity have been on the rise in Mandera County. It is in view of this that a study to evaluate strategic options for climate change adaptation and mitigation strategies in Mandera County, Kenya was carried out.

1.2 The Nexus between climate change adaptation and sustainable development

Sustainable development as a concept is notoriously difficult, slippery and elusive to pin down (Williams and Millington, 2004). Fowke and Prasad (1996) identified at least eighty (80) different, often competing and sometimes contradictory, definitions. To avoid this intellectual contest, the study adopts the most widely quoted Bruntland Report's definition of sustainable development that sees sustainable development as development that meets the needs of the present generation without compromising the

ability of future generations to meet their own needs. This definition considers the world as a system that connects space and time. Sustainable development also refers to the process of sustaining development interventions in order that they continue to deliver desired benefits for an expected period of time (Dimitrov, 2010).

The nexus between climate change adaptation and sustainable development are several and varied (Banuri and Gupta, 2000; Robinson and Herbert, 2001). Sustainable development and climate change are known to interact in a circular fashion. The goal of every nation is to achieve and sustain development. Climate change poses a great threat to the achievement of national poverty reduction and sustainable development particularly the Sustainable Development Goals (AfDB *et al*., 2002; Nelson and Agbey, 2005; MEST, 2010). The worse impacts and burdens of climate change would be visited on agricultural and water systems, forests, fisheries, human health and infrastructure. These impacts could worsen existing conditions of poverty, malnutrition and illness, and put pressure on natural resources and ultimately exacerbate the vicious cycles of those conditions. TERI (2006) has noted that, climate change relates to sustainable development through the impediments that it poses to and the implications on the opportunities for socio-economic development and issues of equity and justice.

Conversely, the impacts of climate change can be minimized through proactive and conscious efforts such as mainstreaming adaptation and mitigation into development processes and strategies (Füssel and Klein, 2004). The wider development goals can be achieved by building institutions to address current socio-economic and environmental problems, and to augment social capital; stimulating technological innovation, promotion of environmentally friendly technologies; development of drought-resistant varieties of crops can help in ameliorating the capacity to cope and adapt to climate variability and change (Kok and de Coninck, 2007).

Because, climate change is an impediment to the achievement of development goals, recognizing how climate change is likely to impact development priorities is crucial in developing cost-effective strategies and build institutional capacity in developing countries where the impacts of climate change are more pronounced and opportunities to adapt are limited. In order to effectively support adaptation and to minimize risks associated with predicted impacts, there is an urgent need to integrate adaptation issues and considerations into development plans and budgets. As noted by Lebel *et al*. (2012) both current and future climate-related risks need to be addressed in plans. This will promote climate proofing and sustainable development (Dazéet *et al*., 2009; CARE, 2010). For example in Ghana, challenges posing a threat to sustainable development have been broadly classified by Kuuzegh (2007) as degraded natural resource base; carbon intensive energy supply and inequitable access to energy; adaptation deficit; and disasters. Government‘s efforts to tackle these problems are constrained by lack of predictable finance, weak institutional coordination, low capacity to retain expertise with the government system, and the persistence of reactive management approaches.

1.3 Adaptation to climate change and human security

Climate change will increase human insecurity in Least Developed Countries (LDCs) and Small Island Developing countries (SIDS) through its direct (biophysical) and indirect (socio-political and economic) impacts. Already insecure communities are less able to cope with and adapt to climate change risks. These impacts will worsen existing problems in volatile regions where adaptive capacity is destabilized by conflict as well as underdevelopment (Weinstein, 2004). Climate change is not a single or direct cause of violent conflict and nor is violent conflict the

unavoidable outcome of climate change, but where climate change acts on conditions of crisis such as existing conflict, poverty, weak institutions, and food insecurity, the crisis will deepen and crucial adaptation activities will be difficult to implement.

Climate change impacts will be felt less severely by populations where social, economic and governance systems function effectively to prevent, cope with, recover from, and adapt to adverse impacts. Special consideration must therefore be made by the international community in terms of how to pursue adaptation to climate change in different locations, both in terms of how it is undertaken in difficult circumstances and how it can be prioritized in a complex situation of competing priorities (IPCC, 2001). Adaptive capacity is lower in situations of underdevelopment and crisis, whatever the cause. According to Barnett (2006) there are three determinants of adaptive capacity – 'the availability of and access to natural, economic, and human and social capital' – it depends on, the ability to access commodity markets and labour markets and the prices paid on these markets, the ability of communities to pool resources to collectively respond to change, access to information, population health, and the existence and effectiveness of national and international policies and measures to sustain resources and livelihoods in vulnerable places.

In the case of violent conflict, it is clear how this denies the population the natural, economic, and human and social capital that would enable them to adapt to the new threats of climate change. It also has the effect of lowering the priority of adaptation to climate change and the longer term view essential to combating the worst effects of climate change, at local, national and international levels. In volatile regions, the priority needs are immediate; socially-wide for conflict resolution, and human-centric daily subsistence in a situation that impacts on livelihoods, availability of food, physical insecurity, and often times necessitates migration (Messer, 2010).

Under these conditions appropriate adaptation responses are unlikely and violent conflict reduces the amount of economic resources available to individuals and states to pay for adaptation responses; suppresses the extent of technological development and diffusion needed to select the most appropriate adaptation responses; suppresses educational attainment and restricts the policy learning necessary for understanding the nature of climate changes, to devise appropriate responses, and successfully to implement those responses; damages the infrastructure needed to deliver resources and information throughout a society; and weakens institutions and social cohesion, and undermines the possibility of collective responses to changes. Indeed, it is reasonable to suggest that no other process can rival violent conflict for its ability to render a population vulnerable to climate change (Barnett, 2000).

The threat of climate change is most often viewed as divisive in terms of increasing competition for fewer resources; however the global nature of the threat as well as the local level of the direct impacts can offer the commonality to divided communities and the international community. As such it is argued that adaptation to climate change has the potential to promote peace and stability by uniting divided communities for a shared common good, and promoting cooperation and innovation between hostile governments (Vellinga & Wood, 2007). Attempts should be made to harness the shared nature of the threat and promote cooperative action. There are a number of initiatives to this end, such as Trans-boundary Protected Areas (also known as Tran-frontier Conservation Areas (TFCAs) or Peace Parks (Adger *et al.*, 2006).

Environmental issues encourage people to cooperate at the societal level, as well as the international. Social

interest groups can use this mutual ecological dependence to facilitate cooperation across territorial borders. This is often the first step toward dialogue, which can be difficult to initiate through official political channels. Over time, regular interaction between academia and civil society actors can help lay the foundation for mutual trust and implicit political cooperation. For example, despite the daily battles on the streets of the West Bank and Gaza, Palestinians and Israelis continue to manage their shared water resources through informal and technical dialogue (Carius, 2007).

A new and powerful addition to this environmental platform could be adaptation to climate change. Climate change captures all the issues associated with environmental cooperation and offers more in its global reach (globally unifying), immediacy and longevity, and as such has the potential to be a useful tool in conflict resolution and peace building activities. Indeed the effect of climate change to multiply existing threats and vulnerabilities means that not considering climate change in peace building solutions may be risky, leading to increased vulnerabilities a decade or two down the line and an undoing of previous successes. The impacts of climate change ignore political borders and therefore the solution must also (McMichael, 2003).

The response requires both short and long term planning for adaptation, participation of local organizations and NGOs, capacity building in administrative and knowledge centers, and social capacity for action. This makes it a mechanism for cooperation and capacity building that will also benefit other areas of society. Whether conflict exists due to the impacts of climate change or despite of it, the solution to climate change lies only with long term cooperation and knowledge sharing. The shared threat as well as the longevity of the problem encourages the bringing together of parties to cooperate that usually would not; 'in divided communities, climate change offers a threat to united against; the need for adaptation offers a task on which to cooperate (Thanos *et al.*, 2008).

There is a unique need for cooperation on building a body of scientific data, on the ground observations, and local shared learning on what works for adaptation at a local and regional level; this is not information that will come from the developed world. In adaptation to climate change the technology transfer is not a material technology or science learned in the North and transferred to situations in the South, it is a body of knowledge from the South of those doing adaptation shared within the South. The cooperation is paramount as without this local knowledge there is little evidence available to base long term planning upon. Parties, even those in conflict, must share their observations of local climate change, knowledge of adaptation projects and lessons learnt, and build their capacity to generate and interpret climatic information and modelling as it becomes more locally relevant (Huq *et al.*, 2003).

The best process of change for a successful adaptation to climate change, in short, is the same as the processes involved in peace building. In both, energies must be engaged in different parts of society –among communities and their leaders, in the private sector, media, political groups, social activists, students and intellectuals – and at different levels – among the elite and among ordinary people (Schubert et al., 2008). In both, the process must include women as well as men, youth as well as mature adults, minorities as well as majority communities, and it must cross political divides as well. The techniques that will be used are also the same: encouraging dialogue; building confidence; addressing the issues that divide groups and out of which they perceive conflicts to grow; learning; mutual education; developing and strengthening civil society organizations to carry the work forward; strengthening both the capacity and the accountability of the institutions of government.

The processes of peace building and adaptation are not only similar in these ways, they are also synergistic. A society that can develop adaptive strategies for climate change in this way is well equipped to avoid armed conflict. In addition, a society that can manage conflicts and major disagreements over serious issues without a high risk of violence is well equipped to adapt successfully to the challenge of climate change. Regional adaptation to climate change projects may not be able to end conflicts within and between communities, but what they may offer in addition to their inherent benefits for the region, are a platform for communication and for collecting and synthesizing data that is shared among parties and requires cooperation to implement solutions (Stern, 2007). Communication and cooperation are seen as the first step of any peace process, and placing people on an equal footing (knowledge and capacity) on the climate change issue can begin to dispel distrust and resentment between hostile and marginalized groups. In conflict and post-conflict societies there is a need for peace-building activities to unite divided communities and to rebuild availability of and access to natural, economic and social capital throughout the population. It is suggested that climate change can play an important part in these activities and thus enable a society to address climate change issues alongside more obviously pressing concerns which might otherwise, push out climate change priorities.

The key to both peace building and adaptation to climate change is to build social resilience which ensures the capacity to adapt to future challenges, whether they are conflict resolution or responses to climatic changes in order to ensure human security. The example of the potential for adaptation to climate change to be partnered with peace building activities to more effectively address insecurity, illustrates how the human security agenda can promote international cooperating strategies on development, adaptation to climate change, disaster risk reduction and peace building which are mutually supportive and reinforcing (Barnett *et al.*,2007). Climate change activities may, of course, have some additional benefits in countries where there are severe biophysical risks. For example, in East Timor, soil erosion, deforestation, uncertainty about the extent and location of water resources, lack of water resource infrastructure, lack of advanced agricultural technologies, and a lack of climate records and monitoring, among many other things, renders much of the population vulnerable to El Niño-induced dry periods. If climate funding mechanisms can help implement disaster management and early warning systems, reforestation, soil conservation, water resource infrastructure, food security measures, and the development of meteorological services, then the UNFCCC may contribute to immediate development problems in East Timor in a substantial way. Indeed, such activities, if implemented carefully, may contribute to peace building. The UNEP (2003) has made a similar argument about the benefits of the UNFCCC to Afghanistan.'

1.4 Sendai framework for disaster risk reduction 2015-2030

Disaster risk is accumulating at an accelerating rate, threatening global efforts to achieve sustainable development. Each year, natural disasters result in the deaths of an average of 93,000 people mostly in developing countries and affected an average of 169 million people. Economic losses from natural disasters are rising rapidly. They have caused more than 141 billion USD in damages a year on average for the last decade, nearly double the average of the previous decade. Over the last decade over 80 percent of natural disasters were climate-related. Climate change is already contributing to this increase in risk and in the coming decades it will only worsen (UNISDR, 2015).

Disaster risk reduction provides solutions that reduce exposure and vulnerability and creates opportunities

to pursue resilience through development and investment decision making. This session looks at countries are already leveraging the tools of disaster risk reduction to support achieve development outcomes in a changing climate. With several landmark international agreements already concluded in 2015, and new climate agreements under consideration in Paris, the momentum to shift from business-as- usual is compelling. Implementation of these agreements calls for approaches that deliver multiple dividends and coordination across sectors that include engagement of local governments, the private sector and other stakeholders (UNISDR, 2015). The Sendai Framework was adopted by the Third United Nations World Conference on Disaster Risk Reduction in March 2015 and endorsed by the UN General Assembly in June 2015. It sets out seven global targets that include measurable reductions in the loss of lives, people affected, economic losses and damage to critical infrastructure. Targets are also set for early warning and risk information, national strategies and international cooperation.

The Sendai Framework shifts the focus from managing disasters to managing risk itself and while continuing to improve management of risks we cannot eliminate. It specifically considers the role of sustainable development, climate change and related policies and advances an approach to be applied in the development and implementation of all relevant sectors. It also identifies priority measures in understanding disaster risk, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction for resilience and enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction (UNISDR, 2015). The Sendai Framework builds on 10 years of work done by Parties and other stakeholders to implement the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (HFA), which served as a foundation for the Cancun Adaptation Framework. It shifts the focus from managing disasters to managing risk; in addition to better management of risks we cannot eliminate. The Framework specifically considers how sustainable development, climate change and related policies can prevent the creation of new risk, reduce existing risk and strengthen resilience.

The Sendai Framework advances an approach to be applied in the development, interpretation and implementation of all relevant sector and overarching local, national, regional and global policy instruments. The framework also promotes the measures that improve preparedness for, response to and recovery from disasters as part of a comprehensive approach. The Sendai Framework specifically addresses climate change and climate action providing measures, guiding principles and means of implementation. It focuses attention on action needed to tackle underlying risk drivers, such as the consequences of climate change and variability, among others. The Sendai Framework establishes the significance of ensuring credible links between disaster risk reduction and the post-2015 development agenda, financing for development and climate change agreements. It calls for enhanced coherence across policies, institutions, goals, indicators, and measurement systems for implementation (UNISDR, 2015). Taking into account the experience gained through the implementation of the Hyogo Framework for Action and in pursuance of the expected outcome and goal, there is a need for focused action within and across sectors by States at local, national, regional and global levels in the following four priority areas: Understanding disaster risk, Strengthening disaster risk governance to manage disaster risk, Investing in disaster risk reduction for resilience and Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

1.5 Methodological approaches relevant to the study

The objective of this study was to evaluate strategic options for climate change adaptation and mitigation in Mandera County. To achieve the above, cross-cultural and evaluation designs were adopted. These research designs have been successfully been used in other parts of the world with similar cases as the Kenyan one as illustrated.

In Zambia, a study was conducted to evaluate the integration of indigenous and scientific knowledge systems for climate change adaptation in Zambia (Kasali, 2011). An evaluation research design was used to evaluate the various aspects of indigenous knowledge systems such as productivity of indigenous pre-colonial farming systems, impacts of western practices on the local food security, combating climate change with conservation farming and indigenous indicators for drought and flood mitigation. This method is used to represent a systematic and objective assessment of ongoing or completed projects in terms of design, implementation and result (Best, 1981). One of the finding of this study was that farmers who practised conservation farming survived droughts while conventional farmers suffered almost total crop failure.

In Kenya, using cross-cultural research, a study on Climate Shocks, Perceptions and Copping options in Semi-Arid Kenya was conducted (Okoba *et al.*, 2011). A key finding of this study was that, over 92% of the respondents observed that the average temperatures are increasing while rainfall is decreasing. It was also noted that various copping options been developed such as change crop variety, change planting season, change of crop type, plant trees for shade, destocking and mixed cropping and, livestock keeping. In western Kenya, a study was conducted to establish the poverty levels in Nzoia Sugar Belt; a case study of Webuye and Nalondo divisions, Bungoma (Morike *et al.*, 2011). A correlational design was adopted to discover the relationship between location and individual income of the respondents and the results revealed that there is a significant relationship between income and the location where an individual lives.

1.6 Anthropogenic theory of climate change

The Anthropogenic theory of climate change contends that human emissions of greenhouse gases, principally carbon dioxide (CO), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism whereby this happens is called the enhanced greenhouse effect. We call this theory "anthropogenic global warming" or AGW for short (IPCC, 2007). Energy from the sun travels through space and reaches Earth. Earth's atmosphere is mostly transparent to the incoming sunlight, allowing it to reach the planet's surface where some of it is absorbed and some is reflected back as heat out into the atmosphere. Certain gases in the atmosphere, called "greenhouse gases," absorb the outgoing reflected or internal thermal radiation, resulting in Earth's atmosphere becoming warmer than it otherwise might be. Water vapour is the major greenhouse gas, responsible for about 36 to 90 percent of the greenhouse effect, followed by CO_2 (<1 to 26 percent), methane (4 to 9 percent), and ozone (3 to 7 percent). These estimates are the subject of much dispute, hence their wide ranges.

During the past century, human activities such as burning wood and fossil fuels and cutting down or burning forests are thought to have increased the concentration of CO_2 in the atmosphere by approximately 50 percent. Continued burning of fossil fuels and deforestation could double the amount of CO_2 in the atmosphere during the next 100 years, assuming natural "sinks" don't grow in pace with emissions. Earth's climate also responds to several other types of external influences, such as variation in solar radiation and in the planet's orbit, but these

"forcings," according to the proponents of AGW, cannot explain the rise in Earth's temperature over the past three decades. The forcing caused directly by man-made greenhouse gases is also small, but the AGW theory posits that positive feedbacks increase the effects of these gases between two- and four-fold. A small increase in temperature causes more evaporation, which places more water vapour in the atmosphere, which causes more warming. Global warming may also lead to less ice and snow cover, which would lead to more exposed ground and open water, which on average are less reflective than snow and ice and thus absorb more solar radiation, which would cause more warming. Warming also might trigger the release of methane from frozen peat bogs and CO_2 from the oceans. Backers of the AGW theory contend the ~0.7°C warming of the past century-and-a-half and ~0.5°C of the past 30 years is mostly or entirely attributable to man-made greenhouse gases. They dispute or disregard claims that some or perhaps that entire rise could be Earth's continuing recovery from the Little Ice Age (1400-1800). They use computer models based on physical principles, theories, and assumptions to predict that a doubling of CO2 in the atmosphere would cause Earth's temperature to rise an additional 3.0°C (5.4°F) by 2100. When these climate models are run "backwards" they tend to predict more warming than has actually occurred, but this, the theory's backers argue, is due to the cooling effects of aerosols and soot, which are also products of fossil fuel combustion.

The models also predict more warming of a layer of the atmosphere (the troposphere) in the tropics than has been observed by satellite and radiosonde measurements, but AGW believers dispute the data showing that disparity. Proponents of the AGW theory believe man-made CO_2 is responsible for floods, droughts, severe weather, crop failures, species extinctions, spread of diseases, ocean coral bleaching, famines, and literally hundreds of other catastrophes. All these disasters will become more frequent and more severe as temperatures continue to rise, they say. Nothing less than large and rapid reductions in human emissions will save the planet from the catastrophic events. The Anthropogenic theory contends that human emissions of greenhouse gases, principally carbon dioxide (CO_2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The global average surface temperature is estimated to increase between 1.4°C and 5.8°C by 2100. Decrease or increase in temperature interferes with the biogeochemical cycle leading to an ecosystem imbalance hence susceptible to limiting factors such as disasters strike.

II. MATERIALS AND METHODS

2.1 Research Design and study area

Research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. The study employed descriptive, survey and cross-cultural research designs (Kothari, 2007). This study had two variables: climate change is the independent variable while mitigation and adaptation strategies are the dependent variable. The study was carried out in Mandera County (Figure 2.1) of the North Eastern region of Kenya located at latitude ($2^0$10'N to $4^0$50'N) and longitude ($39^0$50'E to $41^0$50'E). It borders Somalia to the East, Ethiopia to the North and Wajir County to the South. The county has a population of 1,025,756 of which 54.6 % are male and 45.4 % female. The county covers an area of 25,991.5km² (GoK, 2013). It also has a population density of 39 people per Km² and poverty level of 68 %. The County's population literacy rate is 25.4 per cent compared to the national which is 79 per cent (GoK, 2013). The study area was selected using multistage sampling technique and the following wards were selected; Shimbir fatuma, Khalalio, Wargadud, Neboi, Guticha and Rhamu Dimtu. The study population was 107,015, target population was

3,920 (households) while the sample size was 384 household heads. Key informants included; public health officers, Kenya forest service officers, chiefs, village elders, imams, meteorological officers, programme managers from local NGO's, teachers ,transporters, livestock traders and agricultural extension and livestock production officers from Mandera County.

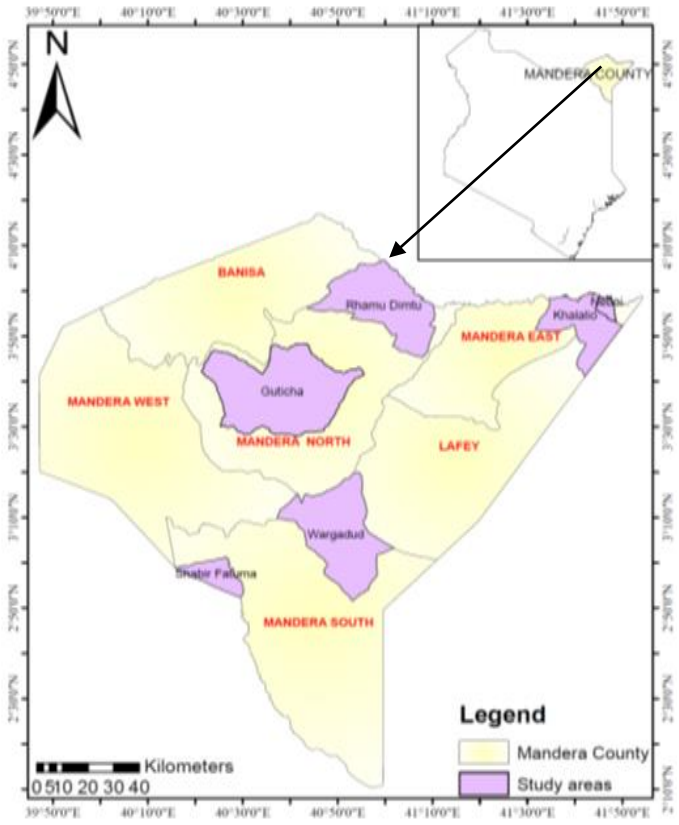

Figure 2.1. Map of Mandera County, Kenya
Source: Modified from GoK (2013)

2.2 Sampling strategy

The study adopted the Fisher's formula (Fisher et al., 2007) used for sampling. Purposive simple random sampling was used in the selection of public health officers, Kenya forest service officers, chiefs, village elders, imams, meteorological officers, programme managers from local NGO's, teachers ,transporters ,livestock traders and agricultural extension and livestock production officers based on the locality of the household heads. A total of 72 key informants were selected for face to face interview. To achieve the objectives of the study, different techniques were used to select the various respondents. Mandera County has six (6) sub counties and multistage random sampling was used in the selection of the sub counties. According to Mugenda and Mugenda (2003) in social science research, if the estimate of the proportion of the target population assumed to have the characteristics of interest is not provided, then 50% should be used. Three stratums based on the setups, rural and urban with each having two (2) sub-counties were selected.

A total of three sub counties were selected in line with Kothari (2007) recommendation that a sample of between 10% and 30% is a good representation of the target population and hence the 30% was adequate for analysis. Each of the three (3) sub counties has five (5) administrative wards and to select the actual wards to be considered for the study, a randomization technique was used and two (2) administrative wards from each sub county were selected based on Mugenda and Mugenda (2003) arguing that in social science research, a sample of between 10% and 30% is a good representation of the target population and hence the 40% is appropriate. Systematic sampling was used to pick the households to be considered for data collection with an interval of one (1) household before selecting the next household for the study. The key informants were also selected purposively based on the locality of the household heads and to select the actual participant, a randomization technique was applied.

2.3 Data collection

Data is defined as facts or information, especially when examined and used to find out things or to make decisions (Kothari, 2007). The study employed questionnaires, interview schedules and focus group discussion.

2.4 Validity and reliability of research instruments

1) 2.4.1 Validity

According to Cohen *et al.*, (1994), validity refers to the extent to which the instruments of data collection measures and what it purports to measure. The instruments and contents were prepared based on the research objectives and research questions of the study. The format of the questions was considered for sequence to ensure clarity of direction to the respondents. To establish the validity of the instruments, the researcher presented the instrument to experienced researchers knowledgeable in the area of study. The researchers' supervisors also assisted in assessing the aspects the instrument is trying to measure to determine the suitability in obtaining information accurately.

2) 2.4.2 Reliability

Mugenda *et al.*, (1999) explains that reliability is a measure of degree to which a research instrument yields consistent results or data after accepted trials. Reliability of measurements concern the degree to which a particular procedure gives similar results over a number of repeated trials. This was achieved after administering the same instrument more than once to the same group, a method referred to as test-retest. The researcher administered the questionnaire to the pilot sample in Rhamu Ward and then scored the questions. To measure the reliability, Alpha (Cronbach, 1951) technique was employed. Cronbach's Alpha is a general form of the Kunder-Richardson (K-R) 20 formula. The use of K-R 20 formula in assessing internal consistency of an instrument is based on the split – half reliabilities of data from all possible halves of the instrument. Use of K-R 20 formula reduces the time required to compute a reliability coefficient in other methods. Its application also results in a more conservative estimate of reliability; the estimated coefficient of reliability of data is lower.

Alpha (Cronbach) is a model of internal consistency based on the average inter- item correlation. The instrument was divided into two parts using even and odd numbers. A large value of alpha (preferably greater than 0.6) indicates high level of consistency of the instruments in measuring the variables. Respondents in the pilot sample were asked to comment on the clarity and time taken to fill one instrument. The co-efficient of internal consistency was 0.86 which is considered good. The instrument was then adjusted on the basis of the findings of the pilot test and the final version developed thereafter.

3. RESULTS AND DISCUSSIONS

3) 3.1 Main sources of livelihood

The daily livelihood of an individual plays a greater role in his or her vulnerability. Most of the household respondents were pastoralists 27.9% (107) and 24.2% (93) involved in business. Nonetheless, 12.5% (48) were not involved in any source of livelihood and the same figures were involved in casual employment. Those formally employed were 10.2% (39) and those in agro-pastoralist practice were 13.0% (50). Those who were not involved in any activity to earn a living usually rely on relief food. Chi-square test conducted on household main source of livelihood gave ($\chi^2_{5,0.01} = 63.375$) which showed that there was highly

significant (P<0.01) variation among household main source of livelihood. Figure 3.1 shows the results.

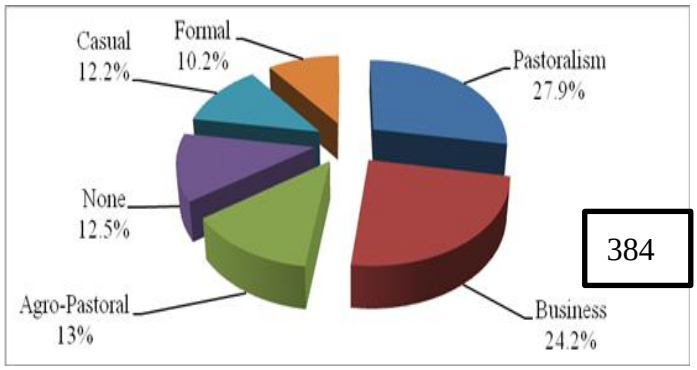

Figure 3.1. Household heads main source of livelihood in Mandera County, Kenya

Source: Author, (2017)

Below is a verbatim expression from one of the respondents:

Our source of livelihood determines what we eat, drink, cloth, participate, invest and general vision of local and global issues that affect us in one way or the other. Those who have low income both in the formal and informal sector are more affected by disasters than their counter parts in high-income bracket that can afford insurance or can replace lost properties or substitute their sources of income. This community's livelihoods are susceptible to drought and conflict shocks, inflation and livestock diseases.

Findings in this study concur with NEPADA (2015) which reported that the main source of livelihoods for most of the households in Mandera county is livestock keeping accounting for (45.3%). Another significant proportion 10.7% is engaged in crop production while, 26% draw their livelihoods from casual labour while another 8% of the residents are engaged in small scale businesses. Only 3% are engaged in skills trade while 3.3% are in gainful employment. With this, the residents face difficult conditions in the context of climate change impacts. The study also indicates that apart from the main sources of livelihoods, 37.3% have no other alternative sources while 15% rely on relief assistance. This implies that a sizeable proportion of the community is largely dependent on relief, while clear lack of diversification of livelihoods is notable. Further, AFSOC (2013) found out that the main source of livelihood in Mandera County is Pastoralism. Mandera County is estimated to have a stock of 964,000 animals with 80% of the households' reliant on livestock-based livelihoods (Government estimates).

3.2 Climate change adaptation strategies for sustainable development in Mandera county

Climate change and global warming phenomena are currently the major cause of human sufferings both in developed and developing countries hence robust adaptation is very critical especially in fragile, sensitive and vulnerable societies. The household respondents were asked to state climate change adaptation mechanisms according to their effectiveness in Mandera County in order to achieve sustainable development. Out of the 384 household heads, 13.3% (51) indicated investment in climate smart agriculture, 11.2% (43) said diversification of livelihood, 9.1% (35) use of green clean energy resources, 8.3% (32) commercialization of livestock and livestock product while 3.4% (13) revealed livestock banking.

Others adaptation strategies included establishment on nomadic health workers 6.8% (26), strengthening alternative dispute resolution mechanism 6.5% (25) and practicing agro-forestry 6.3% (24) respectively. Key opinion leaders also indicated the provision of alternative fuel to replace fuel wood so as to discourage deforestation and charcoal burning, enforcement of mandatory village a forestation activities so that each village would have a forest and reducing the number of livestock kept (destocking). The results are as presented in Table 3.1

Table 3.1. Climate change adaptation mechanisms in Mandera County ,Kenya

Adaptation strategies	Frequency	Percentage	Rank
Investment in climate smart agriculture	51	13.3	1
Diversification of livelihood	43	11.2	2
Use of green clean energy resources	35	9.1	3
Commercialization of livestock and livestock product	32	8.3	4
Water harvesting and conservation of catchment areas	31	8.1	5
Establishment on Nomadic health workers	26	6.8	6
Strengthening alternative dispute resolution mechanism	25	6.5	7
Practices agro-forestry	24	6.3	8
Setting up of nomadic extension and cross breeding centres	23	6.0	9
Planned and controlled grazing	19	4.9	10
Grazing and migration routes variation	19	4.9	10
Setting of group ranches and conservancies	16	4.2	11
Hydro-commercialization	14	3.6	12
Livestock banking	13	3.4	13
Carbon credit financing	8	2.1	14
Climate change proof investment &help desks	5	1.3	15
Total	**384**	**100**	

Source: Author (2017)

Chi-square test conducted on climate change adaptation mechanisms according to their effectiveness in Mandera County in order to achieve sustainable development gave ($\chi^2_{10,0.00} = 97.135$) which showed that there was high significant (P<0.01) variation amongst the respondents. In Ethiopia, Alefu et al. (2017) found there has been concerted effort from different players to mitigate strategies against climate change to enhance agro-pastoralist through diversifying livelihood, seasonal migration, using alternate energy sources other than fire wood and charcoal, improving human health (sanitation) and clean water supply, market and infrastructure development and improvement, using integrated natural resource management, and sound policy and Conflict resolution methods. Create enabling environment and support the construction of small scale irrigation facilities like micro dams, ponds, diversion canals and dikes. In Kenya, Kisiangani (2011) revealed that there is need to invest in building the capacity of pastoralists. Education and training programmes enhance pastoralists' skills and help them to diversify their enterprises, improve resource management, and take up employment opportunities. These must be strengthened through appropriate financial support and policy interventions.

However, Ombaka (2015) revealed that religion and traditional practices also play a major part in the communities' perceptions of non-events. On the positive side, there is the general belief that everything happens only with God's permission. As such, better preparedness is achieved with incorporation of local knowledge and practices. On the negative side, religion can play a role in 'non-preparedness'. Since people believe their fate is in the hands of a higher power, they believe that whatever they do might not have an effect on the outcome of God's will.

Gibbons (2014) found that in the dry lands the government has focused on 'peace building from below'; involving communities in maintaining and negotiating peace. However, one report argues that there needs to be a greater emphasis on the responsibilities of the state and political leadership. The ability of communities to use traditional peace building means are 'being curtailed by modernization, education (influencing the dynamics between elders and youth), the availability of firearms, and the commercialization of the previously cultural practice of cattle rustling. In addition, issues such as the proliferation of small arms, which span administrative and ethnic boundaries, cannot be effectively dealt with at the local level. However, there has been a lack of coordination and collaboration in peace and security between the local and national level.

3.3 Mitigation strategies against climate change to enhance agro-pastoralist development in Mandera County

Disaster mitigation is a key component in disaster risk reduction. The respondents were asked to key mitigation strategies against climate change in order to enhance agro-pastoralist development in Mandera County in Mandera County, Kenya. The results revealed that the main internal (community based) measures included; drilling of boreholes and Wells 9.6% (37), planned grazing 8.1 % (31), promotion of good governance, transparency and responsible leadership at the county level 30(7.8), construction of large scale viable dams 7.6%(29) and diversification of livelihood 7.3% (28).

Other internal mitigation measures were; afforestation 5.9% (23), use of cash transfer voucher to replace relief food distribution 5% (19) and livestock insurance 3.4% (13). Chi-square test conducted on key mitigation strategies against climate change gave ($\chi^2_{11,0.00} = 67.688$) which showed that there was high significant (P<0.01) variation amongst the respondents. Key opinion leaders indicated similar sentiments while focus group discussion participants suggested the promotion of agribusiness and climate smart agriculture. The results for internal mitigation strategies are presented (Table 3.2).

Table 3.2. Internal climate change mitigation measures to enhance agro-pastoral development in Mandera County, Kenya

Internal mitigation strategies	Frequency	Percent	Rank
Drilling of boreholes and Wells	37	9.6	1
Planned grazing	31	8.1	2
Promotion of good governance, transparency and responsible leadership at the county level.	30	7.8	3
Construction of large scale viable dams	29	7.6	4
Diversification of livelihood	28	7.3	5
Creation of public awareness and capacity building	26	6.8	6
Setting up of interest free SACCOs	25	6.5	7
Afforestation	23	5.9	8
Growing of drought resistant crops and solar irrigation	22	5.7	9
Community based resource mobilization	20	5.2	10
Community based resource mobilization	20	5.2	10
Use of cash transfer voucher to replace relief food distribution	19	5.0	11
Promotion & enhancement of livestock marketing	19	5.0	11

Discourage use of charcoal	18	4.7	12
Destocking	13	3.4	13
Livestock insurance	13	3.4	13
Increase in nomadic schools	11	2.9	14
Total	**384**	**100**	

Source: Author, (2017)

In Northern Kenya, Guyo (2011) found that communities living in Northern region of Kenya who are predominantly pastoralist and agro-pastoralists. The FH-Kenya pastoralist livelihoods programme works with communities to identify their resource needs and produce resource maps that show where grazing land and water are in their locality. Elders organise meetings before every wet and dry season to determine the ways forward in grazing management; FH-Kenya supports these meetings. The elders choose guards to ensure that grazing rules are followed to prevent overuse. There are consequences for those who are violating the rules: several people have been fined for breaking the rules, in the form of cash or livestock fines.

Household heads also highlighted various external climate change mitigation strategies. 10.4% (40) and Banning of cross-border charcoal business 5.2% (20). Also 7.3% (28) said there is a need for the development of cross boarder policy on deforestation and desertification while 8.8% (34) preferred the devolution of NEMA and NDMA functions. Chi-square test conducted on the key mitigation strategies against climate change gave ($\chi^2_{10,0.00} = 46.719$) which showed that there was high significant (P<0.01) variation amongst the respondents on the external mitigation measures. Opinion leaders and FGD participants cited similar sentiments on external climate change mitigation strategies and the result are presented in Table 3.3.

Table 3.3. External climate change mitigation strategies to enhance agro-pastoral development in Mandera County, Kenya

External mitigation strategies	Frequency	Percent	Rank
Provision of integrated community based early warning system	48	12.5	1
Construction of viable high capacity dams	46	12.0	2
Provision of subsidized animal feed by the County government	44	11.5	3
Timely provision of water and relief food by government	41	10.6	4
Provision of generators and water pumps for irrigation	40	10.4	5
Devolution of NDMA and NEMA functions	34	8.8	6
Promotion of mechanized agriculture	32	8.3	7
Cross boarder policy on deforestation and desertification	28	7.3	8
Capacity building	27	7.0	9
Banning of cross-border charcoal business	20	5.2	10
Controlled grazing through legislative and policy	10	2.6	11
Responsive development partners and NGOs	7	1.8	12
Implementation of the PARIS agreement of 2016	7	1.8	12
Total	**384**	**100**	

Source: Author (2017)

The results also revealed that there is a need for provision of early warning system 12.5% (48), construction of viable high capacity dams 12%(46), provision of subsidized animal feed by the County government 11.5%(44) , Provision of generators and water pumps for irrigation. This study is consistent

with GoK (2013) where the government initiated projects to drill boreholes due to lack of sufficient rainfall in Ashabito. A Drilling of Marothile Borehole at a cost of 4.5M with National Water Conservation and Pipeline Corporation being the implementation agent at Ashabito in Mandera North with donor and financers being AFREN/EAX oil prospecting Company. This indicated the location is disaster prone zone.

Abdirizak (2016) revealed that on the drought contingency planning activities that the pastoralist communities are involved in as a drought disaster risk reduction in Mandera County, the respondents recapped that they are involved in drilling of contingency boreholes used during drought, strengthening the existing village committees through capacity building, offloading and storage of food aid, facilitating distribution, targeting and registration of the vulnerable household and identification of water trucking points, source of information of cases of sick persons and identify malnourished children.

According to Development Initiatives (2017) NDMA plays a major role by providing the platform for long-term planning on disaster management and contingency planning – this is appreciated by the actors in Mandera. While NDMA's focus is on matters relating to drought management, the manner in which disaster preparedness has been organised in Mandera County encompasses the other natural disasters: disease outbreaks and floods. Flood early warning systems have been installed by WARMA along the river to alert communities of the rising water level when floods are approaching. In Mandera County there was pre-positioning, market assessments, and early warning systems. Konrad-Adenauer-Stiftung (KAS), Kenya is implementing the project dubbed “Crisis prevention through promotion of good governance in the area of food security” in Baringo and West Pokot Counties of Kenya. The overall objective of the project is to promote household and community food security and livelihood resilience through interventions that strengthen good governance and crisis prevention in ASAL regions.

However, according to Gitonga (2016) there is also the diminishing role of traditional institutions in conflict management that is coupled with political incitement, nonresponsive governments’ policies and interethnic hostility. With urbanisation and modernisation, the youth who are mostly involved in cattle rustling are challenging and shunning these traditional ways. Furthermore, national and county administrative structures do not recognise the resolutions passed by the elders. Further, lack of integration of DRR and Conflict resolution policies, CEWARN focuses mostly on early warning, with some effort on response, but not so much on prevention or mitigation. These afore mentioned organisations were in the past focused on their core mandates but in 2011, the Government of Kenya (GoK) developed a comprehensive DRR strategy, the National Disaster Management Policy. This policy has a strong focus on disaster risk reduction, emphasizing the importance of preventive and mitigating measures to minimize the impact of a disaster. Nonetheless, the Gitonga (2016) did not find evidence that there was integration of conflict resolution and drought or disaster mitigation activities. However, Ombaka (2015) revealed that religion and traditional practices also play a major part in the communities’ perceptions of non-events. On the positive side, there is the general belief that everything happens only with God’s permission. As such, better preparedness is achieved with incorporation of local knowledge and practices. On the negative side, religion can play a role in 'non-preparedness'. Since people believe their fate is in the hands of a higher power, they believe that whatever they do might not have an effect on the outcome of God's will.

3.4 Community coping strategies towards climate change effects in Mandera County

Coping strategies have over the years helped communities survive the effects of climate change.

Household heads were asked to highlight measures they undertook as a community to help survive effects of climate change in Mandera County. Out of the 384 household heads, 33.33% (128) cited migration to areas with water and pasture while 12.5% (48) stated praying for rainfall through special prayers i.e robdoon and hersi while 10.2% (39)splitted herds (hoga rac).Other measures undertaken as a community to help survive effects of climate change identified were caring for weak animals 2.3% (9), 8.9% (34) said sharing of food and living with relatives, 5.7% (22) indicated resource mobilization for water taking by community leaders, 3.6% (14) said lending of lactating animals (xiskinsi) while 7.8% (30) cited destocking. However, only 3.1% (12) practiced mate prevention and 3.1% (12) engaged in awareness creation. The results are as presented in Table 3.4.

Table 3.4. Community coping strategies towards climate change effects in Mandera County, Kenya

Measures	Frequency	Percent	Rank
Migration to other areas	128	33.3	1
Praying for rainfall (robdoon and hersi)	48	12.5	2
Herd splitting (hoga rac)	39	10.2	3
Growing drought resistant crops such as millet	36	9.4	4
Sharing of food & living with relatives	34	8.9	5
Destocking	30	7.8	6
Resource mobilization for response	22	5.7	7
Lending of lactating animals (xiskinsi)	14	3.6	8
Awareness creation	12	3.1	9
Mate prevention	12	3.1	10
Cooking and caring for weak animals	9	2.3	11
Total	**384**	**100**	

Source: Author (2017)

Chi-square test conducted on measures undertaken as a community to help survive effects of climate change gave ($\chi^2_{10,0.0.00} = 320.974$), an indicator that there was high significant (P<0.01) variation amongst the respondents on what measures they took. Equally, livestock production, agricultural extension officers and public health officers cited that they continuously engage in awareness creation and provision of risk reduction services.

3.5 Indigenous knowledge mechanisms that help to survive climate change in Mandera County

Indigenous knowledge mechanisms in Africa have enormously played a key role in climate change prediction and preparedness to climate change induced disasters over the years. The respondents were asked to indicate indigenous knowledge mechanisms that help them to survive climate change in Mandera County. The results are as presented in Table 3.5.

Table 3.5. Indigenous knowledge mechanisms that help to survive climate change in Mandera county, Kenya

Indigenous knowledge mechanisms	Frequency	Percent	Rank
Observation of livestock behavior	75	19.5	1
Migration of birds	63	16.4	2
Shading of leaves	51	13.3	3

Direction of winds and speed	49	12.8	4
Movement of rodents	47	12.2	5
Less feed intake by animal due to stress	38	9.9	6
Position of the stars	32	8.3	7
Notable stress on wild life behavior	29	7.6	8
Total	**384**	**100**	

Source: Author (2017)

Out of the 384 household heads, 19.5% (75) indicated that they do observe the behaviour of livestock especially when mating, 16.4% (63) cited observation of migration pattern of birds while 13.3% (51) identified signs of trees shading leaves. 9.9% (38) cited observable reduction in feed intake by livestock due to stress, 8.3% (32) felt that signs of biodiversity loss as an early warning indicator of climate change (Micronutrients)and 7.6% (29) revealed observation of stress on wild life behaviour. Chi-square test conducted on indigenous knowledge mechanisms that help to survive climate change gave) indicating that there was high significant ($P<0.01$) variation amongst the respondents on indigenous knowledge mechanisms that help to survive climate change. Opinion leaders, livestock traders, transporters and FGD participants cited similar factors by household heads in predicting changes in climate.

III. CONCLUSION AND RECOMMENDATIONS

The study established that the main climate change adaptation strategies in Mandera county were; Investment in climate smart agriculture, diversification of livelihood, use of green clean energy resources, establishment on Nomadic health workers, Grazing and migration routes variation and livestock banking.

The results also revealed that the main internal (community based) measures included; drilling of boreholes and Wells, planned grazing, promotion of good governance, transparency and responsible leadership at the county level, construction of large scale viable dams and diversification of livelihood. Other suggested internal mitigation measures were; afforestation, use of cash transfer voucher to replace relief food distribution, livestock insurance and banning of cross-border charcoal business.

The study also revealed that there is a need for provision of early warning system, construction of viable high capacity dams, provision of subsidized livestock feed by the County government, Devolution of NDMA and NEMA functions and promotion of mechanized agriculture as the key external mitigation measures in combating climate change and global warming in Mandera County. The study recommends the adoption of forest conservation, biodiversity and ecosystem banking as a natural capital through the monetization of ecological value.

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