# An Assessment of Climate Change Adaptation Strategies by Smallholder Agribusinesses in Mau Ranges, Nakuru County

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## Abstract

*Smallholder agribusinesses contribute to the generation of grey and blue collar jobs. However, majority of the individuals in smallholder agribusiness production systems do not have the guarantee of sustainability attributed to production and marketing constraints associated with the agricultural value chain. This research focused on the climate change challenge facing the sector. The government efforts and support on the smallholder supply chain optimisation programs requires a participatory process to ensure that there is a capacity building for any future uncertainty. Smallholder production systems can help mitigate climate change by reducing both the production of greenhouse gases and the consumption of fossil fuel-based energy. Greenhouse gas emissions can be reduced by implementing energy conservation measures, through energy efficient lighting and space heating, incorporating greater recycled content in products and selecting production processes that either emit or use less greenhouse gases.*

*This study sought to investigate the strategies employed by smallholder agribusiness production systems in climate adaptation. The research focused on three independent variables; Business innovation opportunities, Smallholder risk assessment measures and Smallholder supply chain optimisation programs on climate change adaptation. The study adopted a cross sectional survey research design targeting 94 smallholders and agribusinesses in Mau Ranges in Nakuru County through a purposive sample size of 47. Data was collected through both structured questionnaires and structured interviews. Quantitative data was analysed descriptively and qualitative data was analysed using content analysis. The finding of the study shall be useful to the stakeholders especially the local farmers and businesses that benefit from agriculture. The supply chain optimisation and value addition technologies will be enhanced, hence Smallholder production systems can capitalise on climate change adaptation and biodiversity loss by developing technologies, products and services that help to improve resilience to the effects of climate related risks and opportunities.*

***Key Words: Smallholder Agribusiness, Climate Change Adaptation, Business Innovation, Risk Management, Supply Chain Optimization, Biodiversity Loss***

**Background of the Study**

Agriculture plays an important role in the global economy and is considered to be the most important sector of Sub-Saharan Africa (SSA). However, this importance notwithstanding, the agricultural sector in Africa has been affected adversely by climate change (Komba, & Muchapondw, 2015). Climate change forecasts concurs that many developing countries, climates in the Sub-Saharan Africa (SSA) will become less favorable to agricultural practices that they currently undertake due to the fact that these climates will become relatively warmer. Developing countries are also vulnerable to climate change because of their heavy reliance on agriculture and lack of appropriate infrastructure and capital to invest in innovative adaptations (Akinnagbe, & Irohibe, 2015). Projections on crop yield from rain fed agriculture in Sub-Saharan Africa, Kenya included, indicate that they could be halved by 2020 and the net revenue from crop production could fall by 90 percent by 2100 ( Mburu, Biu, & Muriuki, 2015). Temperature rise forecasts indicate that there will be a rise in temperature of between 1-2.5 degrees Celsius by 2030 which incidentally coincides with Kenya's development agenda captured in the Vision 2030 blue print (GoK, 2017).

Small holder agribusiness sector plays a key role in the Kenyan national economy today making a contribution of 80 percent of formal employment and 26 percent of GDP (Bernard, Adwera, Kungu, Charles, & Wakhungu, 2012). The Government of Kenya's development programme, *Vision 2030,* envisages agriculture as one of the key sectors to deliver the 10 percent anticipated annual economic growth under the economic pillar (GoK, 2007). Smallholder agriculture is generally used to refer to rural agricultural producers who rely mainly on farm labour for farming as a source of livelihood and income (AGRA, 2014). Smallholder farmers grow most of the country's staple crops such as maize, beans, peas, sorghum, cassava, oilseeds, vegetables etc.

However, smallholder farmers in Kenya face a number of challenges that include increasing production and preserving natural resources (Okumu, 2013). These challenges are further compounded by climate change and variability on food production system, ecosystem integrity and natural resource base (Mburu, Biu, & Muriuki, 2015). This implies that the country's endeavor to meet various social economic development targets is compromised by the smallholder agribusiness sector's vulnerability to climate change. (Ojwang, Agatsiva & Situma, 2016). Indeed, Kenya's human population is facing greater health and life risk than ever before. The increasing food insecurity can be linked to increasing poverty levels. Almost 18 million Kenyans live below the poverty line, majority of residing in the rural areas where more than 90 percent rely on rain-fed smallholder farming for livelihood (Akinnagbe, & Irohibe, 2015).

This study seeks to demonstrate on-the-ground climate adaptation practices and strategies which can enhance the resilience of the smallholder agricultural activities if adopted with a goal of attaining food security in Kenya. Despite the vulnerability to the impacts of climate change, smallholder farmers in Kenya are yet to take the threat posed by climate change seriously. There is credible scientific evidence that human activities have begun to modify climate and such change has significant social and economic implications (Osumba & Rioux, 2015). Vulnerability assessments indicate that climate change has the potential to severely impact on the country because economic and livelihood systems are highly dependent on natural resources. It is approximated that only 20 percent of land area in Kenya is arable, implying that food insecurity, malnutrition and famine are likely to constitute a serious threat to the social-economic development of the country. (Mutimba, 2010, Akinnagbe, & Irohibe, 2015).

A recent study that was conducted by Stockholm Environment Institute (SEI) on the economics of climate change in Kenya, indicates that the future economic costs related to climate change on

market and non-market sectors might be close to 3 percent of GDP annually by 2030 (Stockholm Environment Institute 2009). The emergence of climate smart agriculture responds to the need to reduce vulnerability of the Kenyan agricultural sector through innovative agricultural practices. Increased productivity, enhanced adaption and resilience of smallholder farming systems, reduced emission intensity are essential for sustainable development and poverty eradication. The changing climatic patterns have already impacted Kenya social economic sectors adversely and current projections indicate the situation is likely to worsen if adequate measures are not taken to promote climate compatible development. (GoK, 2016). Given this back drop, there is a need to mainstream climate change into government development strategies including the vision 2030 and linking these efforts to Sustainable Development Goals (SDGs) (Stockholm Environment Institute, 2009).

**Problem Statement**

A vibrant agricultural sector central role in Kenya's economic growth has been recognised in various government policy papers such as the Poverty Reduction Strategy paper (PRSP) of 2001, Economic Recovery Strategy for Wealth Creation (ERSWEC) of 2003, The Strategy for Revitalizing Agriculture (SRA) of 2004 and the Vision 2030 of 2008. However, climate change is already taking a heavy toll on the Kenyan economy. It is estimated that extreme climate conditions could cost the economy as much as US$ 500 million annually accounting for 2.6 percent of the country's GDP.

The changes in the variability or average state of the atmosphere over time scales ranging over decades, requires government intervention and support to climate change adaptions in the agriculture sector to curb a deficiency in capacity building and any future uncertainty related to climate change. For example climate change adaptation by smallholder agribusinesses in Kenya

can help mitigate climate change by reducing both the production of greenhouse gases and the consumption of fossil fuel-based energy. Examples of greenhouse gas emissions reduction strategies include; implementing energy conservation measures such as energy efficient lighting and space heating, incorporating greater recycled content in products and selecting production processes that either emit or use less greenhouse gases (GoK, 2017).

A review of current literature reveals that sufficient attention has not be given to the climate adaptation mechanisms that smallholder agribusinesses need to embrace in order to survive (Okonya, Syndikus, & Kroschel, 2013). More empirical based studies are required in order to provide extant data that government and policy makers can use to inform policy formulation related to climate adaptations in agricultural production systems. This research therefore focused on the influence of smallholder agribusinesses on climate change adaption. The main issues addressed in this study include the impacts of climate change and concerns and the adaptation strategies among the small holder farmers. Specifically three climate adaptation strategies were considered; Business innovation opportunities, climate change risk management measures and supply chain optimization programs by smallholder farmers and agribusinesses in Mau Ranges in Nakuru County.

**Purpose of the Research**

The purpose of the study was to assess climate change adaptation strategies by smallholder agribusinesses in Mau Ranges, Nakuru County. It was governed by three research objectives and focused on three research questions.

**Research Objectives:**

i) To evaluate the effects of business innovation opportunities on climate change adaptation of small holder agribusinesses in Mau ranges Nakuru County.

ii) To assess the effects of risk management measures on climate change adaptation of

small holder agribusinesses in Mau ranges Nakuru County.

iii) To explore the effects of the supply chain optimization on climate change adaptation of small holder agribusinesses in Mau ranges Nakuru County.

**Research Questions:**

i) What are the effects of business innovation opportunities on climate change adaptation of small holder agribusinesses in Mau ranges Nakuru county?

ii) What are the effects of risk management measures on climate change adaptation of small holder agribusinesses in Mau ranges Nakuru county?

iii) What are the effects of supply chain optimization on climate change adaptation of small holder agribusinesses in Mau ranges Nakuru county?

## Literature Review

### Climate change adaptation strategies in smallholder systems

Adapting to climate change involves taking the right measures in response to climate change so as to reduce the negative effects by making appropriates changes and adjustments. Adaption to climate change enable people, societies and countries to minimize exposure to risk of damage resulting from climate variability, develop capacity to cope with unavoidable damage and to take advantages of new opportunities occasioned by climate change (Akinnagbe, & Irohibe, 2015).

The choice of specific climate adaptation strategies in smallholder systems is dependent upon a number of factors that include; social economic, environmental, and institutional as well as the economic structure of the country. The choice of a given strategy is dependent on a number of factors that determine the availability, accessibility and affordability of particular adaptation strategies. The choice of a given strategy is greatly influenced by farmers education level, access to climate information, access to credit and extension, social capital and agro-ecological settings (Deressa, Hassan, & Ringler. 2011). Given this backdrop, three climate change adaptation strategies in smallholder agribusinesses will be addressed in the current study. These strategies include; business innovation opportunities, risk management measures and supply chain

optimization. The relationship between climate change adaptation strategies and climate change adaptation outcomes among smallholder agribusinesses is conceptualized as follows:

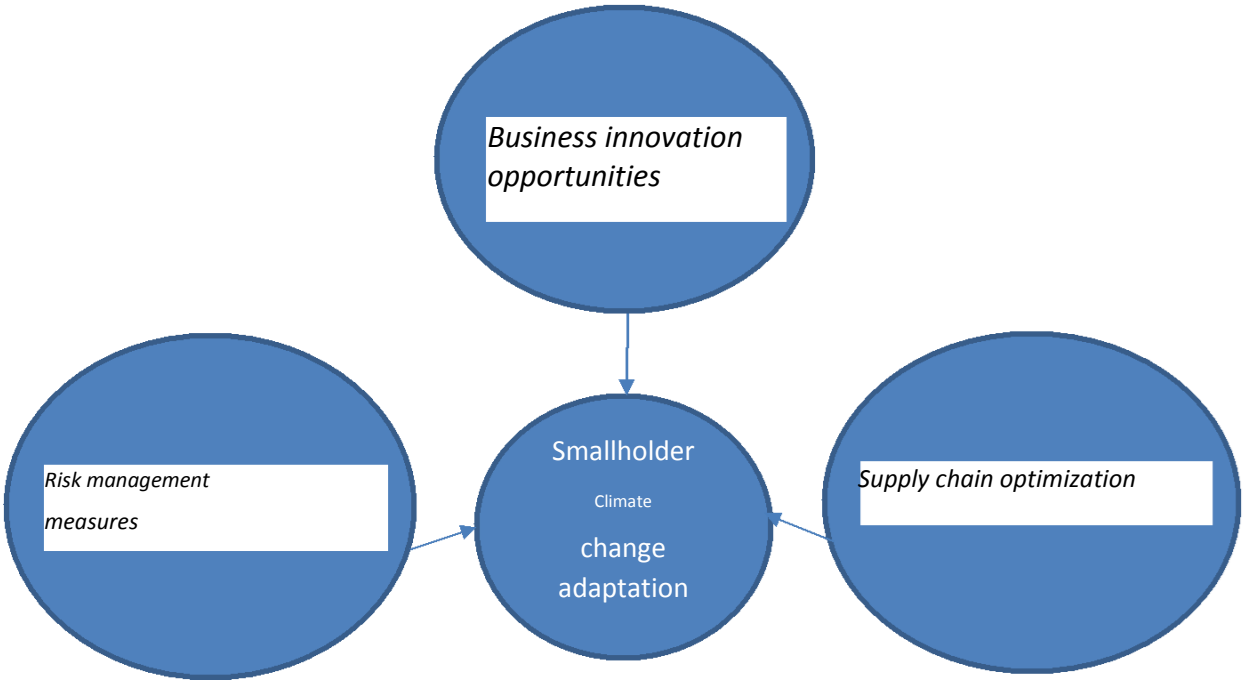


*Figure1.1: Conceptual Framework*

**Business innovation opportunities and climate adaptation of smallholder agribusinesses**

Innovative agricultural practices and technologies can play a key role in climate change mitigation and adaption. This implies that development and diffusion of new technologies and agricultural practices determines the effectiveness of the smallholder agribusinesses in mitigation and adaptation to climate change (Akinnagbe, & Irohibe, 2015). For smallholders to seize innovative business opportunities and invest capital in sustainable agricultural practices, there is need for governments and their partners in developing countries to avail incentives and rewards to encourage farmers adopt new innovative practice (Lybbert, & Sumner, 2010).

There are a range agricultural practices and technologies that include; new crop varieties, water management, production practices, postharvest technologies, information and forecasting and insurance.

However, smallholder farmers face impediments in access and use of new technologies and innovative businesses opportunities that includes; poorly functioning and integrated input and output markets, weak local institutions and infrastructure, inadequate or effective extensions systems and missing credits and insurance markets. These impediments leads to poor agricultural productivity per unit of resource invested (Bennett, & Vanwey, 2015).

Experience has demonstrated the need for policy makers in the agricultural sector to mainstream climate change adaptation in agricultural practices so as to make agricultural production of smallholder farming systems successful (Lybbert, & Sumner, 2010). Availing Business innovative opportunities to smallholder farmers can enable them to practice climate smart agriculture that incorporate climate change adaptation in the agricultural systems. Business opportunities can be availed through adoption of climate smart agriculture which entails improving agriculture through innovation in policies, technologies, management and financing. Climate smart agriculture helps in reducing and /or removing greenhouse gases emissions and also results to more resilient agricultural systems to the adverse effects of climate change (SDSN, 2013, UNTEC, 2014). For example, increased access to mobile phone technologies makes it increasingly easy for the smallholder farmers to access online extension services and marketing of their agricultural produce. Farmers become better adopters of new agricultural technologies accessed through online platforms compared to the traditional extension approaches. Access to carbon markets could also be a powerful policy tool to leverage private capital for green growth, including climate smart agricultural activities.

**Risk management strategies and climate adaptation of smallholder agribusinesses**

Promotion of responsive risk management occasioned by climate change calls for mainstreaming of climatic factors into livelihood improvement of the smallholder farmers so as to prevent major

impacts of climate-related hazards (Okonya, Syndikus, & Kroschel, 2013). Planning and implementing effective climate change adaptation measures requires identification, assessment, monitoring and warning on climate change. Climate risk screening and assessment tools provide critical information for sound decision making in climate change risk management.

However the tools for risk management that includes knowledge, awareness, policy and funds are not widely accessible (Ojwang, Agatsiva & Situma, 2016). In order to succeed in climate change risk management and interventions, governments and other stakeholders need to understand the opportunities for adaptions or lack thereof and the key drivers necessary to promote voluntary adaptation by vulnerable smallholder farmers. Some of the most effective strategies in African countries include soil conservation, improved crop variety, planting trees, changing planting dates and irrigation (Komba, & Muchapondwa, 2015).

However, success rate in risk management related to climate change is still low in most African countries. For example in Nigeria, small holder production systems, lack of awareness and knowledge about climate change and adaptation strategies, lack of water for irrigation and lack of capital and improved seeds are some of the major impediments to climate change adaption strategies (Ishaya, & Abaje, (2008).

A study by Adesoji and Ayinde (2013) sought to identify the mitigation strategies being used by arable crop farmers in Osun State of Nigeria.

The study used a sample size of 120 arable crop~~s~~ farmers and applying multiple regression analysis, the research yielded findings relevant to the current research. The study found that arable crop farmers mainly used indigenous or ethno-methods to mitigate climate change risks which do not involve importation of technologies for sustainable production. The findings also highlighted the importance of considering the age of the arable farmers, the household size, income, sources of information and farm size when planning for an extension program.

Ogalleh, Vogl, Eitzinger, and Hauser (2012) conducted a study on local knowledge perceptions and adaptations to climate change and variability amongst the smallholders of Laikipia district of Kenya. The study used a sample size of 206 farmers and 46 transcripts from focus group discussions were obtained. Using Palmer Drought Severity Index (PDSI) and tabulations and frequency descriptive data analysis methods the study yielded informative results. According to the research, climate variability is increasing. Local perceptions include increasing temperatures, increasing frosts, decreasing rainfall and increasing hunger. The farmers use a variety of coping and climate risk management strategies that include diversification of crop varieties, migration and sale of livestock.

A more recent study by Kombo and Muchapondwa (2015) on adaptation to climate change by smallholder agribusinesses in Tanzania yielded very informative results on climate change adaptation in a developing country in Eastern Africa. The study used a sample size of 534 households with household ~~h~~eads being 30 years and above. The study was carried out in four administrative regions of Tanzania, namely, Morogoro, Dodoma, Iringa and Tanga.

The results provided evidence that Tanzanian smallholder agribusinesses farmers perceive climate change to be occurring in their areas. The farmers were asked to compare the climate with respect to mean and variance precipitation and temperature in two decades between the 1990s and the 2000s. 528 smallholder agribusinesses, or 98.9%, had perceived mean and variance changes in both precipitation and temperature. The perception by the farmers was that mean precipitation had decreased while variance in both precipitation and temperature had increased. This implies that the majority of smallholder agribusiness farmers had perceived climate change to be occurring in their area. The study further sought to investigate the adaptation strategies of the farmers given their perception of climate change. The study yielded interesting results on climate risk management strategies. The strategies employed by the farmers

were as follows; 31 farmers (5.6%) implemented irrigation, 131 farmers (24.1%) implemented short-season crops, 93 farmers (17.3%) implemented crop resistant to drought, 37 farmers(7.4%) implemented planting trees, 60 farmers (11.6%) implemented changing planting dates and finally 182 farmers (34.4%) had not implemented any adaptation. The farmers who had not implemented risk management strategies gave a variety of reasons ranging from lack of funds, shortage of water, poor planning and shortage of seeds.

**Supply Chain Optimization and climate adaptation of smallholder agribusinesses**

The impact of climate change on a range of business, including agribusiness, and supply chains has been significant in this era of globalization and the internationalization of markets (Kreie, 2013). Christopher (1992) defines supply chain as a "network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that each produce value in the form of products and services in the hands of the ultimate consumer". Climate change is already affecting agribusiness supply chains. The negative effects on supply chains include changes in the quality and availability of specific raw materials, degradation in biodiversity and an impact on the human workforce in the supply chain. Businesses can address climate change in the supply chain by engaging suppliers on climate change so as to reduce exposure of their enterprise to supply chain risk. Businesses can seek alternative materials and resources and also look for new ways to ensure supply and minimise disruptions in the supply chain (Norton, Ryan, & Wang, 2015).

Changes in rainfall patterns and rise in the average temperature disrupt business operations and impact crop yields eventually destabilizing agricultural supply chains. Changing weather and climatic conditions can affect the supply of raw material, lead to interruptions in transport and logistics, damage infrastructure and business assets and reduce revenues (Nelson, Morton, Chancellor, Burt, & Pound, (2010). A changing climate also create new market opportunities by

influencing demand for product and services. This implies that there is a need to identify and implement strategies that can enable businesses to take advantage of opportunities and respond to threats occasioned by climate change (Maddison et al, 2007). The supply chain optimization and value addition technologies need to be enhanced to enable smallholder farm systems and agribusinesses to capitalize on climate change adaptation and mitigate biodiversity loss.

This response can be achieved by developing technologies, products and services that help to improve resilience to climate related risks and take advantage of opportunities in agricultural value chains (Nelson et al, 2009).

Dasaklis and Pappis (2013) observe that climate change and supply chains are mutually affected. The supply chain links include; manufacturing, transportation, warehousing and storage, trading, consumption and customer service. Each of these links in the supply chain involved in value addition to a product contributes to environment degradation through release of greenhouse gases. On the same note each link in the supply chain is also subjected to risks and opportunities occasioned by climate change manifested in the form of extreme events that include high winds, sea level rise, flooding, desertification, temperature changes, water shortage and change in local weather patterns. Therefore, agribusiness supply chain provides an opportunity to develop climate resilience through reductions of greenhouse gases emissions and development of adaptive capacity to climate change. Supply chain optimization can be achieved by encouraging farming practices that are more efficient, enabling cost saving per unit of production and enhancing landscapes and biodiversity (Norton, Ryan, & Wang, 2015).

**Summary of empirical review and research gaps**

| Research Study Variable | Author | Year | Research title | Variables used | Methodology | Findings | Gap |
|---|---|---|---|---|---|---|---|
| Business | Akinnagbe, & | 2015 | Agricultural | Crop | Literature review | Major constraints in application | Study |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| innovation opportunities | Irohibe, & Lybbert, Sumner, | 2010 | adaptation strategies to climate change impacts in Africa: A review Agricultural Technologies for climate change mitigation and adaptation in developing countries: Policy options for innovation and technology diffusion | adaptation strategies, livestock adaptation strategies, Other Adaptation strategies Agricultural technologies including new crop varieties, Water management and irrigation, other production inputs | Exploration study | of agricultural adaptation strategies include general lack of knowledge, expertise and data on climate change issues and lack of climate specific institutions Policy gaps in mainstreaming of agricultural technologies and innovation need to be addressed | literature empirical be more i Lack b empirical |
| Risk management strategies | Adfesoji & Ayide Ogalleh et al 2012 | 2013 2012 | Ethno-practices and adaptation strategies for mitigation of climate change by arable farmers in Osun State, Nigeria Local perceptions and responses to climate change and variability: The case of Laikipia District, Kenya | Climate risk mitigation strategies, factors influencing mitigation strategies Local knowledge, Perceptions and adaptations to climate change | Empirical study data analyzed using multiple regression analysis The palmer drought severity index (PDSI) Tabulations and frequency tables | Arable farmers mitigate climate change mostly using indigenous methods, Extension programs should consider age, house hold size, income, sources of information and farm size Climate variability is increasingly changing, local perceptions include decreasing rainfall, increasing temperature, increasing hunger, - Coping strategies include diversification of crop varieties, mitigation and sale of livestock | Study did modern t climate ri Study did regressio establish relationsh variables |

| **Research Study Variable** | **Author** | **Year** | **Research title** | **Variables used** | **Methodology** | **Findings** | **Gap** |
|---|---|---|---|---|---|---|---|
| Risk management strategies | Komboand Muchapondwa | 2015 | Adaptation to climate change by smallholder farmers in Tanzania | Individual farmers' adaptation strategies | Descriptive study | 98.9 % Farmers in Tanzania perceive climate. 64.6 % farmers implement climate change adaptation strategies | The stud the governm climate mitigatio not sug measures |
| Supply Chain | Dasaklis & | 2013 | Supply chain | Climate change | General review of | Supply chain networks run | Addition |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| optimization | Pappis<br><br>Norton, Ryan, & Wang, | 2015 | management in view of climate change: An overview of possible impacts and the road ahead<br><br>Business action for climate-Resilient supply chains | opportunities and threats<br><br>Climate-resilient supply chain strategies | relevant literature<br><br>Literature review of relevant publications and interviews with relevant stakeholders | physical, operational and reputational risks attributed to climate change<br><br>Develops a framework for climate resilient supply chain | research grounded needed andinterc findings empirica<br><br>A need framewo workabil subjectin empirica |

## Research Methodology

The study adopted a cross sectional survey research design and the target population was 94 small holder agribusinesses Mau ranges, Nakuru, Rift Valley. Purposive sampling method was used to collect data from a total of 47 Smallholder agribusinesses. Data was collected using semi-structured questionnaires. Quantitative data was analysed using descriptive and correlation statistics. The findings of the study shall be useful to the stakeholders especially the local farmers and businesses in the agricultural value chain.

## Research Findings and Discussions

The data sample was analysed using IBM SPSS statistics version 20. Data analysis started by coding of the questions in order to facilitate data entry. The questionnaires were checked for completeness in order to ensure that objectivity was maintained in data analysis. Each questionnaire was identified using an assigned serial number. Data entry was done for a total of 47 questionnaires obtained from the respondents. Data analysis followed using both descriptive and correlation statistics.

### Descriptive statistics

### Business innovation opportunities strategy and climate change adaptation

The table below shows the descriptive statistics of the final data sample used in this research (N=47) for business innovation opportunities strategy and climate change in smallholder agribusinesses.

| Variable | Frequency | | Percentage (%) | Percentage (% ) |
|---|---|---|---|---|
| **Business innovation opportunities** | Yes | NO | YES | NO |
| Agribusiness uses table banking in the village | 33 | 14 | 70.2 | 29.8 |
| Agribusiness uses both traditional and modern methods of farming | 37 | 10 | 78.7 | 21.3 |
| Agribusiness uses online marketing and text messages to inform others on the market prices | 9 | 38 | 19.1 | 80.9 |
| Agribusiness uses herbal methods of treating animal diseases and pest control | 16 | 31 | 34 | 66 |
| Agribusiness uses new crops and breeds in the farm | 26 | 21 | 55.3 | 44.7 |
| Agribusiness practices value addition to the farm produce | 32 | 14 | 68.1 | 29.1 |
| Agribusiness farm management has systems in place | *18* | 28 | 38.3 | 59.6 |
| Agribusiness has diversified farming enterprise activities to spread risk and minimize losses | 28 | 19 | 59.6 | 40.4 |
| Agribusiness monitors production of greenhouse gas emission | 13 | 34 | 27.7 | 72.3 |
| Agribusiness uses biodegradable resources | 14 | 33 | 29.8 | 70.2 |
| Agribusiness uses energy saving and conserve the available energy | 15 | 32 | 31.9 | 68.1 |
| Overall rating on use business innovation opportunities in climate change adaptation (very well vs. not very well) | 25 | 21 | 53.2 | 44.7 |

*Table 1.1: Descriptive statistics data sample on business innovation opportunities*

Use of both traditional and modern farming methods had the highest number of farmers indicating that their usage of these strategies was at 78.7 percent. These findings concur with Adesoji and Ayide (2013) observation that arable crop farmers use indigenous or ethno-methods to mitigate climate change risk, which do not involve importation of technologies for sustainable production. On modern farming methods, Kombo and Muchapondwa (2015) avers that some of the most effective strategies in African countries include soil conservation, improved crop variety, planting trees, changing planting dates and irrigation.

These are modern agricultural practices that farmers have adopted in Kenya.

From the data analysis above, at only 9 percent of all the business innovation opportunities, the adoption of online marketing and use of text messages to inform potential customers about product prices had the lowest percentage uptake of the farmers who had taken advantage of this innovative opportunity. This is despite the fact that most of the Kenyan population is able to own a mobile phone. This is also against a backdrop of recent efforts by agricultural experts to encourage the use of mobile technology platforms by farmers to promote their products to potential customers.

These findings concur with Akinnagbe and Irohibe (2015) who assert that the development and diffusion of new technologies and agricultural practices determine the effectiveness of smallholder agribusinesses mitigation and adaptation to climate change. Farmers become better adopters of new agricultural technologies accessed through online platforms compared to the traditional extension approaches (UNTEC, 2014).

The low use of mobile technologies implies that more farmer sensitisation is required to increase their usage in farm produce marketing. Monitoring of the production of greenhouse gases emission and the use of biodegradable resources also had low percentage take up amongst the farmers who have taken advantage of the business innovation opportunities at 27.7 percent and 29.8 percent in relation to these two factors respectively. These two strategies require high capital investments. This implies that for smallholders to seize innovative business opportunities and invest capital in sustainable agricultural practices, there is need for governments and their partners in developing countries to avail incentives and rewards to encourage farmers adopt new innovative practice (Lybbert, & Sumner, 2010). For example, access to carbon markets could be used as a powerful policy tool to leverage private capital for green growth, including climate smart agricultural activities. Encouraging farming practices that are more efficient, enabling cost

saving per unit of production and enhancing landscapes and biodiversity, can also be used (Norton, Ryan, & Wang, 2015). In the overall analysis, 53.2 percent of businesses indicated that they had responded very well to climate change using business innovation opportunities while 44.7 percent had not used business innovation opportunities very well.

**Risk management measures strategy and climate change adaptation**

The table below shows the descriptive statistics of the final data sample used in this research (N=47) for risk management measures strategy and climate change in smallholder agribusinesses.

| Variable | Frequency | Percentage (%) | Percentage (% ) |
|---|---|---|---|
| **Risk management measures** | | | |
| Agribusiness conduct capacity building on risk management | | | |
| Agribusiness has financial support from the agricultural finance corporation | | | |
| Cost of technologies is controlled | | | |
| The stake holders can afford the variability of prices Stake holders support the business projects mitigating risk | | | |
| Post-harvest losses are managed and mitigated The production meet the economies of scale | | | |
| The value chain is well monitored to the latter from production to market | | | |
| Yes NO YES NO | | | |
| 14 33 29.8 70.2 | | | |
| 14 33 29.8 70.8 | | | |
| 16 31 34 66 | | | |
| 19 28 40.4 59.6 | | | |
| 18 29 38.3 61.7 | | | |
| 22 25 46.8 53.2 | | | |
| 23 24 48.9 51.9 | | | |
| 19 28 40.4 59.6 | | | |
| How does your business risk management strategies respond to the climate adaptation? (very well vs. not very well) | 15 32 | 31.9 | 68.1 |

*Table 1.2: Descriptive statistics data sample on risk management measures*

From the data analysis above, only 15 or 31.9 percent of smallholder businesses indicated that their risk management strategies had responded well to climate change adaptation, 32 or 68.1 percent of the smallholder agribusinesses risk management measures had not responded well. Analysis of specific risk management measures is in line with the overall statistics because none of the measures yielded a percentage higher than 50 percent. Actually, smallholder agribusiness production meeting economies of scale had the highest number of agribusiness using this factor in risk management at 48.9 percent. Postharvest losses management and mitigation had the second highest score among agribusinesses at 46.8 percent.

Capacity building on risk management and agricultural funding support on risk management from financial institutions had the lowest scores both at 29.8 percent or only 14 percent of agribusinesses, indicating a positive response on the two variables. The low scores on risk management measures by the Smallholders in Mau ranges farmers, is similar to another study by

Kombo and Muchapondwa (2015), where even though 98.9 percent had perceived climate

change in their locality, 34.4 percent had not implemented any risk management measure in climate adaptation.

Planning and implementation of effective climate change adaptation measures requires

identification, assessment, monitoring and warning on climate change. Ojwang, Agatsiva and

Situma (2016) observe that tools for risk management that include knowledge, awareness, policy

and funds are not widely accessible. This could be the reason why the smallholders in Mau Ranges rank poorly in terms of risk management measures in climate adaptation. Kombo and Muchapondwa (2015) aver that in order to succeed in climate change risk management and interventions, governments and other stakeholders need to understand the opportunities

for

adaptation or lack thereof and the key drivers necessary to promote voluntary adaptation by

vulnerable small holder farmers.

**Supply chain optimization strategy and climate change adaptation**

The table below shows the descriptive statistics of the final data sample used in this research

(N=47) for supply chain optimization strategy and climate change in smallholder agribusinesses.

| Variable | Frequency | | Percentage (%) | Percentage (% ) |
|---|---|---|---|---|
| **Risk management measures** | Yes | NO | YES | NO |
| The products packaging is a major factor in transportation and marketing of the products | 27 | 20 | 57.4 | 42.6 |
| The distribution policies are well structured to meet the needs of both business and distributor | 29 | 18 | 61.7 | 38.3 |
| Storage of our produce is very import in response to climate change and preservation | 38 | 9 | 88.9 | 19.1 |
| The processing of the final produce is important in the value chain | 36 | 11 | 76.6 | 23.4 |
| Early supplier involvement is important in the supply chain | 31 | 16 | 66.0 | 34.0 |
| The business has laid down measures to avoid possible dislocation due to extreme weather events | 25 | 22 | 53.2 | 46.8 |
| Early supplier development and building of relationship | 34 | 13 | 72.3 | 27.7 |



| | | | | |
|---|---|---|---|---|
| is important in the supply chain | | | | |
| The enterprise has adopted technologies and mobile applications that help the business in accessing information about suppliers and potential customers | 27 | 20 | 57.4 | 42.6 |
| Business consider proximity to suppliers and near sourcing as key drivers of supply chain optimization | 32 | 15 | 68.1 | 31.9 |
| How does your supply chain optimization strategies respond to the climate adaptation? (very well vs. not very well) | 28 | 19 | 59.6 | 40.4 |

*Table 1.3: Descriptive statistics data sample on supply chain optimization strategy*

Data analysis on supply chain optimization strategy in climate change adaptation had majority of

the farmers indicating positive response on the factors employed by smallholders in supply chain

optimization with all the factors ranking positively at over 50 percent. Storage of farm produce as a factor in supply chain optimization ranked the highest among smallholder agribusinesses at 88.9 percent or 38 respondents.

The second factor to score highly among the farmers was value addition of the farm produce with 36 farmers or 76.6 percent agreeing that this factor was important in the agricultural value chain.

The overall rating of their supply chain optimization strategies response to climate change have 28 respondents or 59.6 percent indicating that they had done well in this climate adaptation strategy and 19 respondents or 40.4 percent indicating that they had not done very well. The high positive response is in line with Nelson et al (2009) observation, on the need to enhance value addition technologies to enable farm systems and agribusinesses to capitalize on climate change adaptation and mitigation on biodiversity loss.

The researchers further notes that this strategy can succeed through the development of technologies, products and services, that help to improve resilience to climate related risks and take advantage of opportunities in agricultural value chains. Norton, Ryan and Wang (2015) also concur with this view by asserting that supply chain optimisation can be achieved by encouraging farming practices that are more efficient, enabling cost saving per unit of production and enhancing landscapes and biodiversity.

The table below shows the correlation statistics of the final data sample used in this research (N=47) between business innovation opportunities, risk management, supply chain optimisation

and climate change adaptation.

| | **Variable** | **Climate change outcomes** | |
|---|---|---|---|
| **1.** | Business innovation opportunities | Pearson correlation (N=47) | Significance(2tailed) at 0.05 level (N=47) |
| | | 0.301 | 0.040 |
| **2.** | Risk management measures | 0.246 | 0.96 |
| **3.** | Supply chain optimisation | 0.256 | 0.83 |

*Table 2: Correlation between climate change adaptation strategies and climate adaption outcomes*

**Conclusions and Recommendations**

The overriding purpose of this study was to assess the climate change adaptation strategies namely; business innovation opportunities, risk management measures and supply chain optimization by small holder agribusinesses in Mau Ranges, Nakuru County. The study collected data from 47 purposively selected smallholder establishments.

The participants were asked to indicate using yes and no response, the type of climate adaptation practices they perceive to have adopted. There was overarching evidence that farmers have begun to respond to climate change through the three variable factors in this study. Among the three climate adaptation strategies, supply chain optimisation strategies had the highest number of farming agreeing that they had incorporated supply chain optimisation practices into their farming system. 59.6 percent of the farmers indicated that supply chain optimization strategies had done very well in helping them to respond to climate change. Business innovation opportunity also have a high percentage at 52.3 percent of the farmer indicating that this strategy have also done very well in helping the farmers to respond to climate change. However, risk management measures registered the lowest percentage with

only 31.9 percent of the respondents indicating that they had done very well in climate change adaptation. Most of the respondents deemed to not understand the risk management measures hence the low score. Assessment of the climate change adaptation strategies by smallholder farmers thus indicates that sensitization on the importance of implementing appropriate strategies in response to climate change is required among Kenyan farmers.

Kenya is already under pressure from climate change stresses which have increased the vulnerability of small businesses, especially small holder agribusinesses, to further climate change. The adverse effects of climate change also reduce the adaptive capacity of the smallholder agribusinesses leading to devastating effects on agriculture, the mainstay of the Kenyan economy. The outcome of this study shows that there is need to mainstream appropriate climate change adaptation strategies in the smallholder farming systems.

Despite admission by the Kenyan government that climate change is now at the top of the government agenda, responding to climate change will require sustained participation by all the relevant stakeholders, including the government and private players. Through concerted efforts, proactive climate adaptation strategies can improve smallholders' systems capacities to cope with climate change. Some of the interventions that the stakeholders can use include; use of market based mechanisms to promote climate adaptation, improving human capital through education and training, customized extension services and intensive research activities. In

addition to these interventions, the government need to put in place institutional frameworks for proper coordination of climate adaption efforts.

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