INTEGRATION OF CLIMATE CHANGE ADAPTATION STRATEGIES IN SMALLHOLDER POTATO PRODUCTION THROUGH A COLLECTIVE LEARNING COMMUNITY IN MAUCHE WARD, NAKURU COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

I certify that this thesis is my original work and has not been presented elsewhere for an award of a degree, diploma or certificate.

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DEDICATION

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ABSTRACT

Global warming has led to intensity of extreme events that affect agricultural production worldwide, and sub-Sahara Africa in particular, where economies are highly dependent on agriculture and adoption of modern technology is low. Kenyan agriculture is vulnerable to climate-induced risks and uncertainty manifested in low crop yields. Although potato is a food security and cash crop for many smallholder farmers in Mauche Ward of Nakuru County, its production is affected by variability in rainfall patterns, increased pests and diseases and post-harvest loses associated with climate change (CC). This study sought to enhance CC resilience and adaptation capacities of smallholder potato farmers by building their capacity to integrate selected crop, soil and water management intensification strategies in potato production through a Collective Learning Community (CLC) in Mauche Ward. The study adopted both Survey research and Participatory Action Research designs. The study population comprised of all smallholder potato farmers in Mauche Ward. Simple random sampling was used to select 150 smallholder potato farmers to participate in a survey. One active potato Common Interest Croup comprising of 30 farmers was purposively selected to implement the CC adaptation strategies. Data was collected using a structured questionnaire, checklists and topic guides validated by experts in the Department of Agricultural Education and Extension. Cronbach's Alpha coefficient was used to test reliability of the questionnaire. A reliability coefficient of 0.86 was obtained. Statistical Package for Social Sciences was used in quantitative data analysis to test the Null Hypothesis at 5% level of significance. Analytical tools and procedures employed to obtain qualitative data included Potato Value Chain (VC) Analysis, Problem Tree Analysis, Stakeholder Analysis, Net-Map toolbox, Multi-Criteria Analysis and Brainstorming. Multiple Linear Regression was used to analyze quantitative data. The study revealed that CC negatively affects smallholder potato production. Challenges affecting the potato VC were inadequate knowledge on climate change adaptation strategies, limited access to clean seed and lack of collective marketing. There is need to promote participatory research and joint innovation in a CLC to enhance capacity building of farmers, stakeholder networking, CC knowledge generation and dissemination as well as ensuring sustainable utilization of research findings. Positive selection to improve availability of clean potato seed and streamlining of potato marketing are requisite to integration of CC adaptation strategies in potato production.

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ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
APM	Access to Potato Market
ARARI	Amhara Region Agricultural Research Institute
ADC	Agricultural Development Corporation
ATDC	Agricultural Technology Development Centre
CBO	Community Based Organization
CBI	Capacity Building Index
CC	Climate Change
CCAI	Climate Change Adaptation Index
CCI	Comprehensive Community Initiative
CCU	Climate Change Unit
CIG	Common Interest Group
CIP	International Potato Centre
CLC	Collective Learning Community
CPS	Clean Potato Seed
CSA	Climate Smart Agriculture
ECAPAPA	Eastern and Central Africa Programme for Agricultural Policy Analysis
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FGD	Focus Group Discussion
FYM	Farm Yard Manure
GDP	Gross Domestic Product
GIZ	German Agency for International Cooperation
GOK	Government of Kenya
ICRAF	World Agro-forestry Centre
ICT	Information Communication Technology
IPM	Integrated Pest Management
IRG	International Resources Group
KALRO	Kenya Agricultural and Livestock Research Organization
KAS	Knowledge on Climate Change Adaptation Strategies
KENAFF	Kenya National Farmers' Federation

KEPHIS	Kenya Plant Health Inspectorate Services
KNBS	Kenya National Bureau of Statistics
KENDIP	Kenya Domestic Biogas Programme
KDI	Knowledge Dissemination Index
MCA	Multi-Criteria Analysis
MEMR	Ministry of Environment and Mineral Resources
MLND	Maize Lethal Necrosis Disease
MOA	Ministry of Agriculture
MOALF	Ministry of Agriculture. Livestock and Fisheries
MOF&W	Ministry of Forestry and Wildlife
MOLG	Ministry of Local Government
NCCRS	National Climate Change Response Strategy
NEMA	National Environmental Management Authority
NPCK	National Potato Council of Kenya
NGO	Non-Governmental Organization
PAR	Participatory Action Research
PPP	Public Private Partnership
SMACC	Smallholder Farmer Strategies to Cope with Climate Change
SPSS	Statistical Package for Social Sciences
SSA	Sub-Sahara Africa
TCA	Thematic Content Analysis
TOT	Training of Trainers
UN	United Nations
UNCCC	United Nations Convention on Climate Change
UNFCCC	United Nations Convention on Climate Change
USAID	United States Agency for International Development
VC	Value Chain

CHAPTER ONE
INTRODUCTION
1.1 Background of the Study
The global mean air and ocean temperatures have been rising over the last century due to increasing concentrations of heat trapping greenhouse gases (GHC) in the atmosphere, especially carbon dioxide, methane and nitrous oxide (IPPC, 2013). This global warming has led to intensity of extreme events such as increased rains, floods, hail storms, frost, droughts and heat waves, which profoundly impact on the conditions in which agricultural activities are conducted (Bett et al., 2016) and the whole value chain of crop production (Shibabaw et al, 2014). In every region of the world, plants, animals and the ecosystem are adapted to the prevailing climatic conditions (FAO, 2016a). When these conditions change, the result can be an increase or decrease in productivity depending on remedial agricultural practices; with potentially higher negative impacts. Secondary consequences of climate change include increased vulnerability to diseases, susceptibility to nutritional disorders, deprivation of educational opportunities and ultimately, a serious challenge to all biodiversity (Katelyn, 2016). Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience (Chesterman & Neely [Eds] (2015).

The climate of Africa is warmer than it was 100 years ago and model-based predictions of future GHG induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate (Thompson, 2016). Sub-Saharan Africa (SSA) is predicted to be particularly hard hit by global warming because it already experiences high temperatures and low (and highly variable) precipitation. The economies are highly dependent on agriculture, and adoption of modern technology is low (FAO, 2016a). In SSA small-holder farmers are the primary producers of agricultural outputs and account for 80% of all the farms. The smallholder farmers in SSA cultivate small parcels of land which are often degraded and have no access to irrigation. They do not have sufficient labour, little access to financial credits and their production is not commercialized. The effect of climate change challenges facing SSA smallholder farmers is producing enough food for the region (AGRA, 2014).

Although the Kenyan agriculture sector supports the livelihood of over 70 percent of the rural population (Government of Kenya [GOK], 2011a), it is mainly rain fed and hence vulnerable to climate-induced risk and uncertainty. Many of the land management and water-use efficiency initiatives intended to strengthen the climate change adaptive capacity of communities in Kenya have failed partly due to lack of awareness of their availability (Ojwang, Agatsiva & Situma, 2010). In recognition of this, Smallholder Farmer Strategies to Cope with Climate Change (SMACC) project was initiated by Egerton University in collaboration with University of Natural Resources and Life Sciences in Austria, University of Hohenheim in Germany, Bahar Dar University in Ethiopia and two agricultural research institutions: Kenya Agricultural and Livestock Research Organization (KALRO) Njoro in Kenya and Amhara Region Agricultural Research Institute (ARARI) in Ethiopia. The aim of the project was to provide field-to-market strategies for production intensification of selected key crops that are regionally adapted to help sub-Saharan Africa regions cope with climate change. It focused on encouraging actors who depend on rural livelihoods to cope with climate change through production intensification in a cyclical process of collective learning across a systemic innovation value chain.

There is a dual relationship between sustainable development and climate change. On the one hand, climate change influences key natural and human living conditions and thereby also the basis for social and economic development, while on the other hand, society's priorities on sustainable development influence both the GHG emissions that are causing climate change and the vulnerability (United Nations Development Programme, 2017). This study complies with the United Nation's call for implementation of the Sustainable Development Goals (SDGs), especially the call for end of poverty (SDG 1), end of hunger, achievement of food security, improved nutrition and promotion of sustainable agriculture (SDG 2) and taking of urgent action to address climate change and its impacts (SDG 13). To achieve poverty eradication and hunger, by 2030, it is important to strengthen the resilience of communities to protect themselves from climate change disasters and risks.

A changing climate is associated with increased threats to food safety, post-harvest losses and pressure from invasive species, pests and diseases (Beddington et al., 2012). Crop yields could be reduced mainly as a result of erratic rains, floods; droughts and soil infertility (Bie, Mkwambisi & Gomani, 2008). Households that depend mostly on agriculture stand to lose food production due to climate change since falling harvests undermine household and national food security. Adverse climate effects can influence farming outputs at any stage from cultivation through to final harvest (Ayanwuyi, Kuponiyi, Ogunlade & Oyetoro, 2010). Even if there is sufficient rain, its irregularity can affect yields adversely if rains fail to arrive during the crucial growing stage of the crops.

Potato (*Solanum tuberosum L.)* is the world's fourth most important food crop after wheat, rice and maize and the leading non grain food commodity. World potato production is steadily increasing with a total of 385 million metric tons recorded in 2014 (FAO, 2015a). Approximately two thirds of production is consumed as food with the balance being used for animal feed, potato starch in pharmaceuticals, textiles and adhesives. Potato is a staple food and cash crop in the tropical highland regions of sub-Saharan Africa, where it is grown both as a horticultural crop due to its high value, and as a food security crop (Okello et al., 2016). Potato yields in sub-Saharan Africa are very low, averaging 7.8 tons per hectare (FAO, 2015a).

In Kenya, potato ranks second after maize as a most important staple food (Muthoni & Nyamongo, 2009). This study focused on potato which in addition to calories and protein is a vital source of vitamins, potassium and fibre. The International Potato Center (CIP) has partnered with the Government of Kenya to promote the potato as a strategic food security crop due to its high productivity per unit area (Sullivan, 2010). There are approximately 25000 to 30000 hectares grown annually**.** Average yield achieved by the small-scale farmer fluctuates between 8 and 10 tons per hectare (Were et al, 2013) against a potential 50 tons per hectare (FAO, 2015a). The low yields have been attributed to poor agronomic practices, limited access to clean seed and diseases associated with climate change (Beddington et al, 2012).

Potato is an important food as well as cash crop in Mauche Ward of Nakuru County, Kenya, where this study was carried out. Mauche lies in the Mau escarpment where there has been massive environmental degradation mainly caused by human activity such as deforestation and poor agronomic practices on the hilly terrain. Use of firewood by a majority of the households, charcoal burning and timber harvesting have contributed to depletion of the forest cover.

Understanding climate change effects and challenges is important in the efforts to build resilience and enhance adaptation among smallholder farmers. Integrating crop intensification, soil fertility and water management in potato production, as adaptation strategies to climate change and variability are concrete and sustainable options. These include crop rotation which increases the rate of accumulation of soil organic content as different crop species have different rooting forms and depths, thereby enhancing distribution of organic matter in the soil profile (FAO, 2016b). Tied ridging as a water management strategy is known to improve crop performance (Kabanza & Rwehumbiza, 2007). Organic farming entails recycling wastes of plant and animal origin in order to return nutrients to the land, which minimizes the use of non-renewable resources (Wani, Chand, Najar &Teli, 2013). Therefore, it is a low-risk farming strategy with reduced input costs.

Integrating climate change adaptation strategies in potato production is better achieved through participatory innovation in which smallholder farmers become central in the design of research processes as partners in planning and implementation. As noted by Nederlof, Wongtschowski and Van Lee (2011), participatory innovation in agriculture provides an important contribution towards improving agricultural development and food security in Africa. Farmers and other actors become experts instead of simply users or receivers of information from specialists (Krasny & Lee, 2002).

The Collective Learning Community (CLC) concept entails bringing people together in an innovation platform for shared learning, discovery and generation of knowledge. It enhances formation of networks to promote continuous interaction and communication. Initial problem diagnosis engagement with potato value chain actors in Mauche Ward of Nakuru County indicated that very little had been done to involve farmers and other actors together in an innovation platform for CC adaptation. Through Participatory Action Research (PAR), potato value chain stakeholders in a CLC engaged in collective inquiry and experimentation to test, select and integrate CC adaptation strategies relevant for smallholder potato production.

1.2 Statement of the Problem

Farmers in Mauche Ward of Nakuru County depend on rain fed agriculture which is highly vulnerable to rainfall variability within and between seasons, and the negative effects of climate change. Failures in past adaptation practices have led to increased incidence of pests and diseases, post-harvest loses, low incomes and food insecurity. Available technologies to cope with climate change may be economically challenging to smallholder potato farmers who grow potato on one hectare of land or less. Local and traditional knowledge may be readily integrated into newly adapted management strategies but is often inaccessible to researchers if farmers do not participate in research activities. Little had been done in Mauche Ward to involve a wide range of stakeholders in addressing climate change issues in potato production. Collective Learning Community platforms have been found to help in bringing together farmers and other actors including researchers to exchange knowledge and collaboratively innovate for climate change adaptation. However, there has never been such a platform in Mauche Ward with regard to potato. In the absence of a CLC, linkages needed to support growth and development in the potato value chain would remain generally weak and climate change adaptation strategies developed and tested in research stations might never be adopted by farmers. This is the gap that this study sought to fill.

1.3 Purpose of the Study

The purpose of the study was to promote integration of climate change adaptation strategies in potato production through a Collective Learning Community in Mauche Ward of Nakuru County, in order to enhance climate change resilience of smallholder potato farmers by capacity building them to integrate selected crop, soil and water management intensification strategies in potato production.

1.4 Objectives of the Study

The following objectives guided the study.

i. To identify and explain the socio-economic characteristics of smallholder potato farmers in Mauche Ward of Nakuru County.

ii. To determine the climate change challenges, coping strategies and knowledge gaps in smallholder potato production in Mauche Ward of Nakuru County.

iii. To analyze household practices of smallholder potato farmers in Mauche Ward of Nakuru County

iv. To establish a Collective Learning Community for climate change adaptation in Mauche Ward of Nakuru County.

v. To integrate climate change adaptation strategies in smallholder potato production through farmer participation in Mauche Ward of Nakuru County.

vi. To identify the challenges and opportunities of maintaining a Collective Learning Community for climate change adaptation in smallholder potato production.

vii. To evaluate the influence of the Collective Learning Community on integration of climate change adaptation practices in smallholder potato production.

1.5 Research Questions and Hypothesis

In line with the objectives, the following research questions and hypothesis were addressed in the study.

1.5.1 Research Questions

i. What are the socio-economic characteristics of smallholder potato farmers in Mauche Ward of Nakuru County?

ii. What are the climate change challenges, adaptation strategies and knowledge gaps in smallholder potato production in Mauche Ward of Nakuru County?

iii. What are the household practices of smallholder potato farmers in Mauche Ward of Nakuru County?

iv. How does establishment of a Collective Learning Community promote integration of climate change adaptation in Mauche Ward of Nakuru County?

v. How can climate change adaptation strategies be integrated in smallholder potato production through farmer participation in Mauche Ward of Nakuru County?

vi. What are the opportunities and challenges of establishing and maintaining a Collective Learning Community for climate change adaptation in Mauche Ward of Nakuru County?

1.5.2 Hypothesis

The following hypothesis was tested in the study:

H0: The Collective Learning Community has no statistically significant influence on integration of climate change adaptation strategies in smallholder potato production.

1.6 Significance of the Study

Through the study, climate change adaptation strategies were integrated in potato production in Mauche Ward of Nakuru County. Existing knowledge was linked with new knowledge identified through Participatory Action Research to come up with household climate change relevant innovations, as well as marketing strategies to maintain crop quantities and qualities for smallholder livelihoods. The results may be used by policy makers, extension programme planners, farmer organizations and potato producers to foster sustainable farming practices, enhance socio-economic development and reduce negative climate change impacts - hence improved food security and household level poverty reduction in Nakuru County and other areas with similar climatic conditions.

Gathering and dissemination of knowledge and practices to initiate, apply innovations and build capacity was enhanced through establishing a CLC involving all relevant potato value chain actors. Researchers may apply the CLC approach to strengthen the ownership of project findings and ensure a continued use of project results. The study came up with concrete technical, administrative, educational, research and policy recommendations that may be utilized by the National Government, County Governments and agricultural stakeholders as a general model for smallholder farmer strategies to cope with climate change.

1.7 Scope of the Study

The study was confined to Mauche Ward of Nakuru County. It mainly focused on integration of climate change adaptation strategies in smallholder potato production through a CLC. These included crop production intensification strategies such as rotation of potato and a legume such as dolychos bean (*Lablab purpureus*), intercropping potato with garden pea; water harvesting by use of tied ridges and normal ridges; soil fertility management by use of farm yard manure and green manure in the form of *Leucaena triandra* biomass. The study concentrated on 30 smallholder potato farmers purposively selected for the intervention.

1.8 Assumptions of the Study

The following were the assumptions of the study:

i. There were solutions available along the potato value chain, which were not specifically developed to cope with climate change, but might help reduce negative climate change impacts if integrated with local traditional knowledge and applied.
ii. Potato value chain stakeholders in Mauche Ward were willing to participate in building a stable CLC to facilitate integration of climate change adaptation strategies.
iii. Any positive relationship between the specified Collective Learning Community characteristics and integration of climate change adaptation strategies would be a direct indication of its influence on integration of climate change adaptation strategies.

1.9 Limitation of the Study

The research used Survey and Participatory Action Research (PAR) designs which entailed sampling people's opinions that vary from time to time and place to place. This was addressed by having a large randomly selected sample for the survey and application of various qualitative data collection techniques in PAR.

1.10 Definitions of Terms

The following operational definitions were adopted in this study:

Adaptation: Adjustment in natural or human systems in response to climatic effects, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate (Feng et al., 2017). In this study adaptation means the ability of smallholder potato farmers to cope with changing climatic conditions by practicing crop production, soil and water management intensification strategies.

Adaptation Strategies: Practices by farmers in response to a new set of evolving climatic conditions that they have not previously experienced (Cooper, Stern, Noguer & Gathenya, 2013)**.** In this study adaptation strategies refer to selected crop intensification, water and soil fertility management strategies applied by smallholder potato farmers to enable them cope with climate change.

Adaptive Capacity: The ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Lasco, Habito, Delfino, Pulhin & Concepcion, 2011). In this study it refers to the ability of the farmers to cope with the impacts and risks of climate change through learning and applying new knowledge.

Capacity Building: Process of developing and strengthening the technical skills, entrepreneurship and access to resources that communities need to survive, adapt and thrive (GOK, 2011a). This study operationalized capacity building of farmers as training of farmers on climate change adaptation strategies, clean potato seed production, post-harvest management and marketing.

Climate Change: Any variation in the average daily weather pattern over an extended period of time whether due to natural variability or as a result of human activity (Easterling *et al* 2007). In this study, climate change is operationalized as observable changes in weather patterns such as rainfall seasonality manifested in unpredictable onset and intensity, due to natural processes and human influences such as change in land use and deforestation.

Climate Change Vulnerability: A function of exposure to climate conditions, sensitivity to those conditions, and the capacity to adapt to the changes (United States Agency for International Development, 2007). This study considered it as the extent to which the study population is affected by the negative impacts of climate change.

Collective Learning Community (CLC): A network, which involves all relevant actors and organizations in a project area (Freyer et al., 2012). In this study it refers to an innovation platform comprising of selected potato input suppliers, farmers, transporters, traders, processors, researchers, extension service providers, administrators and organizations that deal with potato in Mauche Ward of Nakuru County.

Innovation: Anything new that is put into use and creates value, whether social or economic. It often involves learning through action, or more purposeful action-oriented research (Maatman et al., 2011). In this study innovations refer to the adaptation strategies generated through action research and put into use by smallholder potato farmers to enable them cope with climate change.

Integration: A cyclical, participatory process of scoping, envisioning, experimenting and learning (Wolf et al., 2011). This study considered it as participatory experimentation and application of climate change adaptation strategies in potato production through a CLC.

Knowledge Dissemination: Managing the way knowledge is shared within an organization to encourage innovation or action on the part of the knowledge receiver (Georgopaulos, 2008). Knowledge dissemination in this study meant transfer of knowledge within and outside the CLC with the expectation that it would be utilized by the farmers.

Network Quality: The strengths of social networks which, if properly employed by organizations may encourage, promote and facilitate knowledge sharing and learning (Din et al., 2011). This study operationalized network quality as frequency of attendance in group meetings and the level of interaction between CLC group members to enhance learning and sharing of information.

Smallholder farmers: Farmers who work on land below 2 hectares (FAO, 2015b). In the context of this study, smallholders refer to farmers who grow potato on less than one hectare of land.

Stakeholder: A person or group that has an investment, share, or interest in something as a business or industry (Random House Dictionary, 2013). In this study, a stakeholder refers to an agency, organization; group or individual involved in or has an interest in the Potato value chain.

Stakeholder Participation: Involvement by stakeholders in generation and dissemination of knowledge for initiating learning processes as well as for the development, sharing and application of innovations (Freyer et al., 2012). This study operationalized it as active involvement by stakeholders in the design, management and monitoring of the potato climate change adaptation strategies.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter is a review of literature relevant to the study. It gives a highlight on climate change and agriculture, potato production trends, an overview of the potato value chain in Kenya, rural livelihood challenges under climate change pressure and climate change adaptation strategies that may be applied for potato production. Analysis of household climate change adaptation strategies are explored, as well as the Collective Learning Community concept. A summary of Policy efforts to enhancing climate change adaptation capacities in Kenya is provided, and the chapter ends with the theoretical and conceptual frameworks.

2.2 Climate Change and Agriculture

Climate change is a serious challenge to all biodiversity and is a major challenge for agriculture, food security and rural livelihoods (Katelyn, 2016). Agriculture's contribution to global greenhouse gas (GHG) emissions stands at 14% of total emissions The agriculture sector is the most vulnerable to climate change due to its high dependence on climate and weather, making it an important focus for climate change action (Michura &Njuguna, 2017). Faster rate of evaporation and transpiration due to higher surface temperature lessen availability and quality of water for agricultural use (Lasco et al., 2011). On the other hand, where water is more abundant, agricultural production declines due to increased erosion and silting rather than water availability (Thornton, Van de Steeg, Notenbaert & Herrero, 2008). Increasing surface temperature can cause heat stress in livestock which may result in behavioral and metabolic changes, including reduced feed intake leading to a decline in productivity (Thornton et al., 2008).

Agriculture is not only a fundamental human activity at risk from climate change, but also a major driver of environmental and climate change itself (Zomer, Trabucco, Bossio & Verchot, 2008). In addition to land resources, agriculture is a major user of water. Although approximately 95 percent of the total cropland is managed under rain fed conditions (Cullen et al., 2008), over 200 million ha of arable land is under irrigation, utilizing 2500 billion m3 of water annually. This represents 75 percent of fresh water resources withdrawn from aquifers, lakes and rivers (Tubiello, 2012). Irrigation sustains a large portion of total food supply – about 40 percent in the case of cereals. Significant quantities of chemical inputs are applied to achieve high yields in intensive production systems including about 100 million tons of nitrogen used annually, leading to significant pollution (Zomer et al., 2008).

Climate change affects all four dimensions of food security, namely food availability, stability of food supplies, access to food and food utilization (Tripathi & Mishra, 2016). The poorest and most vulnerable people globally are likely to be most affected, unless significant efforts are made to create models of development that can mitigate and adapt to the impacts of climate change (Ansuategi et al., 2015). It is hoped that smallholder potato farmers will apply climate change adaptation strategies since vulnerability to food insecurity declines with appropriate adaptation (Karfakis, Knowles, Smulders & Capaldo, 2011). Climate change adaptive capacity and resilience may be enhanced if households practice innovations such as land and water management, use of hardy and improved seeds, shorter-cycle and drought-tolerant varieties diversifying the varieties of crops planted and planting more than one crop at the same time (Kristjanson et al., 2012).

2.3 Potato Production Trends Globally and Nationally

Potato is the world's fourth largest food crop after wheat, rice and maize. The potato's high energy content and ease of production have also made it an important component of peri-urban agriculture which provides jobs and food security to some 800 million people globally (Hoffler and Ochieng, 2008). The fluctuations in yields from year to year, compounded by a reduction in area, has driven volatility in prices between seasons.

Potato is a staple food and cash crop in the tropical highland regions of sub-Saharan Africa, where it is grown both as a horticultural crop due to its high value, and as a food security crop (Okello et al., 2016). Potatoes mature in 3-4 months and can yield about 50 tons/ha (FAO, 2015a) and hence ideally suited to places where land is limited and labour is abundant. Potato yields in sub-Saharan Africa are very low, averaging 7.8 tons per hectare (FAO, 2015a). These low yields are largely attributed to inadequate supply and low farmer access to quality seed, pests and diseases, particularly late blight, bacterial wilt, and viruses (Laibuni &Omiti, 2014). Inadequate supply of clean seed and subsequent use of poor quality, disease and pest infested seed, results in low yields - a scenario that hampers commercialization and confines smallholder farmers in subsistence agriculture and food insecurity (Gebru et al., 2017). The need to arrest the decline in potato yields has been a major goal of policy makers in the tropical highland regions of Africa, including Kenya, Tanzania, Rwanda, and Uganda (Ogutu, Okello &Jakinda, 2014). For instance, the government of Tanzania, jointly with Ministry of Agriculture, recently invested in a three-year project intended to develop the potato seed sector and reverse yield declines in the southern highland region.

Potato is an important food crop in Kenya, with production volumes only second to maize and plays a major role in national food and nutrition security (Laibun and Omiti, 2014). Potatoes are grown and eaten locally, with little significant international trade compared to cereals. An estimated 800,000 farmers grow potato in Kenya, while over 2.5 million people in Kenya are employed along the potato value chain (Laibuni & Omiti, 2014). Consequently, potato additionally contributes to poverty alleviation through income generation in both urban and rural households (Muthoni, Shimelis & Melis, 2013). Potato production in Kenya is dominated by smallholder farmers, with a land size below 2 hectares (FAO 2015b). Kenyan potatoes are almost entirely produced for the domestic market, with three quarters of the urban households consuming potatoes regularly.

In Kenya, potato is mainly cultivated in the high altitude areas (1500-3000 metres above sea level). The crop is grown by some 800,000 farmers on about 25000 to 30000 hectares. Its production is mainly concentrated in 13 counties in Kenya; Nyandarua , Meru, Bomet, Nakuru, Elgeyo-Marakwet, Nyeri, Kiambu,Taita Taveta, Narok, Uasin Gishu, Trans Nzoia, West Pokot and Bungoma and is largely grown by smallholder farmers (Kaguongo et al., 2008). Potatoes are often eaten with beans in most poor rural households during the ‘hunger period’ just before the maize crop matures in the long rains (Muthoni & Nyamongo, 2009).

The national average potato yield in Kenya has been reported to fluctuate between 8 and 10 tons per hectare (Were et al., 2013). These yields are very low, compared with the potential of 50 tons per hectare (FAO, 2015a**)** largely due to poor husbandry practices such as low application of fertilizers and other production chemicals, inadequate quality seed and challenges associated with climate change (CIP, 2011). Potato growers mostly use seed from their own harvest with higher disease levels, or purchase seed from a neighbor or the local market. Potato production is characterized by rapid and significant fluctuations in supply and demand. A majority of potato farmers depend on rain and produce potatoes twice a year due to bimodal rainfall patterns in most potato growing areas (Were et al., 2013). Long rains occour in March to July while the short rains are received in October to December. Off-season potato production is limited to a few areas where there is irrigation.

The National Potato Council of Kenya (NPCK) was partnering with the State Department of Agriculture, International Potato Center, Mount Kenya University, Kenya Agricultural and Livestock Research Organization (KALRO), National Youth Service, University of Nairobi and County governments to improve potato production by enhancing adoption of low cost potato seed technologies such as rapid seed multiplication; seed plot, aeroponics and hydroponics (Kaguongo et al., 2014). There were also on-going trials for new heat tolerant potato varieties and implementation of regulation on the 50 kilogram packaging bag that was launched in 2013. Table 1 presents the potato production trends in Kenya.

Table 1

Potato Production Trends in Kenya

Year	**2010**	**2011**	**2012**	**2013**	**2014**
Area (ha)	121,542	135,924	99,475	104,560	115,604
Production (tons)	2,725,936	1,846,576	1,436,718	1,667,690	1,626,027
Yield (tons/ha)	22.4	13.6	12.3	12.4	11.7
Wholesale (Kshs/110kg bag)	1,383	2,542	3,765	2,989	3.100
Total value (billion Kshs)	34.3	42.6	18.9	23.6	22.8

Source: Ministry of Agriculture, Livestock and Fisheries, 2015

2.4 An Overview of the Potato Value Chain in Kenya

The Kenyan potato value chain is characterized by seasonality in production and lack of on-farm ware potato storage. High transaction costs, price inefficiencies and quality losses lead to minimal returns to farmers (Kaguongo et al., 2014). The market is controlled by cartels, which shield producers from receiving any market information. Due to the highly perishable nature of the potato, prices fall during the glut season, hence low net returns to farmers. Transportation of potatoes to the market is expensive due to poor road infrastructure in the producing areas (Hoeffler, 2005**)**. Packaging of the potato in extended bags of 160 kilograms (kg) has led to exploitation of farmers by traders (Gathumbi, 2009). Potato chips and crisps production is a determining factor of growth in demand for potatoes (Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), 2006). Apart from households, other major potato consumers are canteens, hotels and restaurants. Potato chips are a common menu item in hotels and fast food restaurants. Understanding consumer preference helps to assess the real demand in terms of quantity and quality.

The Government of Kenya instituted Legal notice number 44 of 2005 on the packaging weight of ware potato at 110 kg in an effort to protect the farmer from exploitation by potato cartels (Gathumbi, 2009). To further empower farmers by strengthening the seed potato value chain, research should concentrate on more efficient and risk reducing methods of seed production as well as best agronomic measures like improvements in plant nutrition and disease control (CIP, 2011). There is also a need to enhance knowledge of good agricultural practices and promote climate change adaptation in potato production in order to achieve higher yield, good quality of ware potatoes and sustained production.

Market inefficiencies characterized by a fragmented value chain with too many uncoordinated actors lead to poor farmer-market linkages (Kaguongo, 2014). Furthermore, lack of contractual agreement on supplies and integrated quality assurance as well as inadequate information on handling skills result in low quality unreliable supplies. Establishing a Collective Learning Community would enhance communication and knowledge sharing among actors in order to address gaps in the potato value chain and facilitate climate change adaptation for improved production among smallholder potato farmers. Figure 1 illustrates the Kenyan potato value chain, highlighting the micro-level actors, meso-level supporters and macro-level enablers.

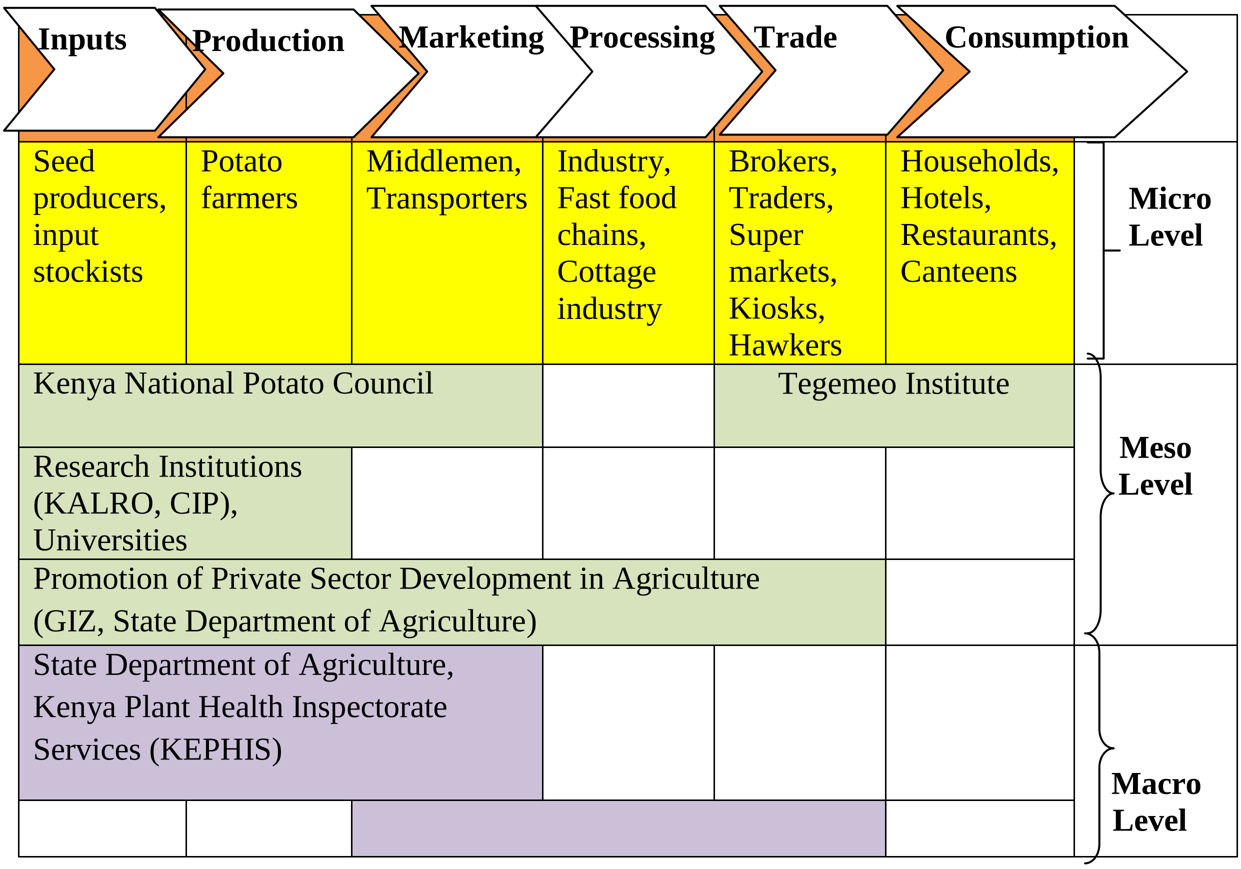


Figure 1: The Kenyan potato value chain: (Adapted from Hoeffler, 2005)

2.5 Rural Livelihood Challenges under Climate Change Pressure in Sub-Saharan Africa

Climate change related risks for agriculture are particularly acute in developing countries, where farmers are vulnerable and lack resources fundamental to resilience (Ali et al., 2017).The impact of extreme climatic events and more intense variability on water resources poses multiple threats to food security and challenge the ability of vulnerable populations to withstand, recover from and adjust to change (Finlay & Adera, 2012).

The loss of crops and productive assets that results from unexpected periods of water surplus or deficit constrains the ability of vulnerable populations to access sufficient and adequate food security and incomes (Ringler, 2011). More intense and frequent precipitation periods also contribute to food insecurity through fluctuations in crop yields and local food supplies, as well as a decline in nutritional intake (FAO, 2015a).

Studies on impacts of climate change on rural livelihoods in Madagascar suggest that rain fed agriculture is most at risk (IRG, 2008). Decline in agricultural production has led to increased vulnerability in food and water security, with direct impacts on human health. Nutrition, water-borne illness and cardiovascular disease are observed more frequently with increased infant mortality reported during drought.

Low yields and high food prices plunge households into poverty straining relations within and among households (Roncol, Okoba, Gathaara, Ngugi & Nganga, 2010). Large-scale migrations may occur when rural poor populations who highly depend on the environment abandon regions that no longer can support livelihoods, food and fuel (Warnecke, Tänzler & Vollmer, 2010). This scenario is witnessed particularly in cases where climate change adaptation projects may not be able to cope adequately with current climate variability, creating the risk that services provided will be inadequate.

Vulnerability assessments and resilience analyses reveal the need for a large range of strategies to enhance regional resilience (Marshall, Tamelander, Obura, Malleret-King & Cinner, 2009). The analysis of smallholder potato farmers' livelihood challenges under climate change pressure highlights "hotspots" of vulnerability in order to facilitate development of strategies by the relevant value chain actors to address them (Morton, 2007). These strategies should not only focus on "technical fixes" (Maina, Newsham & Akoti, 2013), but solutions arrived at under a value chain innovation system facilitated by a Collective Learning Community.

2.6 Climate Change Adaptation in Potato Production

Adaptation to climate change has generally been defined as an adjustment in response to climatic effects to reduce the impact of climate change on the farming operation, livelihoods, and people's lives (Feng et al., 2017). Finlay and Adera (2012) noted that adaptation is nothing new: individuals and communities adapt all the time – hence adaptation should be considered a constant articulation of change rather than an event. Adaptation strategies should be wide ranging in their approach, and to address development priorities holistically rather than with a single, frequently reactive approach that only considers climate-related impacts on communities. Finlay and Adera (2012) further point to the need to link resources and practice to local knowledge, when implementing climate change mitigation and adaptation strategies.

To approach the issue of climate change appropriately, one must take into account local communities' understanding of climate change (Apata et al., 2009; Feng et al., 2017). The assumption is that these communities have an inborn, adaptive knowledge and are able to develop strategies to cope with an erratic climate, severe pest attack, changing agricultural policies and other natural factors. It is necessary to obtain information on the positions of rural farmers and what they know about climate change, in order to integrate this knowledge with available technologies and come up with relevant climate change adaptation practices (Mutekwa, 2009). Thus, community responses are critical to understanding and estimating the effects of climate change on production and food supply for ease of adaptation.

Beddington et al (2012) asserts that widespread uptake of sustainable practices in agriculture and food supply chains is requisite in meeting current and future threats to food security and environmental resilience. Long-term adaptations entail application of crop intensification, land management and water-use efficiency related techniques to maximize yield.

2.6.1 Cropping system intensification

While assessing farmer's perception of impacts of climate change on food crop production in Ogbomoso Agricultural zone of Nigeria, Ayanwuyi et al (2010) noted that farm level climate change adaptation strategies entail establishing crop/livestock mixed systems, using a mix of crop species, cultivar types and sowing dates, combining less productive drought - resistant cultivars and high yield but water sensitive crops. Comparatively, the most popular adaptation strategies in Murowa Ward, Zimbabwe included planting short season varieties, crop diversification, and varying planting dates (Mutekwa, 2009).

Crop specific adaptation strategies include adoption of drought tolerant, early maturing crops & varieties (FAO, 2014a). Other adaptation strategies entail growing legumes (such as beans) towards the end of the rain season when cereals fail, mainly due to excessive rainfall. Crop diversification improves household food security since different crops are affected differently by the same climatic conditions.Post-harvest technologies could be considered for improved food security and household income (Bie et al., 2008). Enhancing smallholder participation in high-value and emerging markets requires upgrading farmer's technical capacity, risk management instruments and collective action through producer organizations (Anandajayasekeram & Berhanu, 2009).

Addressing the stringent sanitary and phytosanitary standards in global markets is even a bigger challenge. Small-scale producers also must follow these rules if they are to go ahead. The potential for rural economic development would remain very limited if the production and marketing strategies are based exclusively on traditional agricultural production, frequently oriented in selling surplus rather than producing for the market.

Climate change may also require shifts in emphasis in already known and practiced coping mechanisms to take advantage of any positive effects of climate change, and adapt to apparently negative effects thus minimizing negative impacts (Bie et al., 2008). Ideas for reducing vulnerability might be economically challenging, hence there is a need for concerted efforts by actors along the potato value chain to develop relevant practices for adaptation to climate change (Elum, Modise & Marr, 2017).

2.6.2 Soil fertility and water management

Management practices such as mulching, mixed cropping; row orientation with respect to slope and conservation tillage practices can increase farm system resilience and improve the capacity of farmers to adapt to climate change (McCarthy, Lipper & Branca, 2011). Supplementary livelihoods, reforestation and investing in small scale construction of dams for irrigation during water limited seasons sustain crop productivity and household incomes.

Farm Yard Manure (FYM) is an organic matter prepared from various kinds of animal excreta mixed with other organic materials such as crop residues, kitchen wastes, vegetable wastes, house sweepings etc. By using simple preservation techniques, the quality of FYM in terms of organic matter and plant nutrient content can be considerably improved and preserved for later use in crop production (Wani et al., 2013). It also enhances the water holding capacity and fertility of soils. Hence, by applying adequate FYM, water holding capacity and soil fertility status can be increased and productivity greatly sustained.

Land and soil management entails adoption of conservation agriculture, agroforestry and tied ridges (FAO, 2014a). A study was carried out to evaluate the performance of sorghum (Sorghum bicorlor, Moench) under conservation tillage methods in Central regions of Tanzania. In the semi- arid zone of Tanzania moisture is most limiting factor in crop production contributing to insecure household food security. Conservation tillage which involved the use of Magoye ripper and ox-ridger tillage implements was initiated. It was noted that tied ridging had better crop performance from fourth week after planting till harvesting (FAO, 2014a).

Organic farming comprises of highly diverse farming systems and thus increases the diversity of income sources and the flexibility to cope with adverse effects of climate change and variability, such as changed rainfall patterns. This leads to higher economic and ecological stability through optimized ecological balance and risk-spreading (FAO, 2014a). The main organic strategies are diversification and an increase in soil organic matter.

Production in organic farming systems is less prone to extreme weather conditions, such as drought, flooding, and water logging. Organic farming accordingly addresses key consequences of climate change, namely increased occurrence of extreme weather events, and problems related to soil quality (Wani et al., 2013). It avoids nutrient exploitation and increases soil organic matter content, hence soils under organic farming capture and store more water than soils under conventional cultivation. As such, it is a viable alternative for low income farmers.

In addition, higher prices can be realized for the products via organic certification. Higher farm incomes are thus possible due to lower input costs and higher sale prices (Wani et al., 2013). The coping capacity of the farms is increased and the risk of indebtedness is lowered. Risk management, risk-reduction strategies, and economic diversification to build resilience are also prominent aspects of adaptation, as mentioned in the Bali Action Plan (United Nations Framework Convention on Climate Change, 2007).

2.7 Analysis of Household Climate Change Adaptation Strategies

Climate change will have different impacts on different households. Whether or not climate change affects the livelihood of a household depends on the household's vulnerability and capacity to implement adaptation strategies (Rafisura & Srinivasan, 2010). The sensitivity of households that rely on ecosystem goods and services is determined by how strongly the households depend on the specific goods and services which will be affected by environmental change (Marshall, 2009; Mahendra, 2011).

Adaptive capacity is the ability of an affected system, region, or community to cope with the impacts and risks of climate change through learning, developing new knowledge and devising effective approaches (Lasco et al., 2011). Enhancement of adaptive capacity can reduce vulnerability and promote sustainable development.

Institutions and policies can either constrain or facilitate climate change adaptation (Tripathy & Mishra, 2016). They can enhance, or on the other extreme, undermine people's capacity to cope. Coping capacities can be eroded by repeated climate shocks**.** No matter how robust some community coping strategies are, these can collapse or be weakened by successive or repeated and prolonged exposure to climate shocks. Critical knowledge gaps exist on how losses or benefits from gradual or extreme climate events are distributed among households (Karfakis, Lipper & Smulders, 2012), hence the need to analyze climate change adaptation capacities among the smallholder potato producing households.

2.8 The Collective Learning Community Concept

A Collective Learning Community (CLC) is a trans-disciplinary approach to tackle fundamental societal challenges (Lang et al., 2012). It entails formation of information-sharing platforms that would enable different actors to come together and analyze shared constraints, promote dialogue, access new technologies, collaborate, engage in joint innovation and investment (CIP, 2011). Collective learning processes provide a basis for the exchange and dissemination of knowledge as well as sharing and application of climate change adaptation innovations (Freyer et al., 2012).

Within the CLC platform, new knowledge is generated and integrated into the existing body of scientific knowledge. It becomes transferable and applicable to other cases and other problem constellations (Lang et al., 2012). Thus, in order to secure the best possible climate change adaptation strategies, this research starts at the production level and follows the potato value chain via households to the local and regional levels. Following the value chain approach engages stakeholders in an action-oriented method that acknowledges the linkages in the chain with a flexible implementation, as well as creating ownership for problems and solution options (Lang et al., 2012).

According to Freyer et al. (2012), the CLC approach is built on three pillars:

Pillar 1: A network, which involves all relevant actors and organizations in the project area, is seen as the logistic center of the project. The network serves to identify the needs, expectations and objectives of each partner, as well as their resources and capacities to contribute to innovation processes. It provides a basis for the exchange and dissemination of knowledge; for initiating common iterative learning processes; as well as for the development, sharing and application of innovations (technology transfer). The network also provides a social component, which serves for strengthening the collaboration between all partners.

Pillar 2: A broad knowledge base gathered from local, regional, national, and international sources, which will be shared with, reflected upon, and rethought by all the involved actors.

Pillar 3: Dissemination of knowledge, initiation and application of innovations at the different levels as well as capacity building. Knowledge dissemination and generation of activities are done on the basis of existing knowledge, research findings and a process of critical reflection aided by ongoing discussions with all members of the CLC network. Figure 2 illustrates the CLC concept for climate change adaptation.

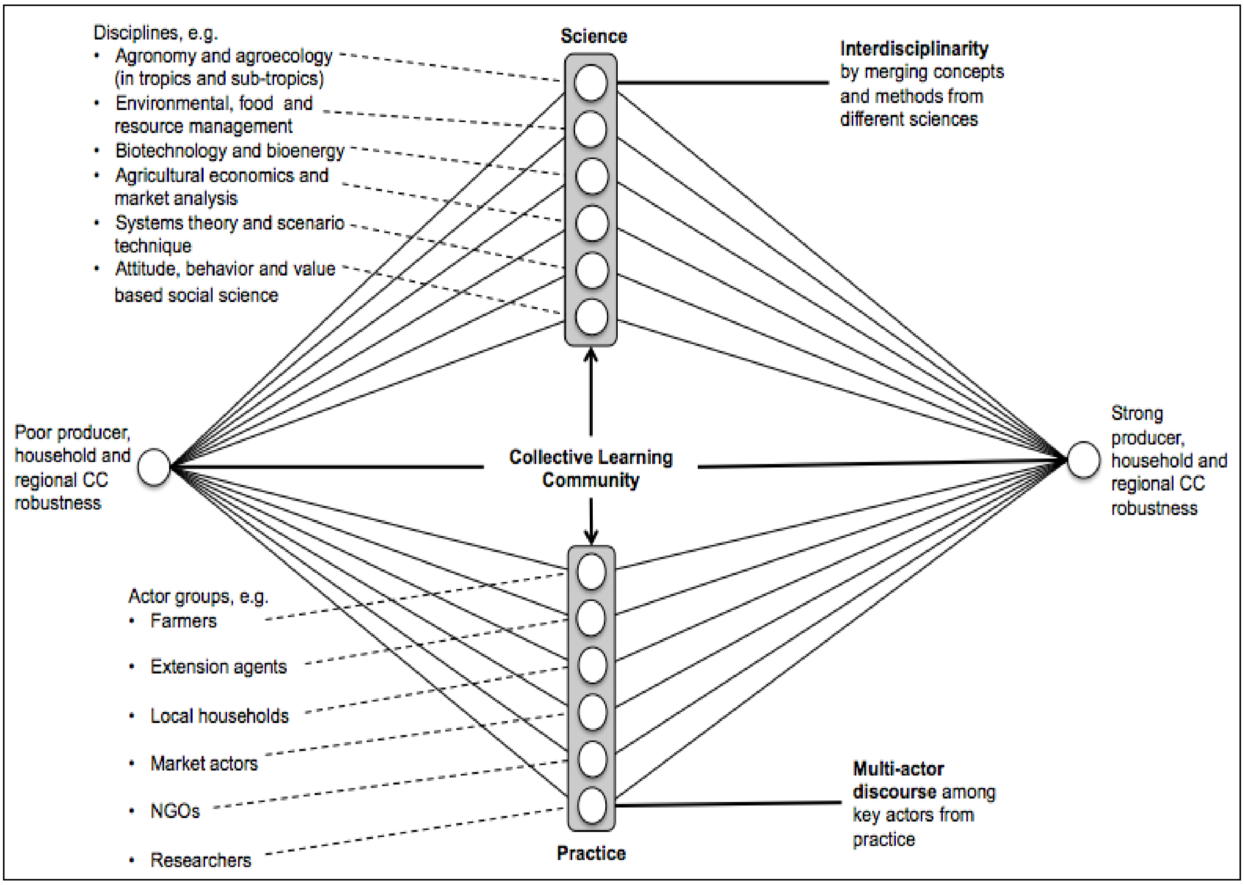


Figure 2: The Collective Learning Community concept - Source: Freyer et al. (2012), adapted from scholz, (2012).

2.9 Enhancing Climate Change Adaptation Capacities in Kenya

Kenya is a signatory to the United Nations Convention on Climate Change (UNCCC) and has ratified the Kyoto Protocol which places great emphasis on mitigation efforts whether through the reduction of Greenhouse Gas (GHG) emissions or the creation of GHG sinks in the terrestrial biosphere. In the face of change in climatic conditions, Kenya's economy bears the greatest brunt given that the agricultural sector supports the livelihood of over 70 percent of the rural population; contributes directly 26 percent of the GDP and 25 percent indirectly and accounts for 65 percent of Kenya's total exports (GOK, 2011b). Climate change is real and is being manifested through variability in temperature and rainfall as well as frequency of floods and droughts. These two scenarios expose the vulnerability of the Kenyan small scale farmer who largely depends on rain fed agriculture to climate change and climate variability.

Climate Change in Kenya has attracted a wide range of agricultural stakeholders and has been acknowledged as a serious threat to agriculture and food security (GOK, 2011a). Policy efforts in Kenya demonstrate a high level of commitment to mainstreaming adaptation and mitigation goals into planning processes, as well as outlining potential measures for doing so (Osumba & Rioux, 2015).

There are a substantial number of institutions in the Country currently working on climate change issues. These include Government ministries and institutions such as the Ministry of Environment and Mineral Resources (MEMR), Ministry of Forestry and Wildlife (MoF&W), the National Environmental Management Authority (NEMA), the Climate Change Unit of the State Department of Agriculture, and several government parastatals and departments; international Non-Governmental Organizations (NGOs), United Nations (UN) and related bodies; regional NGOs and corporations; national NGOs and Community Based Organizations (CBOs); development partners; the private sector and civil society.

Climate policies can be more effective when consistently embedded within broader strategies designed to make national and regional development paths more sustainable. This occurs because the impact of climate variability and change, climate policy responses, and associated socio-economic development will affect the ability of countries to achieve sustainable development goals (UNDP, 2017). Outlined below are Kenyan strategies and polices that address challenges and impacts of climate change.

The National Climate Change Response Strategy (NCCRS) provides a framework for specific interventions in the areas of adaptation and mitigation, capacity building, research and technology generation (GOK 2010). The NCCRS was launched in 2010 and it recognizes the importance of climate change impacts for Kenya's development. As Kenya's first climate change agenda guide, it provides a basis for strengthening and focusing nationwide action towards climate change adaptation and mitigation and has provision for addressing climate change in all sectors. The rationale is that all sectors should find ways and means to adapt to the unavoidable changes that are already occurring and those that will occur in the near future.

To operationalize the NCCRS, the Kenya Government developed the National Climate Change Action Plan (NCCAP) for the period 2013-2017 (GOK, 2012). It identifies six priority actions for low emission, climate-resilient development pathways focusing on agriculture and environment, which include climate smart agriculture (CSA) and agroforestry, restoration of forest and degraded lands, improved water resource management, clean energy solutions (including improved cooking stoves and biogas digesters), geothermal power generation and infrastructure.

The Kenya Vision 2030 identifies integration of environmental protection in agricultural production (GOK 2007). The Ministry of Agriculture Strategic Plan for 2008-2012 is committed to promoting sustainable land use and environmental conservation and addressing the impacts of climate change. It proposes interventions which include promotion of soil and water management as well as farm forestry (MOA, 2009). On the other hand, the Agricultural Sector Development Strategy for 2010-2020 focuses on improvement of environmental resilience and enhancement of conservation and management of resources (GOK 2011a).

2.10 Theoretical Framework

The theoretical basis for this study is the Transdisciplinarity Model (Jahn, 2012).This theory is based upon the proposition that developing solutions for societal problems requires linking these problems to gaps in the existing bodies of knowledge. This model distinguishes three phases in a research process. The first phase entails linking societal and scientific problems to form a common research project, a process called problem transformation. A heterogeneous group of actors cooperate to form a team committed and flexible enough to accommodate individual perspectives and meanings while at the same time maintaining a single identity that is recognized by all parties involved. Problem transformation always takes place when a societal problem is taken as the starting point of research.

The second phase of the model is characterized by formation of new knowledge. It is an iterative process called interdisciplinary integration involving researchers and stakeholders, which sets the framework for a research process that couples societal and scientific progress to generate new knowledge. The third and final phase evaluates the trans-disciplinary research process to determine its contribution to societal progress. It assesses the validity and relevance of the results to solve the initial societal problem and the new insights gained for scientific progress.

This model fits well with the Collective Learning Community concept in which a heterogeneous group of potato value chain actors participated in identifying climate change as a societal problem. Through collaborative research, the actors came up with climate change adaptation strategies to be utilized by farmers to adapt to climate change, as well as contributing to knowledge generation and dissemination.

Figure 3 is a diagrammatic presentation of the Trans-disciplinarity Model.

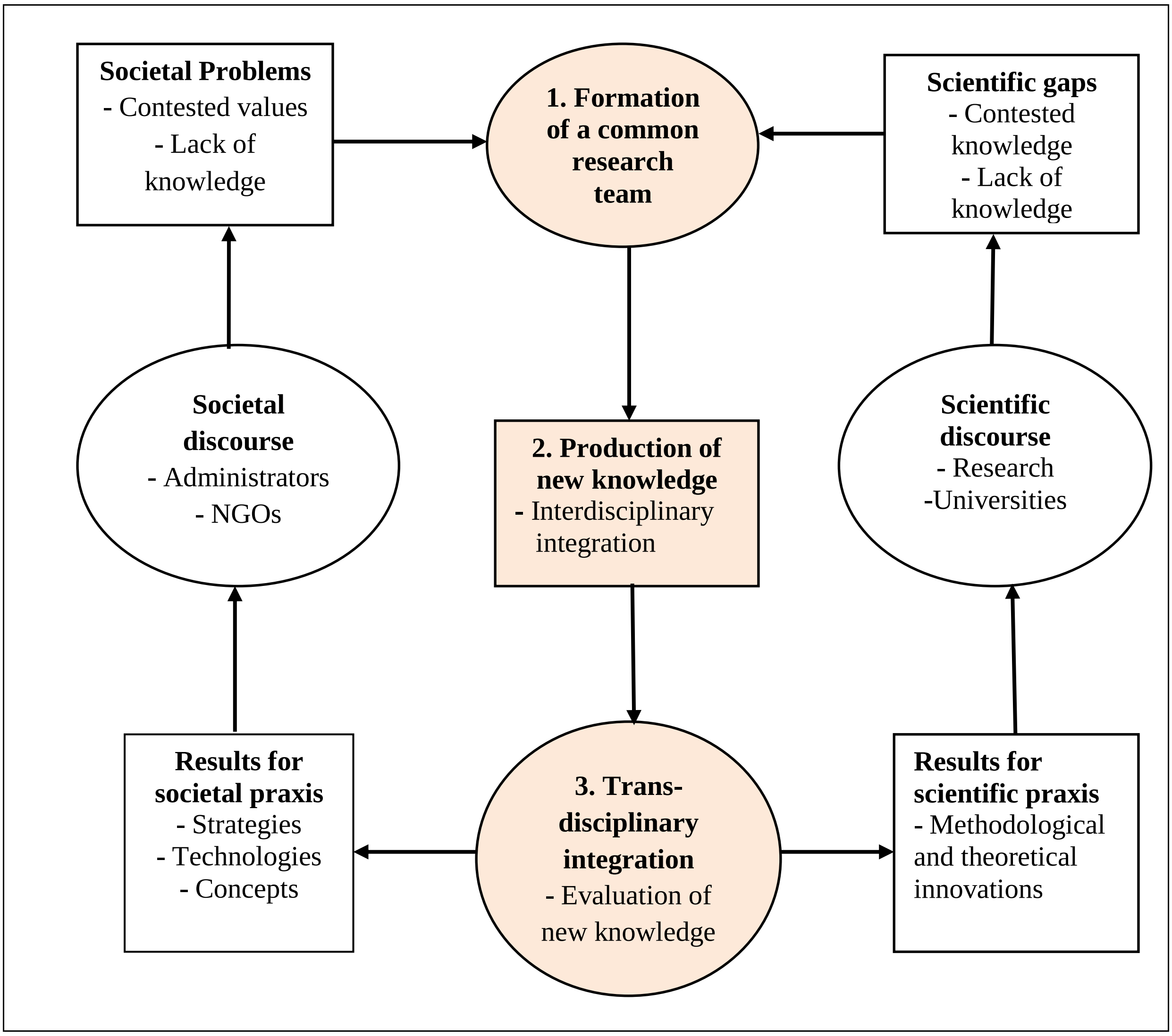


Figure 3: Trans-disciplinarity Model showing integration of societal problems with existing bodies of knowledge (Adapted from Jahn, 2012).

This study is also based on the Diffusion of Innovations Theory (Rogers, 1983), that seeks to explain how, why, and at what rate new ideas and technology spread. The theory proposes that adoption is preceded by a process of knowing about the existence of an innovation, developing an interest and making a decision about adoption. Four main elements influence the spread of a new idea: the innovation itself, communication channels, time, and a social system. Rogers reflects on the relevance of social networks within the two main elements of diffusion: communication channels and social structure. For example, while mass-media such as ICTs and related channels are considered as the most rapid and efficient means in creating knowledge of innovations, interpersonal channels are more effective in persuading an individual to adopt innovations (Rogers, 1983). This, according to Rogers, occurs because people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other individuals within their network, who have previously adopted the innovation.

The categories of adopters are innovators, early adopters, early majority, late majority, and laggards. The criterion for the adopter categorization is innovativeness, defined as the degree to which an individual adopts a new idea.

The CLC in Mauche Ward promoted climate change adaptation strategies, using various capacity building activities, for adoption by farmers. Through the frequent CLC meetings and interaction among potato value chain stakeholders, social networks were created which facilitated knowledge sharing that enabled farmers to adopt climate change adaptation strategies. Figure 4 presents the Diffusion of Innovations Theory.

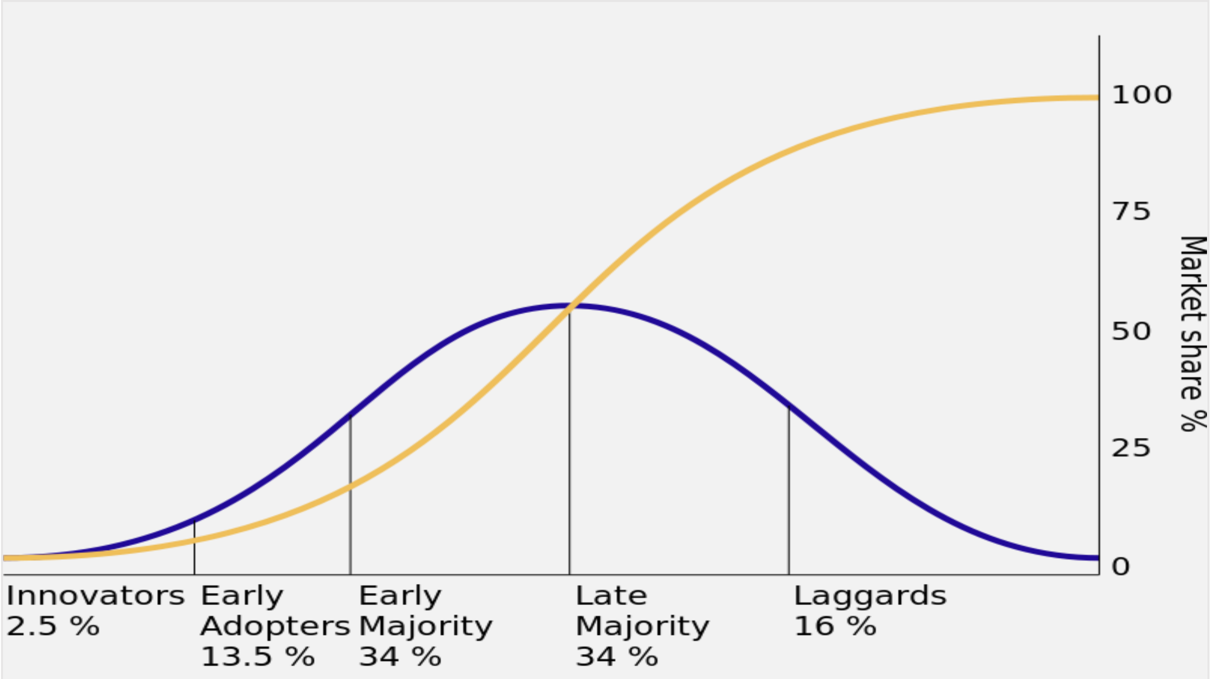


Figure 4: The Diffusion of Innovations Theory - source: Rogers (1983)

The study also draws from Action Learning Theory by Reginald William Revans (Dickenson, Pedler & Burgoyne, 2009), which suggests that the most difficult challenges and problems can be addressed through people's experiences and learning. This is a pragmatic methodology for dealing with difficult challenges and a moral philosophy based on an optimistic view of human potential. According to Revans (1907-2003), there is no learning without action and no action without learning. Action learning brings people together to exchange, support and challenge each other in action and learning. Each person voluntarily joins the team and owns the organizational task, problem, challenge or opportunity on which they are committed to act. Small groups are formed to help each other think through the issues, create options and above all, take action and learn from the experience of taking that action. People learn better, faster and more enduringly from their own problems than from management "experts" importing "prefabricated" knowledge.

Through Participatory Action Research, the CLC engaged potato value chain actors in Mauche Ward in action learning and reflection throughout the research process. Periodic monitoring and evaluation was done to ensure that the implementation of interventions was on course. This ensured ownership and utilization of the research findings by the farmers.

The study is also based on the Theory of Change (Weiss, 1995), which is applied in evaluation of Comprehensive Community Initiatives (CCIs). It explains the process of change by providing the links between activities, outcomes, and contexts of the initiative. The Theory explains how a programme has an impact on its beneficiaries. It outlines all the things that a programme does for of its beneficiaries, the ultimate impact that it aims to have on them, and all the separate outcomes that contribute to that impact.

The theory requires the participation of stakeholders to model desired outcomes and the ultimate outcomes and impacts they hope to achieve as well as the avenues through which they expect to achieve them. It ensures a transparent distribution of resources and inclusivity in in achieving solutions.

A Theory of Change approach can sharpen the planning and implementation of an initiative and can begin at any stage of an initiative, depending on the intended use. If applied during the design phase, it increases the likelihood that stakeholders will have clearly specified the initiative's intended outcomes, the activities that need to be implemented in order to achieve those outcomes, and the contextual factors that are likely to influence them .

An evaluation based on a Theory of Change, therefore, identifies how to measure ultimate and interim outcomes, and the implementation of activities intended to achieve these outcomes. As monitoring and evaluation data become available, stakeholders can periodically refine the Theory of Change as the evidence indicates.

According to Weiss (1995), the ultimate success of any Theory of Change lies in its ability to demonstrate progress on the achievement of outcomes. Evidence of success confirms the theory and indicates that the initiative is effective. Therefore, the outcomes in a Theory of Change must be coupled with indicators that guide and facilitate measurement. Indicators may be said to operationalize the outcomes – that is, they make the outcomes understandable in concrete, observable and measurable terms.

The CLC gave potato value chain actors in Mauche Ward a platform to participate in problem diagnosis, action planning, resource allocation, identification of success indicators and monitoring of implementation of climate change adaptation strategies. Field visits and workshops were held regularly to update the members on progress and address any challenges that may have come up. This ensured successful implementation of planned activities and achievement of the desired change – integration of climate change adaptation in potato production indicated by improved knowledge on CC strategies, improved potato yields, access to clean potato seed and access to potato market.

2.11 Conceptual Framework

The conceptual framework of this study is a reflection of the Transdisciplinarity Model (Jahn, 2012), which emphasizes on developing solutions to societal problems by a heterogeneous group of actors that cooperate to form a committed team. It identifies the societal problem as climate change vulnerability in the context of inadequate knowledge on climate change adaptation, weak linkages between potato value chain actors and low potato performance.

Figure 5 shows the interaction between the independent and dependent variables conceived for this study. The independent variables in the framework are the CLC characteristics namely: network quality, capacity building of farmers and knowledge dissemination. It shows how they influence the dependent variable, which is integration of climate change adaptation strategies in potato production as indicated by the ability of CLC members to access CC adaptation strategies, increase potato yields, access clean potato seed and get linked to potato market The moderator variables are age, gender, education level, farm size, land tenure, farm enterprises and household income. These were built into the study.

Figure 5 is the Conceptual Framework of the study showing the relationship between the Collective Learning Community and integration of climate change adaptation strategies in potato production.

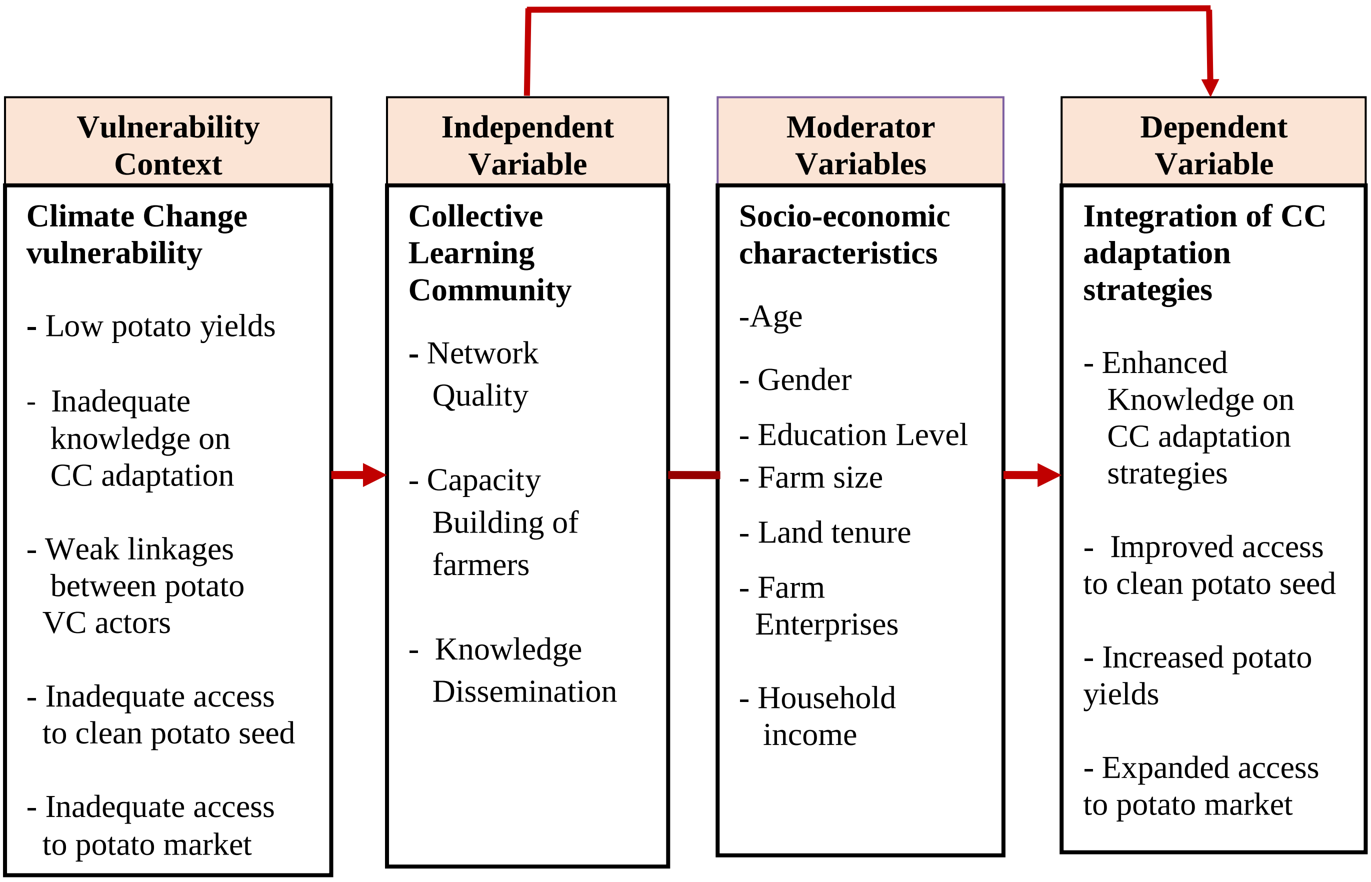


Figure 5: Conceptual Framework showing the relationship between the Collective Learning Community and integration of climate change adaptation strategies in potato production

The Collective Learning Community was measured in terms of network quality, capacity building of farmers and knowledge dissemination. Network quality was operationalized as interaction between group members to enhance learning and sharing of information and was measured by the frequency of attendance to CLC meetings and level of interaction among group members. Capacity building of farmers referred to training of farmers on climate change adaptation strategies in potato production. A likert scale was developed for farmers to rate their level of capacity building attained based on the category of activities conducted in the CLC.

Knowledge dissemination meant transfer of knowledge within and outside the CLC with the expectation that it would be utilized by the farmers. The CLC was rated on the extent to which it facilitated exchange of knowledge using a five point Likert scale.

As a dependent variable, integration of climate change adaptation strategies in potato production was measured by enhanced knowledge on various CC adaptation strategies, improved access to clean potato seed and expanded access to potato market. A five point Likert scale was developed to measure the level of knowledge CLC members had acquired on selected CC adaptation strategies and the level of access to clean potato seed and potato market.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research designs adopted in this study and gives a description of the study area. It also presents the target population, sample size, sampling procedure and instrumentation outlining the process of determining the validity and reliability of the instrument; and how data were collected and analyzed.

3.2 Research Designs

The study employed both Survey Research and Participatory Action Research (PAR) designs. Survey research is defined as the collection of information from a sample of individuals through their responses to questions (Check & Chutt, 2012). It is one of the most important methods in applied social research. It encompasses any measurement that involves asking questions and getting feedback from respondents.

According to Fraenkel and Wallen (2000), surveys are important in research and have been found to be useful in describing the characteristics of a population under study. Survey research allows for a variety of methods to recruit participants, collect data and utilize various methods of instrumentation. This design may apply quantitative research strategies such as using numerical rated items, qualitative research strategies such as use of open ended questions, or both strategies in combination. As it is often used in exploring human behaviour, survey research is therefore frequently used in social and psychological research (Singleton & Straits, 2009).

Participatory Action Research may be defined as 'an approach in which the action researcher and a client collaborate in the diagnosis of a problem and in the development of a solution based on the diagnosis' (MacDonald, 2012). It seeks to understand the world by trying to change it collaboratively and reflectively (Reason & Bradbury, 2008). It emphasizes the principles of collective inquiry and experimentation grounded in experience and social history.

Within a PAR process, communities of inquiry and action evolve and address questions and issues that are significant for those who participate as co-researchers. Participatory Action Research is intended to generate knowledge that will be directly useful to a group of people and empowers them to take up and use the information gathered in the research (Berg, 2007). As suggested by Chaveller and Buckles (2013), PAR integrates the basic aspects of participation (life in society and democracy), action (engagement with experience and history) and research (soundness in thought and the growth of knowledge). Action unites organically with research and collective processes of self-investigation (Rahman, 2008).

Participatory Action Research is a pluralistic orientation to knowledge generation and social change. It entails shared ownership of research projects, community-based analysis of social problems, and community action (Kemmis & Mc Taggart, 2007). Research is not done on participants; research is designed, carried out, and integrated by the participants in partnership with the researchers (Lingard, Albert & Levinson, 2008). This is in contrast with other research methods in which disinterested researchers emphasize on reproductivity of findings (Baum, MacDaugall & Smith, 2006).

3.3 Location of the Study

The study was carried out in Mauche Ward of Nakuru County, Kenya. Mauche is one of the nine Wards in Njoro Sub-County. Others are Njoro, Lare, Makungugu, Nessuit, Kihingo, Naishi, Sururu and Mau Narok. Mauche Ward was chosen because of climate change vulnerability and presence of farmers engaging in potato growing. It covers an area of 166 square kilometers. Its altitude is 2100-2800m above sea level and receives an annual rainfall of 1600-2200 mm. Agro-ecological zones are Upper Highlands and Lower Highlands.

Mauche Ward has a population of 25,088 comprising of 4994 households and 5590 farm families (GOK, 2014). There is a distinction between households and farm families. Rural households need not necessarily be involved in farming; they might not own land, but may be hired as labourers by farm families or engage in other income generating off-farm activities such as trade. On the other hand, not all farm families own the land on which they farm; they could be children or relatives to the owners (FAO, 2014b).

The main crops grown in Mauche are maize, potato, wheat, beans and vegetables. Livestock kept include cattle, sheep and local chicken. The main challenges to agricultural productivity in the Ward include inadequate certified or clean potato seed, high cost of farm inputs, poor road network, crop pests and diseases as well as decreasing soil fertility levels which hamper farmers' realization of potential yields (GOK, 2014).

Mauche farmers are mainly smallholders with farm holdings below 2 hectares. Maize is the staple food crop in the area whereas potato is grown as a cash crop. The main commercial market is Mauche, where farmers sell their farm produce and purchase farm inputs. Mauche Ward lies on the Mau escarpment and is highly vulnerable to soil erosion due to the sloppy terrain. Increased human population and demand for more agricultural land for food production has resulted in destruction of the vegetation cover and subsequent rampant environmental degradation. There has been increasing deforestation and cultivation of water catchment areas and river banks, which have contributed to pollution of water sources as well as changes in climatic conditions.

3.4 Target Population

The target population comprised of all 5590 farm families in Mauche Ward of Nakuru County. These were mainly smallholder farmers engaging in potato growing. The farming population was a mixture of all age brackets - there were old people still actively involved in farming.

3.5 Sampling Procedure and Sample Size

The study selected Mauche Ward for climate change adaptation interventions due to climate change vulnerability as well as farmers engaging in smallholder potato production. Purposive sampling to select one potato CIG out of the existing three in Mauche ward of Nakuru County. The selection criteria entailed how active and cohesive group was. The selected GIG was used to implement the climate change adaptation strategies in three sites in the Ward, which acted as learning the centres for the farmers.

Since the recommended minimal sample size in a survey research for social studies is 100 (Kathuri & Pals, 1993; Dalice, 2010; Conroy, 2016), this study employed simple random sampling to select 150 farmers to participate in the household survey. This was meant to take care of non-response which often reaches 30 percent (Moore, 2000). Survey non-response arises when a targeted respondent fails to cooperate in participating in a survey e.g. by claiming to be too busy or especially being secretive (University of Reading Statistical Centre, 2000).

Purposive sampling was used to select key informants from the Climate Change Unit of the State Department of Agriculture, KALRO Tigoni, International Potato Centre (CIP), Kenya National Potato Council, Kenya National Farmers' Federation (KENAFF), Agricultural Development Corporation (ADC) Molo, Agricultural Technology Development Centre (ATDC) Nakuru and Njoro Canning Factory. The study targeted managers of these organizations. Simple random sampling was employed to select ten potato traders, ten transporters and ten agricultural input suppliers to participate in Focus Group Discussions.

Table 2 presents a summary of all the respondents in the study.

Table 2

Summary of Respondents

Target Group	**Number of Respondents**
Smallholder farmers	150
Chomosa Farmer Group	30
State Department of Agriculture	1
KALRO Tigoni	1
CIP	1
ADC Molo	1
Kenya National Farmers' Federation	1
ATDC Nakuru	1
Njoro Canning Factory	1
Traders	10
Transporters	10
Agro-input suppliers	10
Total	**217**

3.6 Instrumentation

Three instruments were used in data collection. The first was a semi-structured Questionnaire (APPENDIX A) used to collect primary data from sampled farmers in the study area. Section I elicited information on socio-economic characteristics of smallholder potato farmers such as gender, age, level of education, farm size, land tenure, farm enterprises and household income. Section II focused on climate change related challenges, coping strategies and knowledge gaps in smallholder potato production, whereas section III highlighted on household practices by smallholder potato farmers.

Topic guides (APPENDIX B) were used for Focus Group Discussions (FGDs) with actors along the potato Value Chain in Mauche Ward. A total of eight FGDs were conducted. Three FGDs targeted potato input suppliers, transporters and traders and elicited information on climate change related challenges and opportunities along the potato value chain in Mauche Ward. Five FGDs were held with the farmers; two discussed climate change impacts on livelihoods and coping strategies (APPENDIX C-1)), whereas three focused and reflected on their household experiences with the innovation process (APPENDIX C-2).

Checklists (APPENDIX D) were used to conduct key informant interviews. Key informants in this study were organizations regarded as having special knowledge, education or awareness about climate change adaptation. Key Informant Interviews were used to obtain formation from the Climate Change Unit of the State Department of Agriculture, KALRO Tigoni, International Potato Centre, Kenya National Potato Council, Kenya National Farmers' Federation, ADC Molo (Potato Seed multiplier), ATDC Nakuru (Machinery Fabricator), Njoro canning factory (processor) on climate change challenges and coping strategies, climate change policy framework, achievements and gaps in climate change adaptation. Farmer interviews focused on implementation of climate change adaptation strategies and household practices. Barbour (2008) asserts that topic guides and checklists provide extremely rich data with enormous potential for comparison.

A structured questionnaire (APPENDIX E) was used to evaluate the Collective Learning Community. It elicited information from CLC members used to evaluate the influence of the CLC on integration of climate change adaptation strategies in potato production.

3.6.1 Validity

Validity is the degree to which results obtained from the analysis of data actually represent the phenomenon under study (Fraenkel & Wallen, 2000). Content validity refers to how representative the items on the instrument are in relation to the domain of content being measured (Kathuri & Pals, 1993). Face validity refers to the appeal and appearance of the instrument. After the data collection instruments had been designed as per the research objectives, thorough examination of the instruments was done to determine validity by two supervisors and a panel of experts in the Department of Agricultural Education and Extension, Egerton University. The comments of the supervisors and panel of experts were used to adjust and improve the instruments in order to ensure that they yielded valid data from which appropriate, meaningful and useful inference could be made.

3.6.2 Reliability

The survey questionnaire was pilot-tested at Nessuit Ward on 30 farmers to ensure its reliability. Nessuit Ward was chosen because it lies in the same agro-ecological zone and has potato growing farmers as Mauche. The reliability of the survey questionnaire was estimated using Cronbach's Alpha Coefficient, which is a measure of internal consistency (Fraenkel & Wallen, 2000).

Use of Cronbach's Alpha Coefficient reduces the time required to compute a reliability coefficient in other methods (Mugenda & Mugenda 1999). Its application results in a lower estimate of reliability which avoids erroneous conclusions. A reliability coefficient of 0.86 was obtained. This according to Trochim (2006) is acceptable as it is above the threshold of 0.7 for social studies such as the current one.

According to Gibbs (2007) qualitative reliability is the researcher's approach to ensuring consistency among researchers and projects. Patton (2002) advises researchers to engage participants throughout the research and data collection process as a means to guarantee reliability and appropriate dissemination. Through action research this study engaged the research participants in data collection, as well as using them to corroborate the findings as a way of ensuring reliability (Yin, 2009).

3.7 Data Collection

The researcher proceeded to collect data after obtaining the necessary approval from the Graduate School of Egerton University and the National Commission for Science,Technology and innovation (Appendix G). Data collection started with a household survey. The Mauche Ward Agricultural Extension Officer (AEO) assisted the researcher with a list of farmers which formed the sampling frame. The AEO also helped in identification of the sampled respondents.This was followed by identification of five enumerators with some knowledge on social studies and training them on how to administer the household questionnaire. The researcher set specific dates to meet the sampled respondents and administer the questionnaire with the assistance of the trained enumerators, while recording the responses. The language of communication was mainly Kiswahili except in cases where the respondent was competent in the use of English language.

Farmers and stakeholders in Mauche were engaged through participatory forums to obtain an insight into local and regional knowledge as well as farmer experiences. Qualitative interviews and focus group discussions were carried out with the case farmers to seek their views concerning the impacts of climate change and coping strategies in the study area. Existing knowledge was applied to test crop production and water management intensification strategies in on-station trials at KALRO Njoro. The sampled farmer group participated in selecting some of the strategies for implementation to maximize climate resilience on three sites in Mauche Location. These sites served as learning centres in which climate change adaptation options would be further refined and disseminated to other farmers.

3.8 Data Analysis

This study applied several qualitative tools and procedures as well as statistical tests to analyze data. These included descriptive statistics for survey data analysis and qualitative data analysis tools and procedures which included Problem Tree Analysis, stakeholder analysis, potato value chain analysis, the net-map toolbox analysis, multi-criteria analysis and brainstorming. Multiple linear regression was used in quantitative data analysis.

After collection, survey data was edited, coded and analyzed using SPSS. Both descriptive and inferential statistics were employed in the data analysis. Coding of responses was based on the scale of measurement for each item in the questionnaire, for instance items measured on a nominal scale were coded without regard to magnitudes while those on ordinal scales were coded with the magnitude of the responses in mind. Analyzed data was presented descriptively using frequency percentages, means, standard deviation and standard error.

This study employed Problem Tree Analysis to engage farmers in identifying climate change as a core problem in the study area and suggesting appropriate interventions for climate change adaptation. Problem Tree Analysis is a participatory tool used to carry out situational analysis. It provides a pictorial representation of the main problems, along with their causes and effects as well as the strategy of how to solve them in order to address the real needs of beneficiaries (Overseas Development Institute, 2009).

Stakeholder analysis was done to determine the key actors considered to have a significant influence on the success of the intervention. According to Golder (2005), stakeholder analysis helps identify the interests of all stakeholders who may affect or be affected by a project; potential conflicts or risks that could jeopardize the initiative; opportunities and relationships that could be built by various participating groups at different stages and strategies for stakeholder engagement.

Potato value chain analysis was done to understand the constraints along the chain in order to guide local actors come up with strategies for inclusion of smallholder potato farmers into the chain as well as improving linkages between potato farmers and other value chain actors for increased productivity and incomes. Value chain analysis reveals links between actors, identifies opportunities and key constraints within the chain, and has potential to identify market based solutions that promote competitiveness (Donald, 2009).

The Net-Map toolbox was used to assess the links between different actors in the CLC with regard to exchange of information, advice, money, level of command and influence, in order to enhance the way in which they worked together to achieve a common goal - integration of climate change adaptation strategies in potato production.The Net-Map toolbox is a participatory tool that aids a target group of people to clarify, converse and identify situations that can be improved where there are numerous stakeholders and actors that have the ability to impact the outcome (Schiffer 2007). It is a social analysis tool that uses discussion and mapping to help people understand, visualize and improve situations in which many different actors influence results.

Multi-Criteria Analysis (MCA) was used to select the most appropriate crop, water and soil management climate change adaptation techniques from the basket of options developed at KALRO Njoro. Multi-Criteria Analysis is a tool used to compare alternatives on the basis of more than one criterion (Bartolini &Viaggi, 2010). Based on a thorough analysis of the most suitable criteria that decision-makers could adopt in their decision making, MCA was carried out by the CLC to categorize and rank the options which included crop production, soil and water management intensification strategies such as crop rotation of potato with dolychos bean (*Lablab purpureus*); intercropping with garden pea; water harvesting by use of tied ridges and normal ridges; soil fertility management by use of farm yard manure, green manure in the form of *Leucaena triandra* biomass and top-dressing with Calcium Ammonium Nitrate to supply nitrogen. Rock phosphate was applied at planting to supply phosphorus. The selection criteria included crop stand (foliage), disease incidence, potato yield and cost of the technology. Each criterion was given a weight that reflected the preferences of the decision-makers and the weighted sum of the different criteria was used to rank promising and feasible adaptation options.

A combination of the nominal group discussion and the brainstorming techniques were applied by the CLC in a workshop to identify the challenges and opportunities of maintaining a Collective Learning Community for climate change adaptation in smallholder potato production. These techniques ensure active participation by all participants (Jones, 2007). The dialogue in a brainstorming session allows for instant feedback and raising of novel, opposite or supporting perspectives (Himanen et al., 2016). It presents the results of the workshop as a group communication process rather than a collection of individual opinions.

Multiple Linear Regression was applied to test the influence of the Collective Learning Community on integration of climate change adaptation strategies in potato production. Multiple Linear Regression is a statistical tool used to examine how multiple independent variables are related to a dependent variable (Higgins, 2005). It helps in understand how much the dependent variable will change when the independent variables change. First, it considers whether there is linear relationship between the independent variables and the dependent variable in a multiple linear regression model, then further determines the magnitude of relationship ie. the strength of the effect that each independent variables has on a dependent variable (Field, 2009).

The Collective Learning Community was evaluated on the basis of network quality, capacity building of farmers and knowledge dissemination, which were identified as the independent variables for this study. The mean scores of responses to the items measuring network quality, capacity building of farmers and knowledge dissemination were computed to give Network Quality Index (NQI), Capacity Building Index (CBI) and Knowledge Dissemination Index (KDI) respectively. Integration of climate change adaptation strategies, which was identified as the dependent variable for the study was evaluated based on knowledge acquired by the respondents on climate change adaptation strategies, access to clean potato seed and access to the market.

The mean scores for responses to knowledge on climate change adaptation strategies (KAS), access to clean potato seed (CPS) and access to potato market (APM) were averaged using the geometric means of the composing indices. These were computed to give knowledge on climate change adaptation index (KASI), access to clean potato seed index (CPSI) and access to potato market index (APMI) respectively. These indices were compounded into the Climate Change Adaptation Index (CCAI) using the geometrical mean expressed as:

$$CCAI = (KASI \times CPSI \times APMI)^{1/3}$$

Where KASI, CPSI and APMI represent knowledge on climate change adaptation index, access to clean potato seed index and access to potato market index respectively.

To predict the influence of the CLC network on integration of climate change adaptation strategies in potato production, a stepwise Multiple Linear Regression of the form $y = a+b_1x_1+b_2x_2+b_3x_3$ was used to determine contributions of each independent variable. In the model, $x_1 \ldots\ldots x_2$ represent the specific indicators of CLC network.

The Null hypothesis was tested at 5 percent significance level.

Table 3 is the summary of data analysis.

Table 3

Summary of Data Analysis

Research Question/Hypothesis	**Independent variable**	**Dependent variable**	**Statistical procedures and tests**
What are the socio-economic characteristics of smallholder potato farmers in Mauche Ward of Nakuru County?	Socio-economic characteristics	Integration of climate change adaptation strategies	Frequencies, Percentages, Means
What are the climate change challenges, adaptation strategies and knowledge gaps in smallholder potato production in Mauche Ward of Nakuru County?	Climate change challenges, coping strategies and knowledge gaps	Integration of climate change adaptation strategies	Frequencies, Percentages, Means
What are the household practices of smallholder potato farmers in Mauche Ward of Nakuru County?	Household practices	Integration of climate change adaptation strategies	Frequencies, Percentages, Means
How does establishment of a Collective Learning Community promote climate change adaptation in Mauche Ward of Nakuru?	Establishment of a Collective Learning Community	Integration of climate change adaptation strategies	- Problem Tree Analysis - Stakeholder analysis - Potato value chain Analysis - The Net-Map Toolbox Analysis
How can climate change adaptation strategies be integrated in smallholder potato production through farmer participation in Mauche Ward of Nakuru County?	Farmer participation	Integration of climate change adaptation strategies	- Multi-Criteria Analysis
vi. What are the opportunities and challenges of establishing and maintaining a CLC that affect climate change adaptation in Mauche Ward of Njoro Sub-County?	Challenges and opportunities of establishing a CLC	Integration of climate change adaptation strategies	- Nominal group discussion technique - Brainstorming technique

H0: The Collective Learning Community has no statistically significant influence on integration of climate change adaptation strategies in smallholder potato production.	The CLC characteristics: Network Quality Index, Capacity Building Index, Knowledge Dissemination Index	Climate Change Adaptation Index	- Frequencies, Percentages, Means, Standard Error - Multiple Linear Regression

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This study integrated climate change adaptation strategies in potato production through a Collective Learning Community (CLC) comprising of potato value chain actors in Mauche Ward of Nakuru County. A baseline survey involving 150 households was carried out before implementation of climate change adaptation interventions. Analysis of rural livelihood challenges and options under climate change pressure was done, to provide a broad knowledge base on vital and successful climate change related smallholder farming practices, including a problem and actor analysis. It entailed review of scientific and grey literature from various sources relevant to the study. Knowledge from national and international research and advisory organizations was gathered by visiting a number of purposively sampled organizations. The aim of these visits was to seek expert opinion on the impacts of climate change and how to increase climate change resilience and adaptive capacities of vulnerable communities with particular focus on smallholder potato producers.

At the centre of the CLC was a group of 30 smallholder potato farmers purposively selected to participate in problem diagnosis and implementation of the interventions through Participatory Action Research in partnership with the researchers. Workshops and field visits were held regularly whereby innovations and their implications on the household system were discussed and reflected upon within the Collective Learning Community.

This chapter presents the results and discussion of the study as per the following objectives:
i) To identify and explain the socio-economic characteristics of smallholder potato farmers in Mauche Ward of Nakuru County, ii) To determine the climate change challenges, adaptation strategies and knowledge gaps in smallholder potato production in Mauche Ward of Nakuru County, iii)To analyze household practices of smallholder potato farmers in Mauche Ward of Nakuru County, iv)To establish a Collective Learning Community for climate change adaptation in Mauche Ward of Nakuru County, v) To integrate climate change adaptation strategies in smallholder potato production through farmer participation in Mauche Ward of Nakuru County, vi) To identify the challenges and opportunities of maintaining a Collective Learning Community for climate change adaptation in smallholder potato production and vii)

To determine the influence of the Collective Learning Community on integration of climate change adaptation practices in smallholder potato production.

4.2 Socio-economic characteristics of the Respondents

The first objective of the study was stated as:

To identify and explain the socio-economic characteristics of smallholder potato farmers in Mauche Ward of Nakuru County

The respondents for this study were 150 small scale farmers in Mauche Ward who were involved in potato growing. The findings about the socio-economic characteristics of the respondents were as follows:

4.2.1 Age Category of the Respondents

Age as a moderator variable was investigated as it has been found to affect farm level decisions and participation in group activities. The age categories of the potato growing farmers are presented in Figure 6.

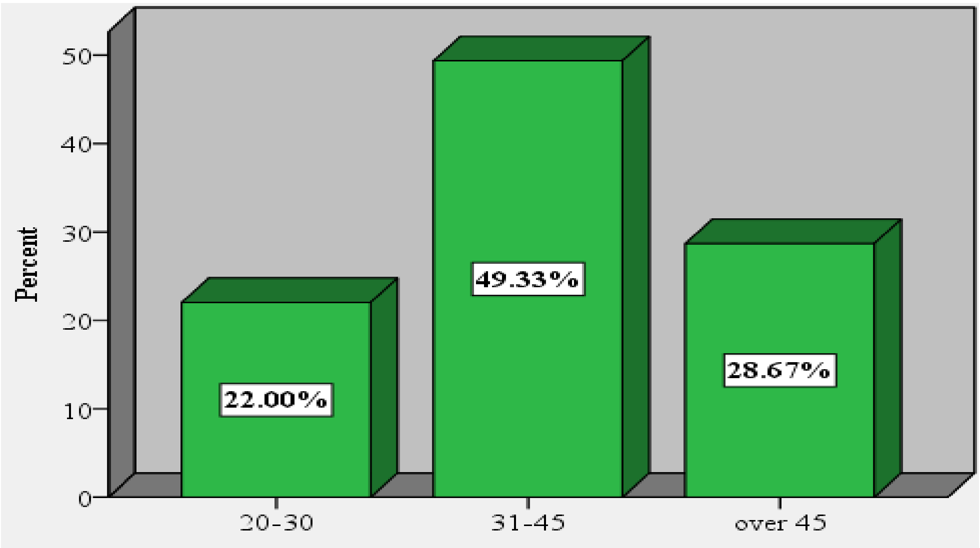


Figure 6: Age of the respondents

A majority of the respondents (50 %) were in the age category between 31 and 45 years, which may be considered as the prime age for productivity. Age as a moderator variable was investigated as it is known to affect farm level decisions and participation in group activities. While working with peasant farmers in South-Western Nigeria, Ongusumi (2007) found out that there is a positive relationship between age and adoption of technologies. Age of the household head predisposes a farmer to better farming techniques through “learning by doing” and better management skills (Khai et al., 2008). Age is assumed to increase the probability of adoption but at a decreasing rate as the age increases. Sebatta et al. (2014) found a positive relation between age and farmer market participation, with older farmers selling higher proportions of their produce to the market.

4.2.2 Gender of the Respondents

The sample population was selected with gender in mind in order to have representation in both the males and the female groups. The gender representation is given in figure 7.

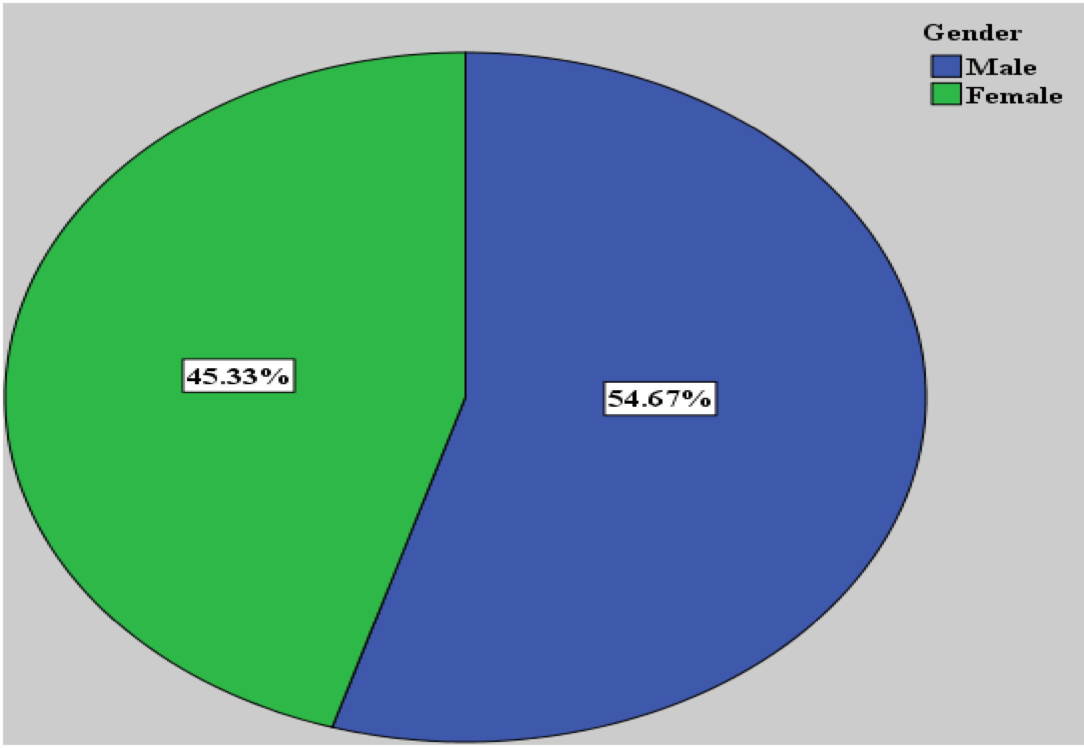


Figure 7: Distribution of respondents according to gender

The study sample was composed of more males than the females. The number of male respondents was 82 which represented 54.7 per cent of the sample as compared to 68 females representing 45.3 per cent. This is a reflection of the situation in the study area where most of the households are headed by male and fewer by females. The respondents were largely household heads, hence the higher male representation. Gender has been known to influence agricultural production through issues and concerns that surround access and control of resources for production. Men as heads of households have greater access to land, credit and extension services (GoK, 2004). Male dominance in decision making in the household and economy has continued even in areas where women are the key providers of labour because the influence of women has rarely been recognized (Damisa &Yohanna, 2007). Females constitute a small portion of land owners though they provide the bulk of farm labour.

4.2.3 Respondent's Relationship to the Household Head

The respondents were asked to state their relationship to the household head, in order to determine whether the respondents were also the owners of the farms they were living in. The responses are given in Table 4.

Table 4

Relationship of respondents to household head

Relationship	Frequency	Percent
Self	87	58.0
Wife	52	34.7
Son	5	3.3
Relative	3	2.0
House help	3	2.0
Total	**150**	**100.0**

The results in Table 4 show the survey was well conducted since the enumerators to a large extent met the household head (58%) or the wife (34.7%). This implies a greater reliability of data as the targeted respondents were met.

4.2.4 Male and female headed households

The household head is mainly responsible for the economic wellbeing of the household. Table 5 presents the respondents' relationship to the household heads in relation to gender.

Table 5

Comparison of household head and gender

Relationship of respondent to Household head	Gender of the farmer				Total	
	Male		Female			
	No	%	No	%	No	%
Self	84	56	5	3.3	89	59.3
wife	0	0	52	34.7	52	34.7
son	5	3.3	0	0	5	3.3
Relative	3	2.0	0	0	3	2.0
House help	1	0.7	0	0	1	0.7
Total	**93**	**62.0**	**57**	**38.0**	**150**	**100.0**

Male headed households were found to be more common (55 %) in the study area than the female headed households (38%). The World Bank (1989) defines delegate heads as women whose husbands are often away and who therefore have substantial but not total responsibility for the household. In this study, the delegate household heads accounted for 34.7 per cent whereas female headed households accounted for 3.3 per cent of the sample. The figures in Table 2 show a marked increase in the number of the female headed households from 23 to 38 per cent, when compared to the Kenya National Bureau of Statistics (KNBS) in the region (KNBS, 2008). The increase could be attributed to the increased number of widows in the area, which was estimated at 16 per cent (KNBS, 2008). The female-run households add up to 38 per cent, when households headed by delegate heads and women are considered together. The figure is critical especially in a patriarchal society (like the case with the Kalenjin community found in the area) where major decisions are made by the males.

Female household heads relative to male household heads have limited access to protective social networks (Flato, Muttarak &Pelser, 2017), education attainment (FAO, 2014a), assets and services (Kassie, Ndiritu & Stage, 2014) as well as market outlets for their farm produce (Sebatta et al., 2014). Gender of the household head affects both the manner in which resources are utilized and distributed within the household (Kamau, Kimani & Wamae-Ngare, 2014).

4.2.5 Education Level of the Respondents

The education level is an important factor in this study because the activities related to the mitigation of climate change need some level of understanding. The farmers were asked to state the highest level of formal education they had attained and the results are given in Figure 8.

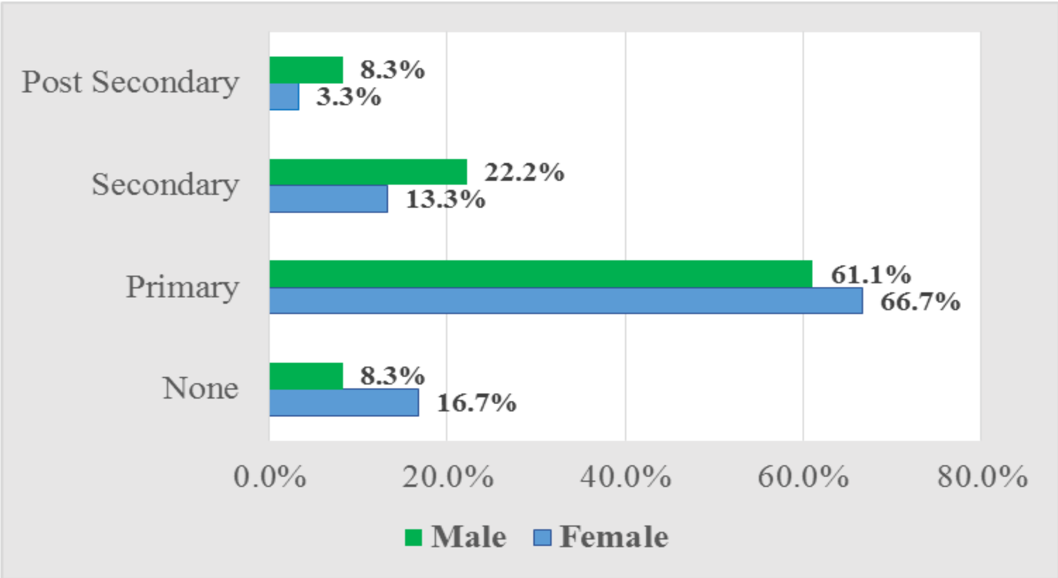


Figure 8: Education level of the respondents differentiated according to gender

More than half of the respondents (66.7 % male and 61.7 % Female) had completed the primary level of formal education, meaning that they were able to read and write and understand many of the concepts primary to this study. There were more males with secondary education at 22.2 per cent and post-secondary education at 8.3 per cent than females with 13.3 per cent and 3.3 per cent.

There is an important link between education level, personal empowerment to escape poverty, possession of appropriate information and making of informed choices Balakrishnan (2001). Farmers with higher levels of education tend to be more efficient in production. As noted by Nyagaka, Obare and Nguyo (2009), better performance by more educated farmers may be attributed to the fact that education gives the farmers the ability to perceive, interpret and respond to new information and improved technology such as fertilizers, pesticides and planting materials much faster than their counterparts. A study on smallholder potato farmers in Uganda revealed that farmers' ability to produce and sell more in a market was highly and positively related to their education levels (Sebatta et al., 2014). Farmers who had attained secondary education and had combined it with informal education, were more likely to produce and sell more.

4.2.6 Farming System

The farming system practiced by the farmers in the study area is described using the following factors: farm size, Land tenure, Crops grown and livestock kept by the respondents.

The size of farm owned by the farmers is an important asset in that it determines the farming system that can be applied and output that can be obtained from the land. A majority of the farmers (59.3 %) owned farms that ranged in size between 0.6 and 2 hectares, while 24.7 percent of the farmers owned 0.1 to 0.5 hectares. Only 16 percent of them owned farms that ranged between 2.1 to 4 hectares. According to FAO (2015b), small farm households work on land smaller than 2 hectares. Many are poor and food insecure with limited access to markets and services.

An increase in farm size may enhance production if the land is effectively utilized, which entails application of appropriate farm practices and inputs (Tolno et al., 2016). Farm size is a direct positive correlate of productivity as it offers the farmer endowment with productive assets. Farmers with relatively large holdings produce and sell larger volumes of their produce as compared to those with smaller land holdings (Sebatta et al., 2014) and are expected to benefit more from the economies of scale.

The type of land ownership determines the type of innovations and developments that a farmer will initiate on his land. The farmers who own the land will be willing to initiate permanent long term activities on their pieces of land. The type of tenure existing in the study area is summarized in Table 6

Table 6

Land tenure system in the study area

Tenure	Frequency	Percent
Owned with title deed	75	50.0
Owned without title deed	64	42.7
Rented	9	6.0
Owned by Parents/Relatives	2	1.3
Total	150	100.0

Two main forms of land tenure were captured in the study. The farmers either owned land with title deeds (50 %) or owned land without title deeds (42.7 %), while 7.3 per cent of the farmers did not own the land they were using to grow potatoes. Farmers' ability to obtain credit may be correlated with land tenure (Ngeno et al., 2011). It may be difficult for a farmer whose land is not titled to obtain credit, which is common for many smallholders.

The respondents grew five different types of crops on their farms, which included maize, potatoes, beans, vegetables and garden peas. The area allocated for each crop and the frequency of the farmers growing the crop is given in Table 7.

Table 7

Types of crops grown by the respondents

Crop	Farm size (Hectares)			
	0 (None) (%)	0.1-0.5 (%)	0.6-2 (%)	2.1-4 (%)
Maize	0	71.3	27.3	1.3
Potatoes	0	88.0	10.0	2.0
Beans	44	50.0	4.0	1.3
Vegetables	50	50.0	0	0
Garden Peas	38.7	61.3	0	0

(N=150)

Main crops grown by the respondents included Maize, potato, beans, garden peas and vegetables.The majority (88 %) of the farmers grew potatoes on land size between 0.1 and 0.5 hectares. This means that potatoes were grown on majority of the small scale farms in the area.

Crop diversification improves household food security since different crops are affected differently by the same climatic conditions (Mutekwa, 2009). In addition, it is a strategy for enhancing the welfare of low-income rural households, mitigation of risk, employment generation and conservation of biodiversity (FAO, 2013). The possibility of interruption in insect and diseases cycles and utilization of resources make the diversified system more preferable compared to the monocrop production system.

Five different types of livestock were kept by the respondents, these included: Cattle, sheep, goats, chicken, and bees. The type and number of animals kept by the respondents is given in Table 8.

Table 8

Type and number of livestock kept by the respondents

Livestock	Number of animals			
	None (0) (%)	1-5 (%)	6-10 (%)	Above 10 (%)
Cattle	7.6	86.4	6.1	0
Sheep	53.0	39.4	6.1	1.5
Goats	74.2	22.7	3.0	0
Chicken	19.7	39.4	18.2	22.7
Bee hives	83.3	10.6	4.5	1.5

(N=150)

A majority (92.5 %) of the respondents kept cattle, followed by chicken by (80.3 %) and sheep (47 %). There were fewer of the farmers that kept goats (22.7 %) and those engaging in beekeeping (16 %). The climate of Mauche is too cold and therefore less suited to the keeping of goats. Farm level climate change adaptation strategies entail establishing crop/livestock mixed systems (Ayanwuyi, Kuponiyi, Ogunlade & Oyetoro, 2010). The people in this study area generally exhibited this trend.

Information on sources and amount of income was gathered from respondents in order to gauge variations existing within the households. Income earned by the farmers is crucial as it determines the investments the farmers can initiate. The sources and the amount of income earned by the farmers are summarized in Table 9.

Table 9

Sources and amounts of income

Income sources	Income categories (K.Shs)					
	None (%)	**<10,000 (%)**	**10,000-30,000 (%)**	**30,001-50,000 (%)**	**50,001 70,000 (%)**	**Over 70,001 (%)**
Livestock	13.6	7.6	40.9	22.7	4.5	10.6
Crop	0	3.0	33.3	22.7	10.6	30.3
Salary	0	1.5	1.5	0	0	4.5
Small scale business	77.3	6.1	10.6	1.5	0	4.5
Relatives / lenders	90.9	4.5	4.5	0	0	0
Others	97.0	1.5	1.5	0	0	0
Total	**0**	**9.1**	**19.7**	**31.8**	**34.8**	**4.5**

(N = 150)

The respondents relied on six different sources of income, which could be classified into two main categories: farm income and non-farm income. Farm income included income from livestock and crops, while non-farm income included incomes from employment salary, small scale business and relatives. Income from the farm formed the highest portion of the farmer’s income.

Income category of K.Shs 50,000 and 70,000 annually accounted for 34.8 per cent of the respondents, whereas those earning between K.Shs 30,000 and 50,000 formed 31.8 per cent of the sampled households. The respondents who earned less than K.Shs 10,000 (9.1 %) had low income and could be considered to be poor. According to Ali and Erenstein (2016), wealthy households tend to adopt climate change adaptation strategies because of their ability to invest capital in new technology and methods to adapt to climate risks.

From the feedback session with farmers, it came out clearly that farmers do not cost the food consumed in the households which is largely produced on the farm and hence perceived as free. According to Diiro (2013), off-farm earnings may induce technology adoption by providing farmers with capital for purchasing inputs.

4.3 Climate Change Related Challenges, Adaptation Strategies and knowledge gaps in Smallholder Potato Production

The second objective of the study was stated as:

To determine the climate change challenges, adaptation strategies and knowledge gaps in smallholder potato production in Mauche Ward of Nakuru County.

To fulfill this objective, key informant interviews and a baseline survey were carried out. The key informant interviews targeted organizations deemed to have special knowledge, education or awareness and have contributed to climate change adaptation initiatives. The aim of these interviews was to seek expert opinion on the impacts of climate change and how to increase climate change resilience and adaptive capacities of vulnerable communities with particular focus on smallholder potato producers.

The survey was carried out using a semi-structured questionnaire to obtain information from farmers regarding the following aspects related to climate change in their area: (i) Farmers' perceptions on the occurrence of climate change indicators, (ii) Farmer Strategies to Cope with Climate Change, (iii) Sources of information on climate change, (iv) Organizations training farmers on climate change and (v) Level of knowledge acquired on the listed climate change adaptation strategies for potato production.

4.3.1 Climate Change Adaptation Initiatives by Key Organizations in Kenya

A cross section of organizations dealing with agriculture and climate change was sampled for expert opinion on the challenges associated with climate change and adaptation interventions in place, with particular reference to potato production. These included the Climate Change Unit of the State Department of Agriculture, Kenya Agricultural and Livestock Research Organization (KALRO) Tigoni, International Potato Centre (CIP), Kenya National Potato Council (KNPC), Kenya National Farmers' Federation (KENAFF), Agricultural Development Corporation (ADC) Molo, Agricultural Technology Development Centre (ATDC) Nakuru and Njoro canning factory. The aim was to obtain information on climate change challenges and coping strategies, climate change policy framework, achievements and gaps in climate change adaptation.

A key informant at KALRO Tigoni identified constraints faced by potato farmers that have become complicated due to climate change. These include diseases such as bacterial wilt, early and late blight; insect pests eg aphids; lack of clean potato seed and poor market access. KALRO has come up with farming strategies which may enhance adaptive capacity in the face of climate change and climate variability. These include early sprouting of seed potato which leads to fast establishment, hence early maturity. Several blight tolerant varieties have been developed and released such as K. Sherekea, K. Mavuno and Purple gold. Other strategies include development of heat and drought tolerant varieties; mulching to reduce soil temperature and moisture loss; early planting; manipulation of seed size at farm level - smaller seeds tend to have increased seedling mortality as opposed to large seeded material. Larger seeds enable fast establishment of the canopy.

Pit storage of ware potatoes has also been used to sustain adequate supply during the dry spell. Inter-cropping potato with other crops eg maize, peas and beans is a common practice in Central Province around Limuru. Other innovative research carried out at KALRO include use of hormones to suppress sprouting hence sustaining supply of potato seed for a relatively longer time; use of diffused light in seed storage and use of hydroponics to produce miniature seed for further multiplication by seed producers such as the Agricultural Development Corporation, Molo.

The International Potato Centre (CIP) in Nairobi has partnered with the Government of Kenya to promote the potato as a strategic food security crop. The CIP respondent reiterated that so far there was no drought tolerant potato variety that had been released, but several lines were being evaluated for drought tolerance.

The State Department of Agriculture has put in place a Climate Change Unit (CCU) whose overall objective is to roll out the Department's part of the National Climate Change Response Strategy (NCCRS) and mainstream Climate Change adaptation and mitigation in all agricultural programmes, projects and activities. A key informant at the CCU of the State Department of Agriculture explained as follows:

> “*NCCRS has provided for establishment of climate change focal points in government ministries and agencies with a view to networking, collaborating and sharing information in meetings and fora on matters of climate change adaptation and mitigation.The shared resolutions are then customized for implementation by respective ministries or agencies to enable them meet their goals as well as ensure sound environmental management, climate change adaptation and mitigation*”.

According to the CCU, climate change related challenges in Kenya are widespread and include environmental hazards such as floods, landslides, prolonged droughts and attacks by crop pests which have contributed to increased frequency of crop failure and the country’s food insecurity. The worst drought in Kenya was experienced in 2000-2001 and it was declared a national disaster on 13^{th} June, 2000. The prolonged drought caused widespread crop failure, famine and malnutrition which affected 4.7 million people. The most recent drought was experienced in the country in 2008/2009 and more than 10 million people experienced starvation. The Government imported over 2.6 million bags of maize worth 6.7 billion Kenya Shillings to bridge the food deficit.

Dry spells in Kenya are invariably followed by floods. The flooding of 2003 was particularly intense and was declared a national disaster on 6^{th} May, 2003. The most recent floods were experienced in 2009 and affected the pastoral plains of the northern and northeastern part of the country, the Nyando River and Nzoia River plains in the western part of the country. On all occasions, the floods submerged farmland, reduced crop yields and exacerbated food insecurity occasioned by drought. Although the State Department of Agriculture has committed to promote sustainable land use and environmental conservation to address the challenges and impacts of climate change, the CCU is faced with various challenges. These include inability to fulfill its mandate due to inadequate resources and lack of structural arrangement – since climate change mitigation and adaptation falls under the docket of the Ministry of Environment and Mineral Resources.

A key informant at the National Potato Council of Kenya (NPCK) described NPCK as a Public Private Partnership (PPP) and a multi-stakeholder outfit that has the responsibility of planning, organizing and coordinating activities along the potato value chain. Its range of stakeholders includes local and international research institutions, extension service providers, farmer organizations, potato seed and ware producers; financial institutions, universities, agribusiness entities including processors and entrepreneurs; and development partners. Its intervention in climate change mitigation and adaptation is creation of a platform for information management, capacity building for various potato value chain actors and policy debate. The main climate change related potato production challenges include blight, bacterial wilt and aphids. NPCK promotes climate change adaptation technologies such as the aeroponic technology, potato seed plot and positive selection in collaboration with CIP and KALRO Tigoni.

The Kenya National Farmers' Federation (KENAFF) is the umbrella farmers' federation representing interests of 1.8 million farm families according to a key informant representing the organization. Besides being the legitimate farmers' voice in Kenya, KENAFF has taken on board the climate change issue through its Department of Environmental Management and Renewable Energy. The Department focuses on environmental preservation, conservation and increased use of renewable energy as a way of mitigating and adapting to climate change. It also coordinates implementation of the Kenya National Domestic Biogas Programme (KENDIP) by promoting the installation of over 15000 domestic biogas plants by 2014.

A respondent at a major local processor of agricultural produce, Njoro canning factory, was concerned that erratic rains led to increased pests and diseases which lowered the quality of produce delivered to the factory. On the other hand, with increased rains it took longer for crops to ripen in the farms and supplies to the factory was not obtained as scheduled.

Despite interventions by the varius actors, climate change awareness is still low especially in the rural areas where there is high dependency on rain fed agriculture and climate sensitive natural resources (Ojwang, Agatsiva & Situma, 2010). The loss of crops and productive assets that results from unexpected periods of water surplus or deficit constrains the ability of vulnerable populations to access sufficient and adequate food security and incomes (Ringler, 2011). Vulnerability assessments and resilience analyses reveal the need for a large range of strategies to enhance regional resilience (Marshall et al., 2009).

4.32 Farmers' Perceptions on Occurrence of Climate Change Indicators

Respondents were asked to give their perception on occourance of selected climate change indicators. The respondents were asked to rate the incidence of occurrence of eleven climate change indicators using a 5-point Likert scale ranging from 'Very low' indicating a very minor occurrence to Very high indicating a common occurrence. The results of the ratings are given in Table 10.

Table 10

Rate of occurrence of indicators of climate change

	Percent of Respondents				
Indicators of climate change	**Very low**	**Low**	**Moderate**	**High**	**Very high**
Rainfall seasonality changes	4.5	22.7	57.6	10.6	4.5
Temperature trend changes	9.1	18.2	37.9	30.3	4.5
Water quality and quantity	4.5	25.8	43.9	13.6	12.1
Forest cover change	19.7	21.2	28.8	22.7	7.6
Soil fertility change	7.6	34.8	39.4	12.1	6.1
Natural resources reduced	33.3	19.7	16.7	21.2	9.1
Effect on human health	4.5	15.2	33.3	37.9	9.1
Pest and disease increase	4.5	3.0	16.7	48.5	27.3
Crop yields reduced	6.1	19.7	28.8	30.3	15.2
Fodder reduction	6.1	22.7	37.9	22.7	10.6
Fire incidence increase	60.6	18.2	13.6	3.0	4.5

(N=150)

Although the indicators were there, the farmers exhibited lack of a clear perception of the indicators of climate change. The indicators that were rated highly (high and very high combined) by the farmers in terms of their occurrence included: increase in crop diseases and pests (75.8 %), effect on human health (47 %) and reduction in crop yields (45.5 %). Climate change may increase the impact of pests by allowing their establishment in areas where they could previously not establish (Van Aelst & Holvoet, 2017). Due to climate change, pests and diseases are likely to move into areas less prepared to them, biologically and institutionally, with potentially higher negative impacts. Climate change may also increase the impact of pests by allowing them to appear earlier in the season due to higher temperatures (Connolly-Boutin & Smit, 2015).

The effect of climate change on crop yield depends on temperature, precipitation patterns and atmospheric carbon dioxide. Inadequate precipitation leads to reduced rate of leaf photosynthesis, hence reduced production (Van Aelst & Holvoet, 2017). Indirect effects of climate change on crop yields occour as a result of invasive weeds, scarcity of useful insect species such as pollinators, increasing pests and disease vectors.

During the feedback session with the respondents, it came out clearly that climatic conditions affect human health both directly, through ailments such as malaria and infectious diseases transmitted by vectors and pathogens that thrive with increase in temperature and indirectly, through influences on the levels of pollution in the air and water sources. On the other hand, dry spells led to scarcity of nutritious indigenous African leafy vegetables such as black nightshade (managu), amaranthus (terere), spider plant (saget) and pumkin leaves (malenge) that are also known to be medicinal. This concurs with Darkwa and Darkwa (2013) and Kimiywe et al. (2017) that the dietary diversity of indigenous African leafy vegetables provide essential nutrients and in addition, have medicinal value and may be used to treat diseases such as diabetes, gout and gastro-intestinal tract infections among others.

Rainfall seasonality is seen as a challenge as it is manifested in unpredictable onset, which affects timeliness in farm operations. Increase in rainfall causes flooding which affects quality of water sources impacting negatively on human health and expected agricultural productivity. It also causes severe soil erosion on farms hence reduced soil fertility. Climate change in the study area is associated with rampant incidence of potato pests and diseases which lead to reduced crop yields. Due to intermitent rainfall, natural resources have been reducing consistently especially forest cover, pasture and fodder for livestock. Spontaneous fires often occur during the drought period causing massive destruction of flora and fauna. This concurs with Elum, Modise & Marr (2017) that climate change impacts are felt by those whose livelihoods depend on natural resources.

4.3.2 Farmer Strategies to Cope with Climate Change

There were a number of possible adaptive responses available to deal with climate change in the study area. These included technological options such crop diversification, use of drought-tolerant and early maturing varieties; as well as behavioral responses such as timely planting. The respondents did not demonstrate adequate application of available climate change adaptation options to reduce vulnerability or enhance resilience. It was only in the areas of disease control (26%) and timely planting (24.7%) where they made an effort. Crop diversification was adopted by 16.7 per cent of the respondents. Although 14 per cent of the respondents indicated undertaking water harvesting, only 5 per cent practiced irrigation. This is in agreement with Michura and Njuguna (2017) that there is low uptake of adoption of climate smart technologies in Nakuru County since adoption of these practices by smallholder farmers remains below expectations.

Smallholder farmers lack resources to adequately protect themselves or adapt rapidly to changing weather conditions (Arumugam et al., 2014). Mitigation and adaptation to climate change are necessary to ensure food security, which is requisite for sustainable economic development (FAO, 2015b). Although the extent to which a system will adapt is a function of its vulnerability to climate change which is in turn influenced by its level of exposure and sensitivity to climate change impacts (Elum, Modise & Marr, 2017), it can be argued that some adaptation interventions require policy and infrastructural support in order to be adopted. For instance, water harvesting and irrigation may not be implemented by farmers in Mauche without the necessary capital investment by the National Government and County Government of Nakuru. On the other hand, use of tolerant and early maturing potato varieties may be adopted if the seeds are adequately availed to the farmers at affordable prices. Beddington et al (2012) asserts that widespread uptake of sustainable practices in agriculture and food supply chains is requisite in meeting current and future threats to food security and environmental resilience.

4.3.3 Sources of information on climate change

The institutions that provided the respondents with information on climate change were recorded. The respondents exhibited inability to obtain information from available sources. Their major sources of climate change information were the Nakuru County Department of Agriculture (42.7 %), followed by the mass media (36.7 %), whereas 13.6 percent did not receive any information on climate change at all. It is necessary to obtain information on the positions of rural farmers and what they know about climate change, in order to integrate this knowledge with available technologies and come up with relevant climate change adaptation practices (Mutekwa, 2009).

Acquisition of information about a new technology determines adoption of the technology. Farmers will only adopt a technology they are aware of, and its benefits demonstrated. Access to information reduces the uncertainty about a technology's performance, hence may change an individual's assessment from purely subjective to objective over time (Bonabana-Wabbi 2002). However access to information about a technology does not guarantee its adoption by all farmers. Farmers may perceive the technology and subjectively evaluate it on the basis of its complexity, cost effectiveness and compatibility with the existing practices on the farm.

Access to information may also result to dis-adoption of the technology. For instance, where experience within the general population about a specific technology is limited, more information induces negative attitudes towards its adoption, probably because more information exposes an even bigger information vacuum hence increasing the risk associated with it (Bonabana-Wabbi 2002). It is therefore important to ensure the information is timely, reliable, consistent and accurate. Farmers can only adopt a technology if they are sensitized on how to use it and its benefits.

4.3.4 Organizations training farmers on climate change

There was evidence of lack of training and unclear knowledge acquisition on climate change given that a majority of the respondents (50.7 %) reported not having received any training. The main institutions that had conducted some climate change training in Mauche Ward were the County Department of Agriculture (30.7 %) and Smallholder Farmer Strategies to Cope with Climate Change (SMACC) project (16.6%), which was relatively new in the study area. The respondents cited the Department of Agriculture as a major institution training farmers on climate change due to the close interaction the department has with farmers. The department had carried out some training related to crop diversification (36.7 %), water harvesting (5.3%), timely planting (4.1 %), and planting of drought tolerant varieties (3.3%). Extension workers usually provide information on crop production technologies and market opportunities.

Emphasis on crop diversification as a climate change adaptation strategy is essential since it is imperative to protect the livelihoods of communities as well as sustain food security. Studies conducted in several parts of East Africa indicate that women have the lowest access to climate information in general and yet they are the main players in agricultural production (AGRA, 2014). Chesterman and Neely (Eds) (2015) noted that climate-smart agriculture practices are not enough on their own: they need to be delivered in association with climate-related information targeting farmers such as when to plant, crop choice, varieties to plant and management practices. Barriers to adaptation that need to be addressed include lack of access to resources and knowledge needed for adaptation (FAO, 2014a).

4.3.6 Level of Knowledge Acquired on the Listed Climate Change Adaptation Strategies for Potato Production

There is need to understand farmers' knowledge of existing climate change adaptation strategies for potato production. Such information is important for designing and implementation of a suitable intervention. The respondents were asked to indicate the level of knowledge acquired on the climate change adaptation strategies for potato production on a five point Likert Scale. Table 11 presents their responses.

Table 11

Level of knowledge acquired on climate change adaptation strategies

	Percent Respondents				
Knowledge items	**Very Low**	**Low**	**Medium**	**High**	**Very High**
Use of organic fertilizer	21.2	18.2	40.9	15.2	4.5
Use of intercropping	10.6	18.2	43.9	19.7	7.6
Relay cropping	22.7	16.7	42.4	15.2	3.0
Crop rotation	6.1	7.6	42.4	16.7	27.3
Control of potato diseases	1.5	6.1	45.5	21.2	25.8
Post-harvest management	10.6	15.2	40.9	21.2	12.1
Storage of potatoes	12.1	12.1	47.0	15.2	13.6

(N=150)

Climate change adaptation builds on existing efforts to achieve sustainable agriculture intensification for sustainable productivity increases, thereby supporting the achievement of national food security and sustainable development goals (FAO, 2016b). Despite this fact, the respondents generally exhibited inadequate knowledge on the listed climate change adaptation strategies, except in the areas of potato diseases control (47%), crop rotation (44%), potato post-harvest management (33.3%) and use of intercropping (27.3%) when high and very high levels of knowledge were combined. This concurs with Ngo et al (2016) that farmers' access to climate change information is limited.

The respondents expressed confidence in their ability to identify and control potato pests and diseases having received training from the local agricultural extension workers. During the feedback session with the farmers, it emerged that the most common potato diseases in Mauche were bacterial wilt, late blight and viruses; whereas important pests included potato tuber moth and aphids. Farmers controlled potato pests and diseases using pesticides and fungicides purchased from agro-chemical shops in Mauche and Mau-Narok markets. These agro-chemicals are prone to misuse by farmers hence, as suggested by Okonya and Kroschel (2016), there is need to train farmers on more environmentally friendly approaches such as integrated pest management (IPM) and organic soil nutrient management (FAO, 2016a).

Crop rotation entails planting different crops in the same field following a defined order; usually the preceding crop has a positive effect on the succeeding crop in the rotation, leading to higher production. Practicing rotation leads to reduced risk of pest and weed infestations; better distribution of water and nutrients through the soil profile; exploration for nutrients and water of diverse strata of the soil profile by roots of many different plant species, resulting in a greater use of the available nutrients and water; increased nitrogen fixation through certain plant-soil biota; improved balance of nitrogen, phosphorus and potassium (N-P-K) from both organic and mineral sources; and increased formation of organic matter (FAO, 2016b). Better nutrient management through crop rotation can decrease nitrogen fertilizer use by up to 100 kg N per hectare per year, substantially lowering related greenhouse gas (GHG) emissions – hence reducing the costs of production.

Post-harvest management of potato is crucial, due to its perishable nature. During the feedback session with the farmers, it came out clearly that post-harvest losses occour during manual harvesting due to splits and damage on the tubers caused by the harvesting hoes as well as left overs in the field. Use of inappropriate multi-purpose stores accelerates spoilage and sprouting, making it necessary for the farmers to dispose of the potato very fast, rendering them vulnerable to exploitation by potato cartels. This agrees with Tolno et al (2016) that potato Post-harvest losses are excessive due to inadequate harvesting techniques, combined with improper storage, packaging, and transport.

Intercropping refers to the cultivation of two or more crops together in time and space, with the aim of maximizing productivity per land area using only few external inputs (FAO, 2013). Intercropping can strengthen the climate change adaptive capacity of households. It increases soil nutrient and protein self-sufficiency as well as conservation and maintenance (Ratnadass, 2012). Reduced pathogen and insect pest infestation levels have been reported in several crop and variety mixtures (Himanen et al., 2016). The main challenges associated with intercropping are related to the lack of information on crop variety performance and optimal yielding in mixtures, crop post-harvest management and the economic risks associated with experimenting with novel mixtures.

4.4 Analysis of Household Practices of Smallholder Potato Farmers

The third objective of the study was stated as:

To analyze household practices of smallholder potato farmers in Mauche Ward of Nakuru County.

The study investigated household practices of sampled smallholder potato farmers with specific
focus on: (i) Access to potato seed (ii) Motivation for growing potatoes (iii) Potato storage
(iv) Household food sufficiency (v) Potato consumption at household level
(vi) Potato marketing (vii) Water conservation (viii) Sources of household energy

4.4.1 Access to Potato Seed

Access to potato seed by the respondents was assessed based on the source of seed and availability to the farmers. Source of quality and certified potato seed was a major constraint in Mauche Ward. There was no structured seed supply and distribution system. A majority of the farmers (47.3 %) identified open air markets as their main source of potato seed. Farmers saving their own seed accounted for 34.7 percent whereas 8 percent acquired seed through their self-help group. Farmer-to-farmer exchange of seed accounted for 6 percent. Research centres such as KALRO and the Agricultural Development Corporation (ADC) Molo which is a major seed multiplier in the region supplied seed to 2 percent of the respondents each.

During a focus group discussion, it became clear that farmers mainly planted seed from unknown market sources or saved their own seed. This is a common occurrence in other parts of the country (Muthoni, Shimelis &Melis, 2013) and in the Eastern Africa region (CIP, 2011). In Kenya, Uganda and Ethiopia farmers are known to renew their seeds after six, seven and three seasons respectively (Gildemacher, 2012).Because of inadequate clean seed, most of the seed planted by the farmers is not certified and the quality is not guaranteed (Gaur, 2010;Gebru et al., 2017)), hence the potential risk of introducing pathogens or pests (Pandey, 2009). Plate 1 illustrates the open air potato market at Mauche.

Plate 1: Open air potato market at Mauche – Photo taken by Rael Taiy on 2/7/2014

Availability of seed was a major issue. Farmers who obtained potato seed in the quantities required every year constituted 53.3 percent of the respondents compared to 46.7 percent who did not. High price of potato seed and unavailability of seed at the right time were cited as the main reasons for not getting the right quantities of seed.

4.4.2 Motivation for Growing Potatoes

The study further attempted to understand what motivates the farmers to grow potato given that Mauche is a high potential area and a wide variety of crops can do well. A majority of the respondents were motivated to grow potato due to high consumer demand (80.7%) as well as high demand for potato seed (15.3%). Potato is grown in Mauche mainly as a cash crop to enable the households to meet their financial obligations. The staple food crop in the area is maize. During the feedback session, farmers indicated that the main variety of potato grown is Shangi. Tigoni and Kenya Mpya are also grown to a limited extent. Their choice of shangi is determined by high yield, shorter maturity time, marketability, disease resistance and good taste. Shangi matures after three months and allows up to three crop cycles within a year.

4.4.3 Potato Storage

Majority of the respondents (65.3%) indicated that they store their potato seed by spreading it on dry grass in the store, 21.2 percent said that they kept the potato seed in bags in darkness while 10.6 percent said that they spread the seed on the floor under shed. Spreading ware potato (for household consumption and sale) on dry grass in the store was a storage option for 54.7 percent of the respondents; 21.2 percent kept it in bags while 19.7 percent of them just left the potatoes in the farm and removed it whenever they needed to use it.

Mauche farmers have multi-purpose stores that cater for all household items including farm implements and bicycles. Appropriate potato storage using locally available materials has been a major area of focus during the farmers' trainings. Although potato is a perishable commodity, good storage can be a climate change adaptation strategy as it ensures continuous availability of ware potato as well as seed. Appropriate storage is necessary to maintain good quality of potato, which is an important factor in optimizing productivity (Biniam et al, 2014). It is requisite for food security. As noted by Tripathy and Mishra (2016), climate change affects all four dimensions of food security namely: food availability, stability of food supplies, access to food and food utilization. Plate 2 is a typical storage facility in Mauche.

Plate 2: A farmer admires a potato tuber in a multi-purpose store – photo by Rael Taiy on 3/7/2014

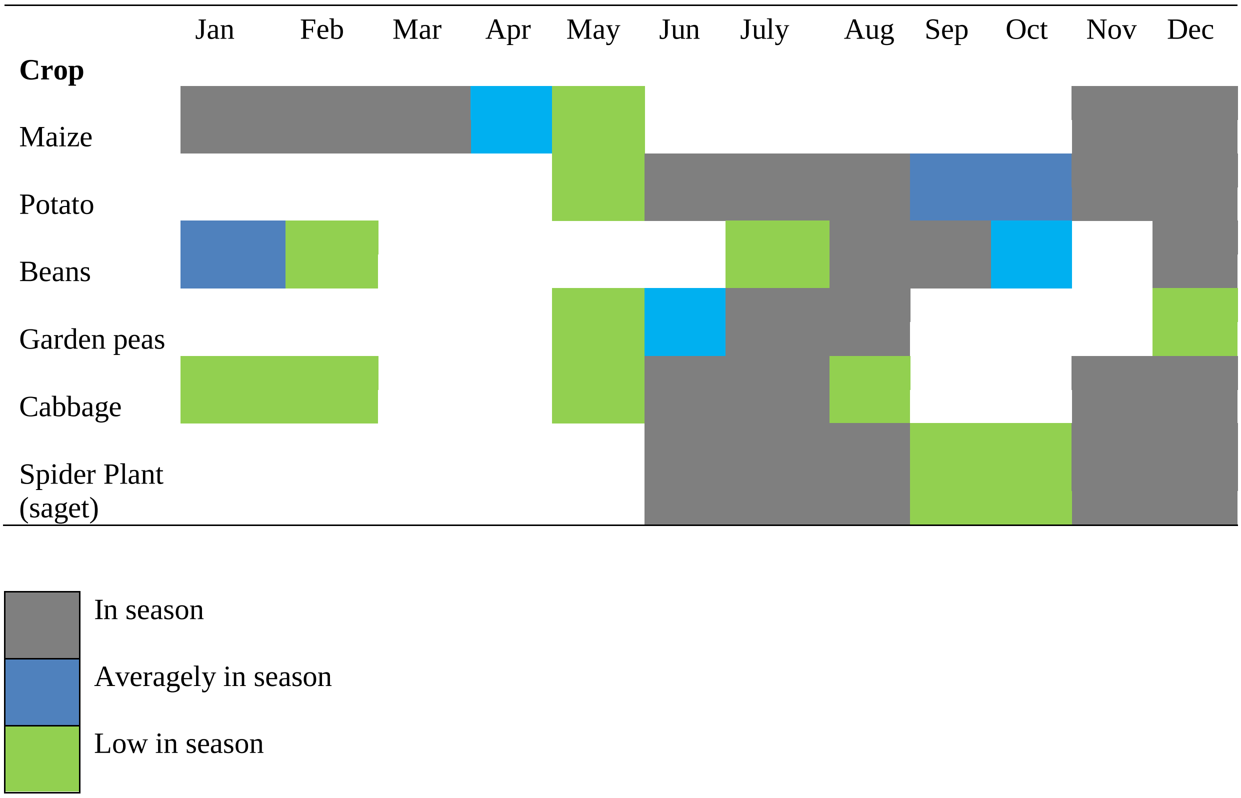
4.4.4 Household Food Sufficiency

Household food sufficiency was chosen as a parameter to measure availability of food in the right quantity and quality. Food insecurity and food shortages are often experienced by poor people living in rural communities either during parts of the year or throughout the entire year.

Table 12 is the crop calendar for Mauche Ward as illustrated by the farmers.

Table 12

Crop calendar for Mauche Ward



Respondents claiming that their households have sufficient food were 60.7 percent while 39.3 percent do not have sufficient food. During the feedback session with the farmers, household food insufficiency was mainly attributed to low yields due to soil degradation and post-harvest loses as a result of inadequate storage. These may be addressed by crop rotation or inter-cropping with nitrogen fixing crops as well as construction of adequate stores at farm level. The farmers clarified that in most cases what is perceived as shortage of food refers to shortage of maize since it is a staple food in the study area. As illustrated in Table 14, shortage of maize is common during the months of June to October when potato, beans, garden peas and vegetables such as cabbage and spider plant are in abundance.

Potato is a special staple food crop in several communities in Kenya, only second to maize (Muthoni & Nyamongo, 2009). The respondents were asked whether they use potato as a major food item in the household. The study revealed that 77.3 per cent of the respondents use potatoes in their households. The respondents not utilizing potatoes cited various reasons which included low preference for potato as food, preference to sell it as a cash crop and lack of knowledge and skills on how to prepare food recipes from potato. This concurs with Sebatta et al. (2014) that having other food sources in the farmer's household has a positive effect on the decision to participate in the potato market. This is due to the fact that potato being a food as well as a cash crop, presence of other sources of food ensures surplus potato oriented towards the market.

4.4.5 Potato Marketing

Integration of climate change adaptation strategies in potato production must be supported by a structured marketing system that enables farmers get better returns on their investment. To gain a better understanding of the marketing of potatoes, the respondents were asked if they had any constraints in marketing their potato. A significantly large number of respondents (89.3%) indicated that they had constraints in marketing their potato while only 10.7 percent reported having none. The respondents were further asked to either agree or disagree with eight statements relating to the different constraints to the marketing of potatoes using a 5-point Likert scale. Their responses are highlighted in Table 13.

Table 13

Potato Marketing Constraints

	Percent Respondents				
Marketing Constraints	**Strongly Disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly Agree**
Low quality of produce	4.5	24.2	1.5	43.9	25.9
Low market price	0	1.5	0	54.6	43.9
Unavailability of market	4.5	25.7	6.1	47.0	16.7
Lack of market information	1.5	18.2	4.5	48.5	27.3
Difficulty in processing	3.0	12.1	6.1	43.9	34.9
Difficulty in storage	6.1	25.8	3.0	43.9	21.2
Poor transportation	3.0	13.6	3.1	45.6	34.8
Lack of collective organization	1.5	3.0	3.0	34.8	57.7

(N=150)

Low market price (43.9%) was found to be a major constraint in potato marketing followed by difficulty in processing (34.9%) and poor transportation (34.8%). Farmers respond to

higher prices that enable them get higher incomes from their produce. Farmers tend to study price trends over seasons and can appropriately predict and respond to the prices.
Sebatta et al. (2014) support this observation by stating that unfavorable prices may affect household incomes and consumption adversely.

Individual potato farmers in Mauche did not produce economic volumes for competitive marketing. As a result, farmers sold their potato through middlemen, resulting in inefficient marketing and high transaction costs. This, together with the domination of brokers and traders in the value chain, made the smallholder farmers prone to price fluctuations and exploitation by potato cartels that bought potatoes in extended bags. During the feedback session, farmers complained that traders extend the 110kg bag to 160kg and the 50kg bag to 80kg. Due to lack of collective marketing by the farmers they were not able to bargain for better prices. Lack of cold storage in Mauche aggravated the situation as potato is a highly perishable produce hence farmers were forced to dispose of the produce immediately after harvesting.

4.4.6 Sources of Household Energy

Sources of household energy is important in gauging the climate change adaptive capacity of the farmers. The respondents were asked to indicate their sources of energy in the household. Fuel wood was the main source of energy for the households in Mauche (100%). Very few respondents substituted fuel wood with cooking gas (9.3%). Solar energy was used by 5.3 percent respondents mainly for lighting. Use of charcoal and electricity were limited due to deforestation and inadequate electricity connectivity in Mauche. Dependence of fuel wood aggravates depletion of the tree cover in Mauche and this has contributed to climate variability and climate change.

4.5 Establishment of a Collective Learning Community for climate change adaptation

This section presents results for the fourth objective which was stated:

To establish a Collective Learning Community for climate change adaptation in Mauche Ward of Nakuru County.

The innovation process was spearheaded by a Collective Learning Community, a platform consisting of representatives of key actors with high influence on the potato value chain in

Mauche. As noted by Chesterman and Neely [Eds] (2015), inclusiveness, contextualization and the importance of local dynamics should be embodied to ensure sustainability of climate smart agriculture (CSA) interventions. Furthermore, CSA is context specific and must be developed within social and cultural norms.

An inception workshop was therefore held to introduce the project in the study area, identify and enlist all actors at all segments of the potato value chain. The actors included farmer groups, input suppliers, transporters, traders, processors, researchers, extension service providers, faith based organizations, non-governmental organizations and local administrators. Common needs were identified, roles defined and linkages established between partner institutions.

The CLC network facilitated knowledge generation and knowledge sharing for climate change adaptation, monitoring and evaluation of the innovation process. This was achieved through workshops, field visits, trainings and public presentations. Farmers and stakeholders in the CLC were engaged through participatory forums to obtain an insight into local and regional knowledge as well as farmer experiences. The CLC approach was intended to strengthen the ownership of project findings and secure a continuous use of project results.

Establishment of the CLC for climate change adaptation in Mauche comprised of two main processes:

i) Process of CLC formation

ii) Activities carried out by the CLC

4.5.1 Process of CLC formation

The essence of CLC formation was to provide a demand driven engagement framework for multi-sectoral and trans-disciplinary co-learning across research, extension and implementation of climate change adaptation interventions in Mauche. The process of CLC formation entailed profiling of the study area, potato value chain analysis, stakeholder analysis, inception of the Smallholder Farmer Strategies to Cope with Climate Change (SMACC) project and constitution of the CLC membership.

4.5.2 Profiling of the study area and problem identification

Profiling of the study area was done at the onset with a visit to the Sub-County agricultural office at Njoro that provided basic data and introduced the SMACC team to the Mauche Ward Agricultural Office. The extension officer in charge of Mauche Ward assisted in purposive sampling of a farmer group to participate in problem identification using the Problem Tree analysis. This is a participatory tool used to carry out situational analysis. It provides a pictorial representation of the main problems, along with their causes and effects as well as the strategy of how to solve them in order to address the real needs of beneficiaries (Overseas Development Institute, 2009).

The problem tree analysis was carried out in a group discussion involving 18 farmers, 2 researchers and the area extension worker, with the aid of a flip chart. The first step was to discuss and agree on climate change as the core problem to be analysed. The problem was written in the centre of the flip chart and became the ‘trunk’ of the tree. Next, the group identified the causes of the focal problem – these become the roots. They then identified the consequences, which become the branches. There was a lot of discussion as factors were arranged and re-arranged.

The Problem Tree was later converted into an Objective Tree by rephrasing each of the problems into positive desirable outcomes. The root causes were turned into root solutions influencing the desired change, which was climate change adaptation. Plate 3 depicts a farmer leading other farmer in Problem Tree and Objective Tree analysis.

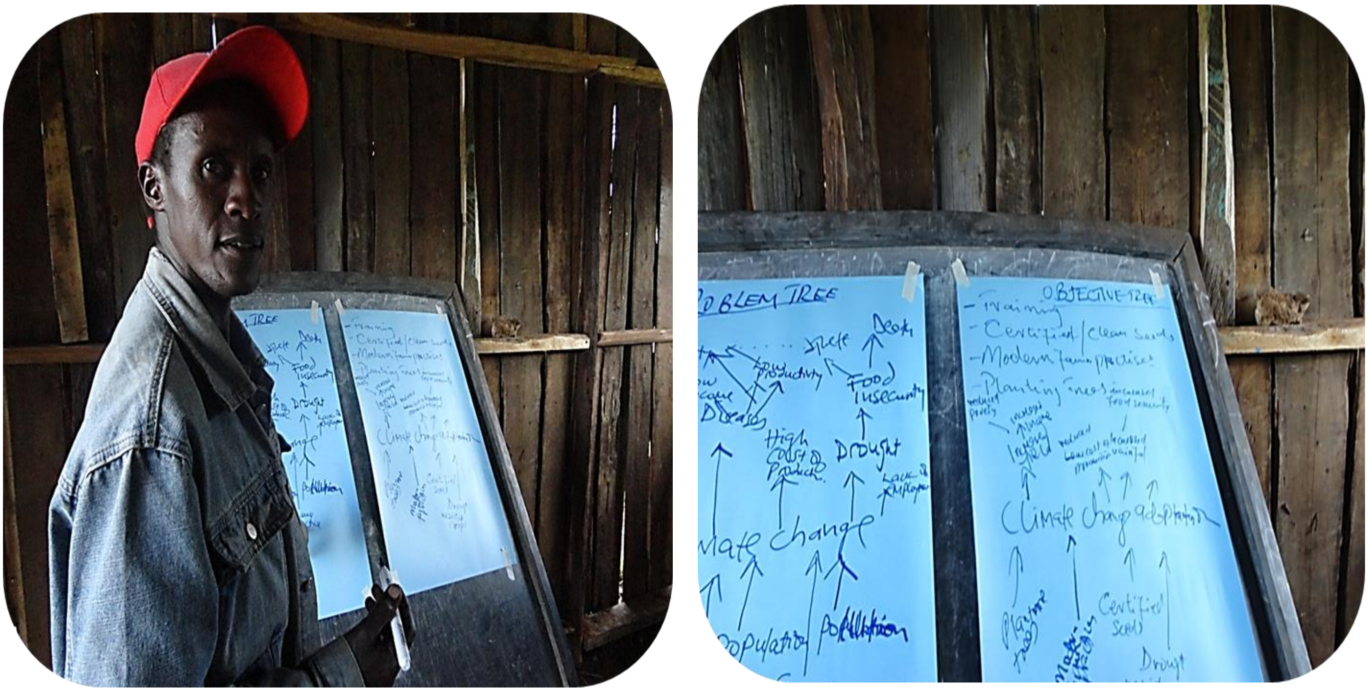


Plate 3: A farmer leading other farmers in Problem Tree and Objective Tree analysis – photo by Rael Taiy on 16/4/2013

The core problem was climate change exhibited by variability in rainfall pattern in the recent past. The on-set of the rains was no longer predictable and this had affected farm operations. The farmer group cited the major causes as rampant felling of trees in Mauche; inadequate extension services leading to poor agricultural practices, especially ploughing on the slopes without adequate soil conservation measures; poor soil fertility due to soil erosion; pollution of water sources when there is excess run-off during the rainy season and increase in population which had led to land sub-division and destruction of soil conservation structures. The effects of these changes ultimately led to unemployment, food insecurity, low productivity and low investment.

For clarity and legibility, the Problem Tree generated from the discussion with the farmers was digitized as presented in Figure 9.

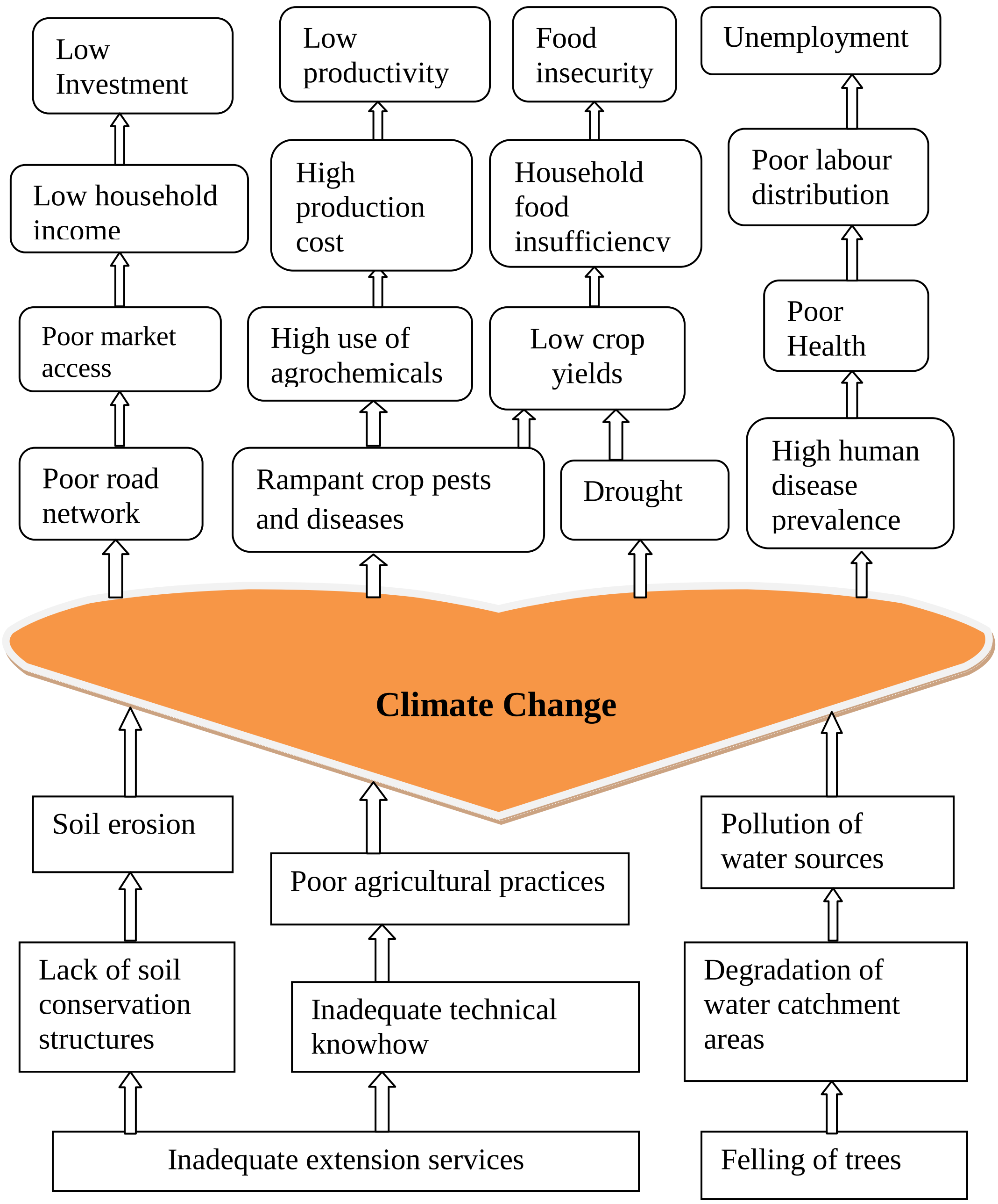


Figure 9: Problem Tree

The problem tree was converted into an objective tree (Figure 10) that suggests solutions to the identified issues. The key highlights in the objective tree included provision of adequate extension services, establishment of farm conservation structures and good agricultural practices. More trees should be planted to restore water catchment areas and protect water sources. The ultimate aim is climate change adaptation requisite for creation of employment opportunities, food security, high productivity and high investment.

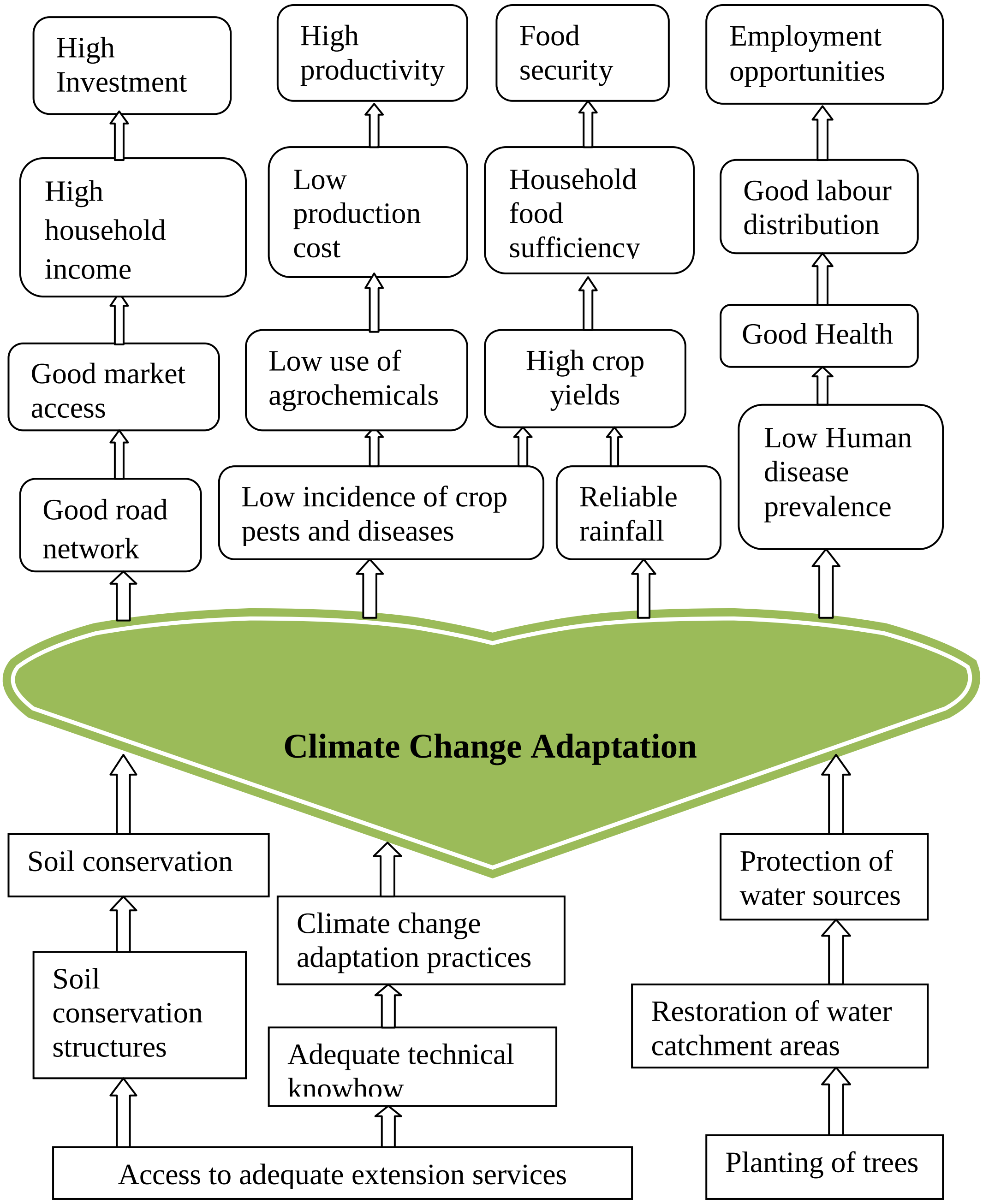


Figure 10: Objective Tree

Mauche Ward has witnessed diminishing of the vegetative cover over the years due to deforestation and limited tree planting initiatives. Plate 4 shows the extent of deforestation and poor agronomic practices in Mauche.

Plate 4: Landscape of Mauche Ward, Nakuru County: deforestation and poor agricultural practices have contributed to climate variability and climate change - photo by Rael Taiy on 4/2/2013.

4.5.3 Potato Value Chain Analysis in Mauche

Value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), and delivery to final consumers and disposal after use (Kaplinski & Morris, 2003).

Value chain analysis is increasingly being used because of its focus on identifying opportunities and key constraints within the chain, and its potential to identify market based solutions that promote competitiveness (Donald, 2009). Value chain analysis reveals links between producers and markets; identifies constraints along the chain and clarifies the relationships between actors in the chain. This study analyzed the local potato value chain in Mauche. It sought to understand the real scenario on the ground in order to guide local actors come up with strategies for inclusion of smallholder potato farmers into the chain as well as improving linkages between potato farmers and other value chain actors for increased productivity and incomes.

Data collection was done in two phases. The first phase entailed use of topic guides for focus group discussions (FGDs) with potato value chain actors in Mauche Ward. Three FGDs were conducted with input suppliers, transporters and traders. In-depth interviews were conducted with ADC Molo, Njoro Canning Factory, supermarkets and restaurants with the aid of checklists. The key informant interviews and FGDs provided information on challenges and opportunities along the potato value chain in Mauche Ward. As noted by MacDonald (2012), topic guides and checklists provide extremely rich data with enormous potential for comparison.

The second phase of data collection was household survey using a pre-tested semi-structured questionnaire. The questionnaire captured socio-economic characteristics of smallholder potato farmers, their household practices, climate change challenges and adaptation strategies. Figure 11 presents the potato value chain in Mauche.

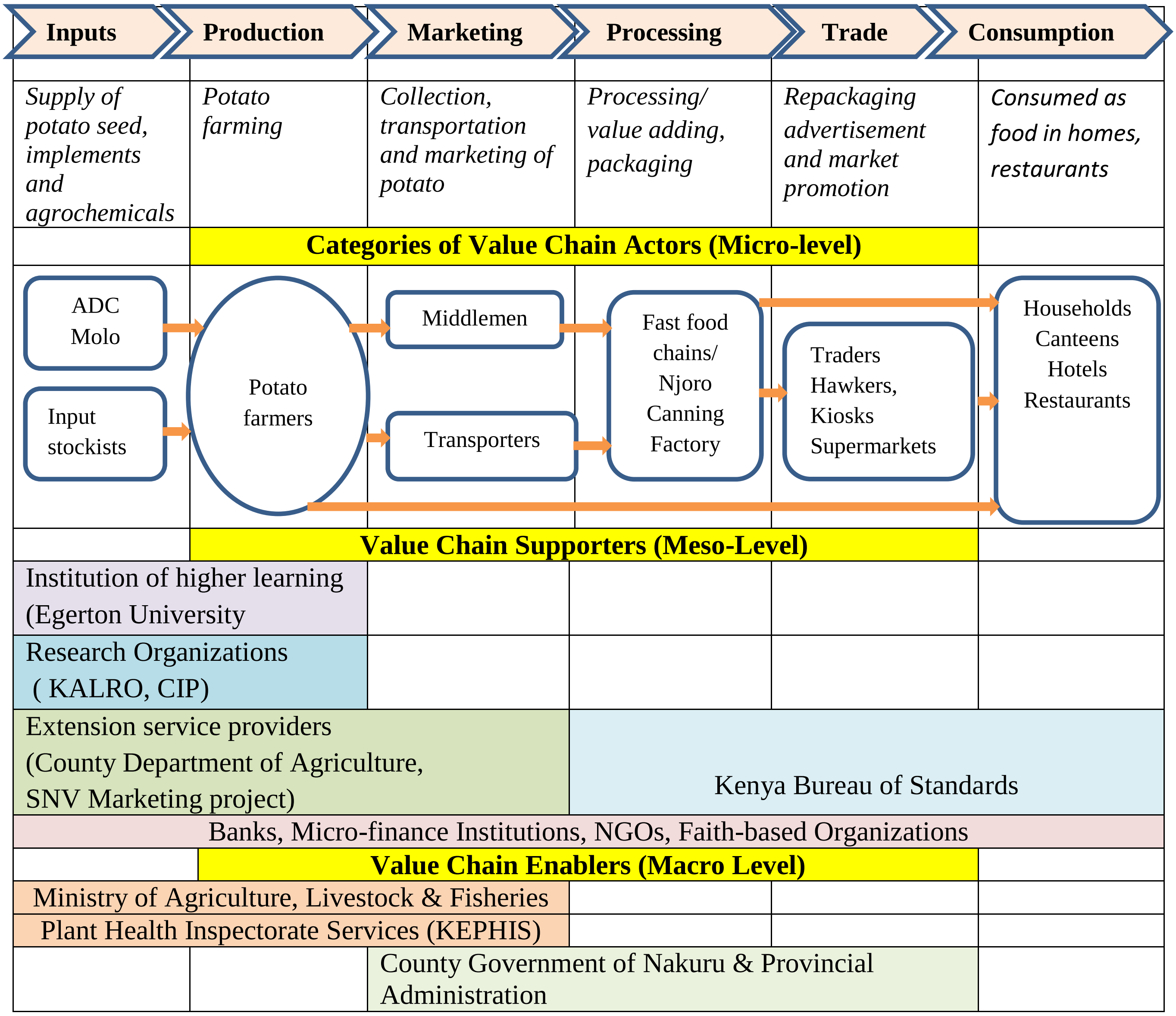


Figure 11: The potato value chain in Mauche Ward of Nakuru County

The primary actors in the chain were smallholder farmers, farm inputs suppliers, transporters, market intermediaries (traders and brokers), agro-processors, wholesalers, retailers and consumers. Value chain supporters at the meso-level included research organizations (Kenya Agricultural and Livestock Research Institute, International Potato Centre), institutions of higher learning (Egerton University), extension service providers (County Department of Agriculture), financial service providers, religious social organizations and Non-Governmental Organizations. Value chain Enablers at the macro-level were the regulators, policy makers (Kenya Plant Inspectorate Services and Ministry of Agriculture, Livestock and

Fisheries); and providers of resources and local administrators (Provincial Administration and the County Government of Nakuru).

i) Potato input supply

The potato value chain in Mauche began with the input supply, which mainly focused on supply of inputs and agro-chemicals for potato production. A majority (47.3 %) of the sampled farmers identified open air markets as their main source of potato seed, followed by private suppliers (34.7 %). Farmer-to-farmer exchange of seed accounted for 6 percent; farmers obtaining seed through their self-help group accounted for 8 percent; whereas ADC Molo and KALRO supplied seed to 2 percent of the respondents each.

The main certified seed supplier in Mauche was ADC Molo. The institution cited climate change related challenges to seed production such as severe cold temperatures resulting in frost, unpredictable and irregular rains, high post-harvest losses, rampant diseases in the field, waterlogging, pest infestations such as leaf miners and cutworms. Other challenges included shortage of breeders' seed, unpredictable weather conditions and high cost of inputs especially fuel, fertilizers, inspection costs. Coping strategies included use of green houses to produce seeds, proper agronomic practices, ridging on time to ensure proper establishment of roots of the tubers, tree planting- to ensure controlled climate and wind breaks for crops at the farms.

Potato agro-chemicals sold included inorganic fertilizer (Di-ammonium phosphate, foliar feed), fungicides, insecticides, herbicides and soil conditioners. These were obtained from agro-chemical companies operating in Mauche and Mau Narok such as Amiran, Osho Limited, Green life, Syngenta, Coopers and Ultra-vetis through local stockists. Main challenges facing farm input stockists were shortage of supply due to delay in importation; misuse of agro-chemicals by farmers with inadequate technical knowhow leading to ineffectiveness; fluctuating prices of products charged by suppliers; credit borrowing of agro-chemicals by farmers and high charges for business licenses by the County Government of Nakuru.

ii) Potato production

The first link in the potato value chain was potato production. In Mauche potato production is an important food security and income generating activity. It is practiced by smallholder farmers who mainly allocate up to one acre of land for potato growing. This is usually done in two seasons per year. With proper management, a farmer may harvest 80-130 bags of 110kg each per acre in one season. However farmers complained about rampant pests and diseases such as blight which is common during the rainy season. This calls for a higher use of agro-chemicals which reduces the profit margin of potato.

Mauche is a high rainfall zone; hence excess water run-off damages the road network making it impossible for the farmers to access the market. It also causes severe soil erosion on the farms hence reduced soil fertility which subsequently leads to reduced potato yields. Access to clean potato seed was a major challenge. Farmers cited unavailability of certified seed when it is needed as well as the high cost of seed. Post harvest losses occour during harvesting due to inappropriate tools that cause cuts and splits in the tubers.Lack of appropriate potato storage at the farm level is a major issue in Mauche as farmers store their potato in multi-purpose stores.

iii) Potato Marketing

The second link in the chain was potato marketing. The main players were potato transporters and middlemen or brokers. Farmers presented potato marketing constraints which included low potato prices and lack of collective action, poor transportation to the market, lack of market information, low quality produce, poor linkage to the market and inadequate storage. Governance in price determination is market-based. Here there is little or no formal cooperation among buyers and sellers in price determination. The prices are determined by the extent of supply and demand in the market. Discussions with the farmers revealed that there was no active cooperative society in Mauche. Due to this, Farmers in Mauche were prone to exploitation by potato cartels that paid low prices for potatoes in extended bags. Farmers complained that traders extend the 110kg bag to 160kg and the 50kg bag to 80kg. Due to lack of collective marketing by the farmers they were not able to bargain for better prices.

Lack of cold storage in Mauche aggravated the situation as potato is a highly perishable produce hence farmers were forced to dispose of the produce immediately after harvesting. Whenever there was glut the extended 50kg and 110kg were sold for ksh 800 and kshs 1400 per bag instead of the normal price of 1300 and 2500 respectively. Potatoes in Mauche were transported from the farms by brokers using hired motorcycles and lorries. In some cases, the transporters were also brokers. The main challenges cited by transporters included overloading when brokers extended the bags to more than 150 kg. This situation was aggravated by poor access roads which were very muddy during the rainy season.

Mauche being close to the Nakuru-Narok border, transporters complained of multiple taxation by the County Governments of Narok and Nakuru. They also had to meet levies charged by traffic police and villagers who erected barriers on the roads. Transporters also complained of inadequate parking space for potato trucks at city markets. Since there was no off-loading of potatoes in the market, transporters had to meet daily parking charges for potato trucks which ranged from Kshs 400-1200.

Traders purchased potatoes from farmers through brokers. Available potato varieties were Shangi, Tigoni and Kenya Mpya. The most preferred variety was Shangi which had a higher demand in the open air market. The market outlets were Nakuru, Nairobi, Mombasa, Sirare, Kisii, Mombasa, Homabay and Uganda. A 110 kg bag of potato in Nakuru Municipal market attracted a 40 percent increase in prices compared to Mauche. The main challenges reported by traders were losses due to unscrupulous farmers or brokers packing small or rotten potatoes inside the bags. They had no adequate storage facilities and suffered post-harvest losses due to rotting. Very huge tubers were associated with over-use of agro-chemicals, hence not popular.

Supermarkets were other market outlets for potatoes from Mauche. Tuskys and Ukwala supermarkets in Nakuru town received potatoes from contracted suppliers or farmers. They demanded for clean potatoes without splits. The supermarkets could pay a better price for a higher quality produce. Potato prices were pegged on weight in Kilograms. At the time of this study, supermarkets were paying ksh 30/kg which was 100 per cent higher than the farm gate price of potato in Mauche. Supermarkets had no storage problems since they purchased enough potatoes to keep on shelves.

iv) Potato Processors

The third link in the chain was processing. Njoro Canning Factory was the main potato processor and received potatoes from contracted farmers at negotiated prices. The most preferred potato variety for processing was Tigoni which had a better storage quality. The factory processed potato into chips and potato cubes to be supplied in frozen form to supermarkets. Climate variability affected supply of potatoes to the factory. Too much rain led to poor quality of potato due to disease and pest incidences. Low quality of potato produced low quality chips which could not compete in the supermarkets. Application of climate change adaptation strategies such as soil and water management and crop intensification practices might help maintain potato quality.

v) Potato Consumers

The final link in the potato value chain were the consumers which consisted of households, canteens, hotels and restaurants. Consumers could receive potatoes from producers, market outlets or processors. Two restaurants in Nakuru town (Shirk Park and Le Rhino) sampled for interview received potatoes from traders or farmers at negotiated prices but insisted on good quality produce. Although potato was available throughout the year, the restaurants complained of inadequate storage and poor keeping qualities. The varieties of choice for consumers were Shangi for several potato recipes and Tigoni for Chips.

4.5.4 Stakeholder Analysis

Stakeholder analysis was done to determine the key actors considered to have a significant influence on the success of the climate change adaptation intervention in smallholder potato production in Mauche. According to Golder (2005), stakeholder analysis helps identify the interests of all stakeholders who may affect or be affected by a project; potential conflicts or risks that could jeopardize the initiative; opportunities and relationships that could be built by various participating groups at different stages and strategies for stakeholder engagement. Table 14 presents a matrix of key potato value chain stakeholders in Mauche Ward.

Table 14

Matrix of potato value chain stakeholders in Mauche Ward

Stakeholder	Attribute	Interests	Resources	Impacts
Chomosa Farmers' Self Help Group	Smallholder potato farmers, primary decision makers	Primary producers of potatoes	Land Labour Farm inputs	Implementation of climate change adaptation strategies, knowledge dissemination and potato seed supply.
Egerton University	Primary decision maker, project coordinator	Agricultural training, technology generation and dissemination	Technical Capacity, financial input.	Funding implementation of the interventions, monitoring and evaluation
KALRO Njoro	Main partner	Agriculture and Livestock research	Technical capacity	Testing of climate change adaptation technologies in the Mother and Baby trial sites
Department of Agriculture	Effective local partner	Extension service provider	Technical capacity, data source	Dissemination of climate change adaptation strategies, co-funding of the interventions.
Local Leaders (Chief, Member of County Assembly, Mauche)	Primary decision makers and facilitators	Community mobilization and security	Law enforcement	Provision of an enabling environment for project implementation
Faith-based organization (African Gospel Church)	Local partner	Religious and social welfare of the community	Social Capital	Community mobilization for climate change adaptation
Agricultural Development Corporation, Molo	Facilitator	Multiplier of potato seed	Potato seed, technical input	Supply of certified potato seed

Continued…..

Agricultural Technology Development Centre, Nakuru	Facilitator	Fabrication of farm implements, storage and value addition equipment	Technical capacity	Supply of climate change adaptation implements
Farm input suppliers	Facilitators	Sale of assorted farm inputs	Farm inputs	Supply of appropriate agro-chemicals to potato farmers
Potato traders	Facilitators	Purchase and sale of potatoes	Cash, market premises	Provide a market for potatoes, link producers to consumers.
Potato transporters	Facilitators	Transport potatoes from farmers to the markets	Means of transport	Enable potato farmers to access the market
Processor (Njoro Canning Factory)	Facilitator	Value addition to agricultural produce	Processing facility for local agricultural produce	To contract farmers for supply of potatoes to the factory.

4.5.5 SMACC Inception Workshop

An inception workshop for the SMACC project was held at Mauche in which 76 participating potato value chain stakeholders were guided through a brainstorming session. Brainstorming is a participatory process in which participants in a forum discuss an issue and arrive at a consensus. The workshop facilitators started by introducing the climate change agenda to the participants. The group was then divided into eight mixed groups. Each group deliberated on a particular thematic area and recorded their findings on a flip chart. During the plenary session, the leader of each group made presentations with input from the group members for validation and adoption by the workshop participants. The thematic areas were:

1. Local awareness of climate variability and trends and associated impacts on natural resources

2. Consequences and impacts of climate related changes on livelihoods
3. Expectations of future changes and perceptions of vulnerability
4. Observations on Responses and Adaptation
5. Observations about barriers to Climate Change adaptation
6. Main Options (alternatives) during climate change pressure
7. Main Impact of Climate Change on Women
8. Possible Solutions as Suggested by Farmers for Climate Change Pressure

Potato value chain stakeholders in Mauche asserted that rainfall has generally been increasing but the onset is unpredictable, which affects timeliness in farm operations. This concurs with the Njoro rainfall data in Figure 12.

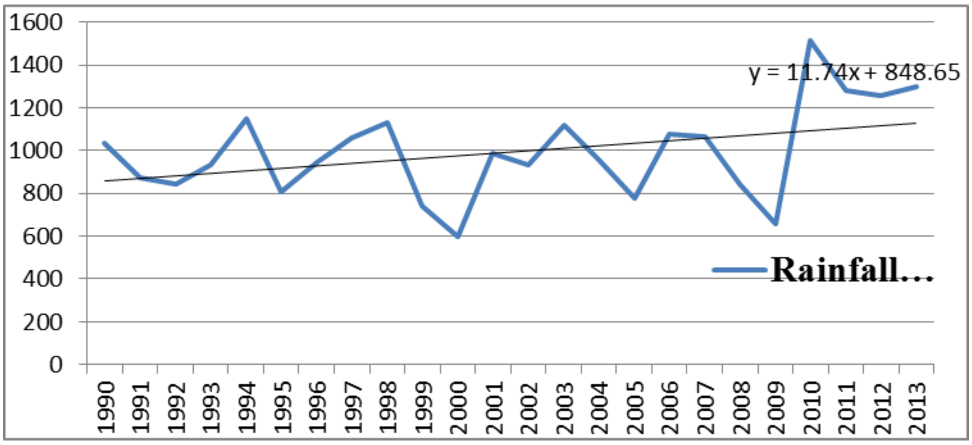


Figure 12: Rainfall data for Njoro: 1990-2013 – Source, KALRO Njoro

Rainfall amounts and distribution are of paramount importance to rain-fed agriculture in Kenya. Rainfall seasonality affects agricultural production and the livelihoods of people. The potato value chain stakeholders complained that excess water run off damages the road network and transportation of potatoes to the market is expensive due to poor road infrastructure in the producing areas. Increasing rainfall also causes severe soil erosion on the farms hence reduced soil fertility as well as rampant incidence of potato pests and diseases which calls for further investment on pesticides and fungicides. Flood increase affects quality of water sources. This has a negative impact on human health and expected returns to agriculture, which concurs with International Resources Group (2008). More intense and frequent precipitation periods also contribute to food insecurity through fluctuations in crop yields and local food supplies, as well as a decline in nutritional intake (FAO, 2008).

To approach the issue of climate change appropriately, one must take into account local communities' understanding of climate change (Feng *et al*, 2017). The assumption is that these communities have an inborn, adaptive knowledge and are able to develop strategies to cope with an erratic climate, severe pest attack, changing agricultural policies and other natural factors. Furthermore, indigenous observations and interpretations of meteorological phenomena have guided seasonal and inter-annual activities of local communities for millennia. This knowledge contributes to climate science by offering observations and interpretations at a much finer spatial scale with considerable temporal depth and by highlighting elements that may not be considered by climate scientists (Nakashima et al, 2012).

Vulnerability assessments and resilience analyses done during the research revealed the need for a range of strategies to enhance regional resilience. Unpredictable rainfall onset calls for adaptation strategies such as planting short season varieties, crop rotation, crop diversification, and varying planting dates (Mutekwa, 2009). Establishing the challenges to smallholder potato production under climate change pressure will highlight "hotspots" of vulnerability in order to facilitate development of strategies by the relevant value chain actors to address them (Morton, 2007).

4.5.6 Constituting the Collective Learning Community membership

Based on the outputs of profiling of the study area, potato value chain analysis, stakeholder analysis and stakeholder deliberations during the SMACC inception workshop, a Collective Learning community comprising of 50 members was formed. Purposive sampling was applied to select a community based organization (Chomosa farmer group with 30 members), a representative of agricultural institutions (Egerton University); potato seed multiplier (ADC Molo); faith based organization (African Gospel Church); processor (Njoro canning factory); Researcher (KALRO Njoro); extension service provider (County Department of Agriculture); local Administration (Chiefs Mauche and Tiyotich Locations); department of social services (Mauche Community Development Assistant); a Non-Governmental Organization (East African Grain Council); Four officials of 2 other potato farmer groups (Ogiilgei Self Help

Group and Kaplelach Youth Group). Simple random sampling was used to select 2 agro-input suppliers, 2 potato traders and 2 transporters to participate in the CLC.

4.5.7 Activities of the Collective Learning Community

Activities of the CLC included assigning of stakeholder responsibilities, identification of a leading team, assessment of linkages between actors and capacity building through training and action learning in the baby trial sites.

i) Assigning of stakeholder responsibilities

A CLC workshop was held to deliberate on the needs, interests and goals and assign responsibilities to the members according to their capacities. Responsibilities were assigned based on the relative advantage of each stakeholder as presented in table 15.

Table 15

Stakeholder responsibilities

Action	Responsibility
Access to CC adaptation strategies	KALRO Njoro, Egerton University, County Department of Agriculture
Implementation of CC adaptation strategies	Chomosa Farmers' Group
Availability of clean potato seed	ADC Molo, Chomosa Farmers' Group, County Department of Agriculture, KALRO Njoro, Egerton University,
Reduced cost of farm inputs	County Department of Agriculture, farmer groups, Chief Mauche
Improved potato storage	Farmer groups, local administrators
Linkage to the market	Egerton University, County Department of Agriculture, farmer groups, Njoro Canning Factory, Chief Mauche
Lobby for improved infrastructure –	Local administrators, farmer groups
Lobby for policy enforcement	Local administrators, farmer groups

ii) Identification of a leading team

Elections were democratically carried out to identify CLC officials after which roles were spelt out. The Chairperson's role was to convene and chair meetings as well as take charge in resource mobilization. The secretary was to be a custodian of records, minutes and all project documents. The treasurer was to be in charge of finances. The Mauche Ward Agricultural Extension Officer was coopted into the CLC committee to spearhead linkages with government, stakeholders and service providers. The CLC Committee's ultimate role was to ensure sustainable utilization of climate change adaptation strategies.

iii) The Net-Map Toolbox Analysis

The Net-Map toolbox was used to assess the links between the actors based on exchange of information, sharing of resources and influence. The Net-Map toolbox is a participatory tool that aids a target group of people to clarify, converse and identify situations that can be improved where there are numerous stakeholders and actors that have the ability to impact the outcome (Schiffer 2007). It is a social analysis tool that uses discussion and mapping to help people understand, visualize and improve situations in which many different actors influence results.

The Net-Map toolbox presents the structures of a situation; the actors and what their power relations are, the influence different actors hold, links between the actors, and the objectives of the various actors. It enhances the way in which people work together to reach a common goal.The toolbox aids in comprehension of a complex system and issues through visualizing the situation (Schiffer 2007). The Net-Map toolbox enabled the CLC to clarify the roles and power relations among the actors; and also to identify strong and weak points in the network that needed addressing.

Members of the CLC who participated in producing the Net-map tool box included farmer representatives, researchers, extension service providers, processors, traders, transporters, input suppliers, area chief and a pastor representing several churches in the area. Links between actors were demonstrated using arrows. Linking the actors clarifies the roles within the organization and which actors gave and received commands, advice, information and money. These links were demonstrated through the use of different colored arrows with red representing exchange of information, green money, blue advice and black command.

Actors were specifically asked about their perception on the SMACC project’s aim of enabling farmers to cope with climate change through potato production intensification. It was essential to find out which actors supported the goal of the project. The actors were ranked according to who had more influence on the success of the project on a scale of 1-10. A higher scale represented higher influence.

A Netmap of stakeholder linkages drawn by participants on a flip chart with felt pens is presented in Plate 5.

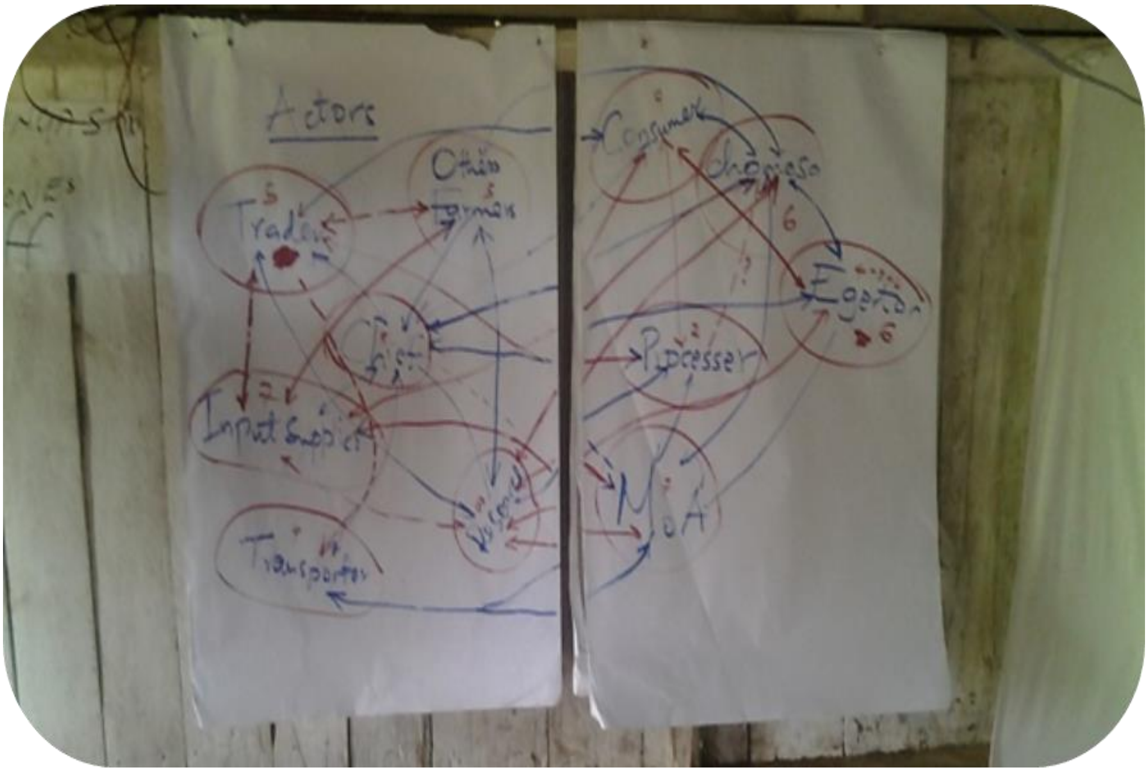


Plate 5: A Net-Map of stakeholder linkages in Mauche – photo taken by Rael Taiy on 26/5/2015

The Net-Map of stakeholders was re- created in word as a digital processed net-map (Figure13) showing the actors involved, the links between different actors with regard to exchange of information, advice, money and commands. It provided a working structure that could be modified by recommendations and changes over time.

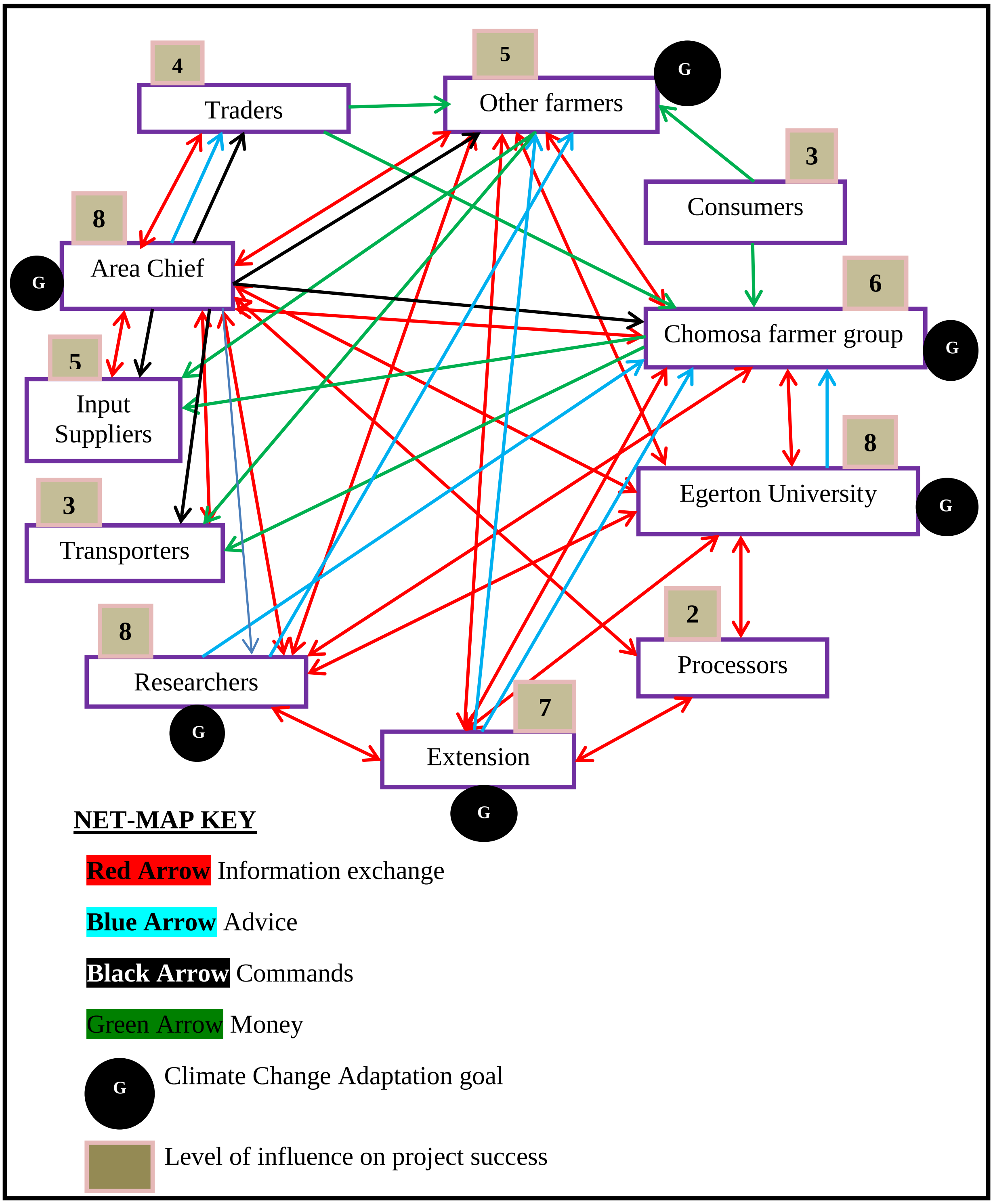


Figure 13: Digital Net-Map of stakeholder linkages in Mauche

Based on the Net-Map findings, it became clear that:

The climate change adaptation goal spearheaded by Egerton University and KALRO had overwhelming support from the local administration, extension service providers and farmers. The private sector notably traders, transporters and processors did not demonstrate much contribution towards the goal; neither did they have much influence on the success of the project. There emerged an opportunity for these private sector players to be more responsive in supporting climate change adaptation initiatives because they stood to gain more from higher productivity resulting from climate change adaptation.

There was no linkage between farmers and processors. The Njoro Canning Factory representative consequently invited officials of the CLC for a discussion with the factory management with a view of signing a contract to enable farmers supply potatoes and other produce such as garden peas, beans and chillies to the factory. He informed the participants that the factory preferred Tigoni variety for potato chips due to its good freezing qualities. However, other varieties could be used to make potato cubes, githeri (maize and beans mixture) and mixed vegetables.

Traders had a lot of influence in dictating potato prices. Lack of collective action in potato marketing by farmer groups and a court injunction on the 50kg packaging legislation by potato cartels in Nakuru County had led to continued exploitation of farmers. It therefore came out clearly that good governance in potato marketing required farmers to engage in contract farming as well as group marketing.

The area Chief commanded a lot of power and influence. He mainly provided security, advice and enforced law and order within the community. Based on this finding, the Chief was coopted into the CLC committee in order to tap into his influence to assist in mobilizing farmer groups in his area for collective action in potato marketing. This paid within a short time as the chief was instrumental in the formation of Chomosa Farmers' Cooperative Society to mobilize farmers for collective marketing.

iv) Capacity building activities carried out by the CLC

Activities were carried out by the CLC during the research period included selection of climate change adaptation strategies, farmer trainings, field visits, a farmer field day and a tour.

A CLC meeting was held at KALRO Njoro to select climate change adaptation strategies from the options being tested at the mother trial (Plate 6). The details of the activity are presented in section 4.6.1. Fourty one members of the CLC participated in the activity.

Plate 6: The Mother Trial site at KALRO Njoro – Photo taken by Rael Taiy on 12/6/2014

The CLC members visited the Mother trial site to appreciate the effects of each treatment on the performance of potato (Plate 7). This involved observation of the crop stand, pests and disease incidence and counting of the tubers (Plate 8), which would later form part of the selection criteria in addition to cost effectiveness.

Plate 7: Viewing of the Mother Trial plots by the CLC – Photo taken by Abraham Onyango on 16/7/2014

Plate 8: Analysis of potato performance according to each treatment - Photo taken by Abraham Onyango on 16/7/2014

A total of 6 farmer trainings were carried out in collaboration with the International Potato Centre (CIP) and the topics covered were i) climate change adaptation ii) potato production

iii) positive selection of potato seed iv) diseases and disease control v) post-harvest management vi) crop calendar tool which entailed listing of the major crops grown in Mauche and identifying which months of the year the crops were in plenty. This enabled the farmers to realize the business opportunity they could take advantage of if they implemented climate change adaption strategies such as water harvesting to produce vegetables during the dry season.

One Training of Trainer (TOT) seminar was held at KALRO Njoro for 15 selected farmer representatives. Selection of the farmer TOTs did not target Chomosa farmer group. It also involved representatives of two other potato farmer groups (Kaplelach Youth Group and Ogiilgei Farmer Group), for purposes of knowledge dissemination. The TOTs later carried out 3 trainings for 90 farmers with backstopping from SMACC and CIP.Training of other farmers by the farmer TOTs involved both theory and practicals on the potato farms. This proved to be very effective especially for some of the farmers who could neither read nor write. It also provided an opportunity for the farmers to identify potato pests and diseases and prescribe control measures.

Twelve field visits were carried out to monitor household adoption of CC adaptation technologies. This was necessary to asses if the demonstration in the baby trial plots were making any impact. Households were also monitored with regard to post harvest handling of the potato, acceptability of the potato as a major food item, water harvesting techniques and energy sources. It became clear that farmers had adopted some of the recommendations from the baby trials. Plate 9 illustrates a monitoring farm visit.

Plate 9: A farm visit at Kaplelach village in Mauche – Photo by Amos Sareto on 11/11/2015

A farmers' field day was held as a forum for disseminating climate change adaptation strategies by the CLC to a wider audience in Mauche Ward. It was attended by 302 participants including 210 farmers, 53 pupils from Mosop and Saramek Primary Schools, 6 University students, 10 Agricultural Extension Officers, 2 SMACC PhD students, officials from Egerton University, KALRO, the County Government of Nakuru and 21 stakeholders including local administrators, agro-chemical companies and Non-Governmental Organizations. The field day showcased the climate change adaptation technologies promoted on the baby trial plots which included crop intensification through potato intercrop with garden pea, rotating potato with dolychos bean, soil management by use of farm yard manure and green manure in the form of *leucaena triandra* biomass, normal ridging and tied ridging for water use efficiency. Plates 10-13 present some of the strategies implemented on the baby trial plots.

Plate 10: Healthy potato due to farm yard manure application - Photos taken by Chadwig Digo on 11/6/2015

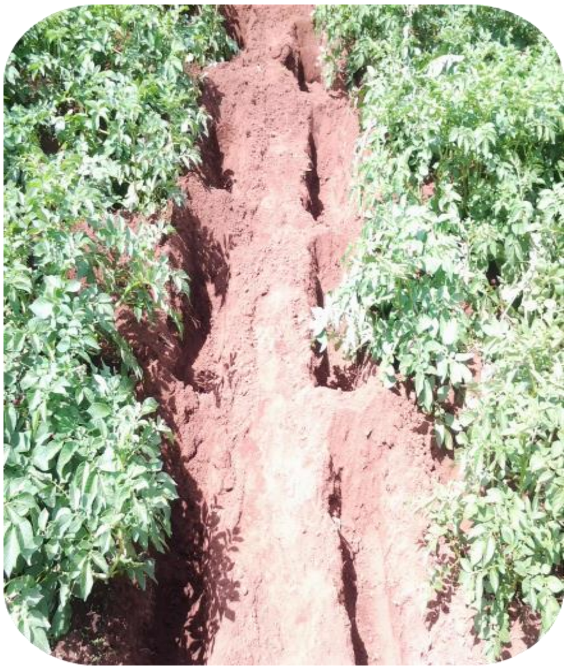


Plate 11: Tied ridging for water use efficiency

Plate 12: Dolychos bean on previous potato plot

Plate 13: Potato/garden pea intercrop

Other stakeholders also had the opportunity to display their climate change adaptation interventions. The Agricultural Technology Development Centre in Nak mhuru promoted climate change adaptation implements, processing and storage facilities; County Department of Livestock Production showcased feeds and fodder production, conservation and utilization whereas the County Department of Agriculture focused on potato diseases and their control, water harvesting using water pans and value addition to potato.

A tour was organized for the CLC to visit Elgeyo-Marakwet County, which enabled the CLC members to appreciate collective marketing of potato through an active marketing association in the County. The farmers also learnt about e-marketing of potato through an Anglican Church supported farmer ICT Centre. Farmers also visited a potato cold storage facility made of charcoal and grass with a capacity of 3000 bags (Plate 14). This tour motivated the CLC committee members to initiate a process of uniting farmer groups for collective marketing of potato in Mauche.

Plate 14: A cold potato storage made of locally available material at Nyaru in Elgeiyo-Marakwet County – photo taken by Rael Taiy on 29/9/2015

The also CLC participated in marking, establishment and management of the baby trial plots. Six CLC workshops and 12 meetings with Chomosa farmers were held to review activities as illustrated in Plate 15.

Plate 15: A meeting with Chomosa farmers' group – photo taken by Amos Sareto on 16/6/2016

4.6 Integrating climate change adaptation strategies in potato production

This section discusses results for the fifth objective which stated thus:

To integrate climate change adaptation strategies in smallholder potato production through farmer participation in Mauche Ward of Nakuru County.

Integration of climate change adaptation strategies in potato production in the study area began with establishment of three baby trial sites on which climate change adaptation strategies tested at the mother trial site at KALRO Njoro would be further refined and through Participatory Action Research (PAR) involving researchers, extension service providers, farmers and other key actors in the potato value chain in a CLC. These baby trial sites acted as learning centres whereby, through action and reflection, knowledge was generated and disseminated within and outside the CLC for enhanced climate change adaptation.

The study realized that integration of climate change adaptation in potato production has to be supported by clean seed and linkage to the market (Chesterman and Neely [Eds] (2015), the CLC organized for training of farmers on potato seed quality improvement through positive selection and disease control in collaboration with the International Potato Centre (CIP). To streamline potato marketing among members of the implementing farmer group, capacity building on collective marketing of the potato was done. This enabled the group members to attain bargaining power and earn better prices for their potato.

4.6.1 Establishment of learning centres

Existing knowledge was applied to test crop production, soil and water management intensification strategies in on-station trials at the Kenya Agricultural and Livestock Research Organization (KALRO) Njoro. The CLC participated in selecting some of the strategies for implementation to maximize climate resilience in three sites in Mauche Location. These sites would serve as learning centres in which climate change adaptation options were further refined and disseminated to other farmers.

Crop intensification strategies incorporated in the experimental design for the Mother trial included crop rotation of potato with Dolychos bean (*Lablab purpureus*) and inter-cropping with garden pea, which were envisaged to address the issues of soil fertility through nitrogen fixing as well as control of crop pests and diseases. Soil intensification strategies entailed the use of farm yard manure and green manure in the form of *Leucaena trichandra* biomass. Declining soil fertility to some extent was also attributed to water run-off because of the sloppy terrain in the study area; hence water harvesting was included as a strategy in the form of tied ridges and normal ridges. A part from restoring soil fertility, tied ridges were intended to help conserve soil moisture during the long rains when there is excess moisture. The conserved moisture would benefit the crop potato planted during the short rain season when rainfall is inadequate and unreliable.

The process of establishing learning centres entailed: i) Multi-criteria analysis to select climate change adaptation strategies ii) Integration of selected climate change adaptation strategies at the baby trial plots iii) Monitoring of climate adaptation practices of the innovating households.

i) Multi-Criteria Analysis to select climate change adaptation strategies

Multi criteria analysis (MCA) was employed to categorize and rank the options to be applied in CC adaptation. According to Bartolini &Viaggi (2010), MCA compares alternatives on the basis of more than one criterion. An action or an alternative is preferred if its expected utility is higher than expected utility of the alternatives to which it is compared. The available CC adaptation options were crop production, water management and soil fertility intensification strategies which included crop rotation of potato with a legume – dolychos bean *(Lablab Purpureus)*, intercropping with garden pea, water harvesting by use of tied ridges, water harvesting using normal ridges, soil fertility management by use of farm yard manure and use of green manure in the form of *Leucaena triandra* biomass. In order to be able to compare the performance of various CC adaptation strategies, each strategy was given a score of 1-10 against established selection criteria. These criteria included crop stand (foliage), disease incidence, potato yield and cost effectiveness of the technology. Each criterion was given a weight that reflected the preferences of the CLC and the weighted sum of the different criteria was used to rank promising and feasible adaptation options. The ranking of CC adaptation strategies based on MCA is presented in Table 16.

Table 16

Ranking of climate change adaptation strategies based on MCA

Climate Change adaptation strategy	**Crop Stand (wt =2)**	**Disease incidence (wt =3)**	**Potato Yield (wt = 3)**	**Cost of the Technology (wt = 2)**	**Overall Score**	**Rank**
Crop rotation	7	8	7	8	7.5	1
Intercropping	6	7	6	7	6.5	4
Water harvesting using Tied Ridges	8	7	8	6	7.3	2
Water harvesting using Normal Ridges	7	6	7	6	6.5	4
Use of Farm Yard Manure	7	6	7	7	6.7	3
Use of Green Manure	5	6	5	7	5.7	5

Since farmer preferences are the key determinants for acting on climate information with appropriate measures (Chesterman & Neely, [Eds] 2015), the CLC ranked the strategies based on the provided criteria to obtain the overall score for each strategy. Crop rotation (7.5) and water harvesting using Tied Ridges (7.3) were the most preferred options followed by use of Farm Yard Manure (6.7). Intercropping and water harvesting using Normal Ridges (6.5) ranked fourth while the least preferred was Use of green manure in the form of *Leucaena triandra* biomass (5.7).

ii) Integration of selected climate change adaptation strategies at the baby trial plots

The CLC identified three sites for the experimental plots (baby trials) at three different localities at Mauche - Kaplelach, Ewaat and Mosop. Each experimental plot was one acre. Smallholder farmer strategies to cope with climate change (SMACC) project provided inputs for half an acre for four seasons while the implementing farmer group (Chomosa) provided inputs for the adjacent half an acre group plot in each site. The CLC participated in marking, land preparation, planting, management of the plots and data collection. The farmers had a hands-on experience in the research process as the researchers also benefited from the practical experiences of the farmers and incorporated local knowledge in the management of the experimental plots. The baby trial plots acted as learning centres for farmers to access climate change adaptation strategies. Plate 16 illustrates farmer participation in marking the baby trial plots.

Plate 16: Farmers participate in marking the baby trial plots – photo taken by Rael Taiy on 6/9/2015

iii) Assessment of Climate change adaptation at household level

The implementation of climate change adaptation strategies was accompanied by an on-going monitoring to identify the added value of measures jointly developed by researchers and farmers. Workshops and field visits were held regularly whereby innovations and their implications on the household system were discussed and reflected upon within the Collective Learning Community. The CLC conducted the evaluation of the technology options for potential dissemination in the study area. The farmers transferred the knowledge they had gained from the experimental plots directly to their group farm and the positive change in performance of their crop was significant.

The farmers further adopted the technologies on their own farms. Observation and semi-structured interviews were carried out with the 30 members of Chomosa farmer group to assess their climate change adaptation practices at household level. Figure 14 illustrates level of adoption of the various climate change adaptation strategies based on household practices of the 30 innovating farmers belonging to Chomosa farmer group.

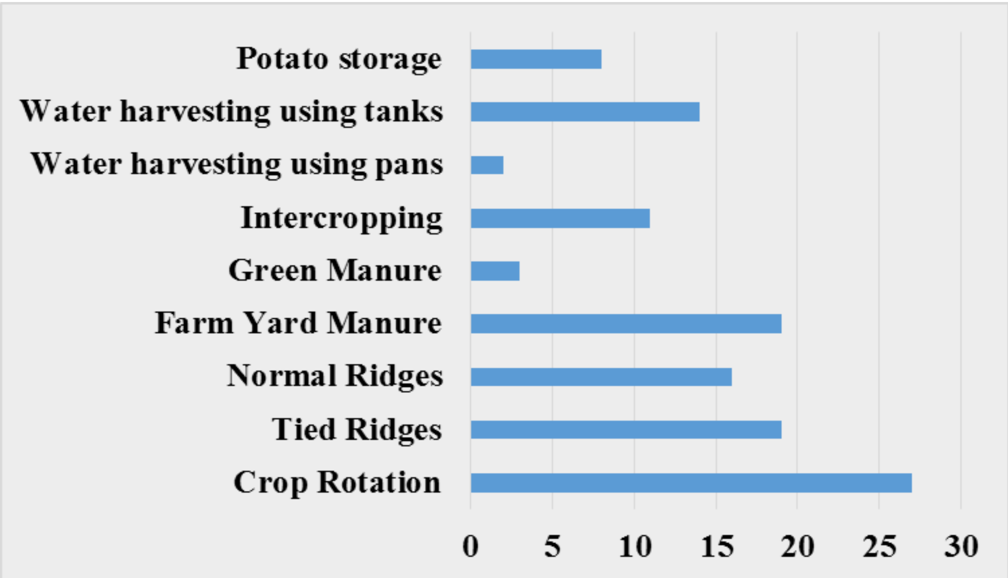


Figure 14: Household Level of adoption of climate change adaptation strategies

Crop rotation (27) was the most adopted strategy, followed by tied ridges (19), use of farm yard manure (19), Normal ridges (16), water harvesting using tanks (14), inter-cropping (11), potato storage (8), use of green manure (3) and water harvesting using water pans (2).

Involvement of farmers as key members of the Collective Learning Community in research by their active participation in the management of the baby trial plots generally led to adoption of climate change adaptation strategies. This concurs with Chesterman and Neely [Eds] (2015) that analytical capacity of farmers facilitated by local experimentation and testing of climate smart agriculture through action research, enhances uptake.

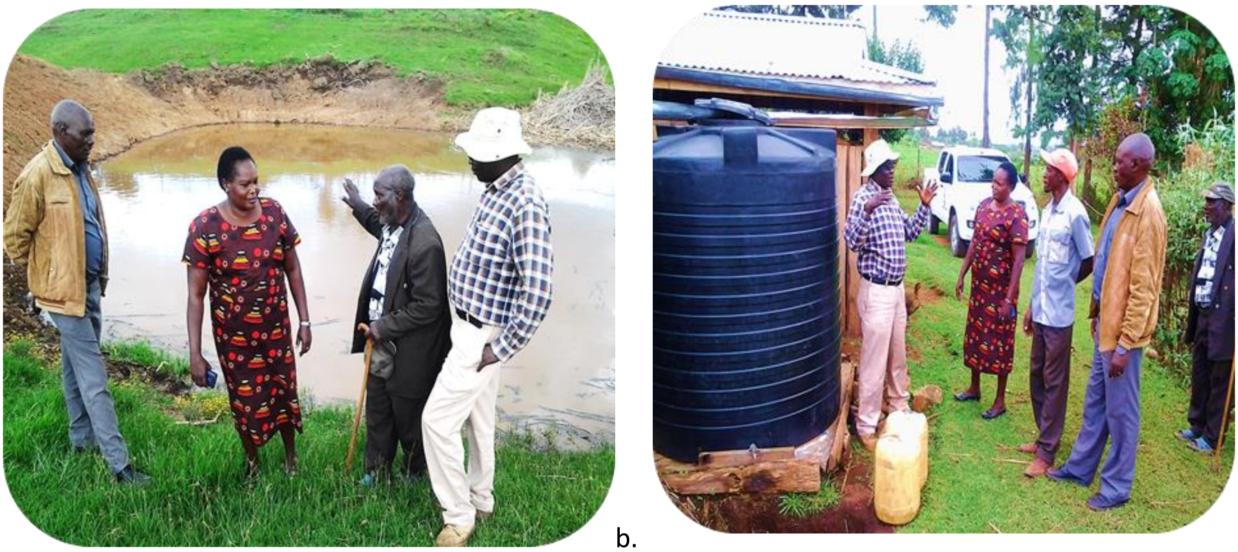
Three focus group discussions were held with the innovating farmers in order to understand their position regarding the various climate change adaptation strategies tested. Crop rotation of potato with field beans or garden pea was the most adopted strategy due to the ease of its adoption. Dolychos bean *(lablab purpureous)* was less preferred as it is not popular as a food item among the community in the study area. Many farmers initially rotated potato and maize which was detrimental to the soil as both crops are heavy miners of the soil.

Use of tied ridges proved to be very effective in water conservation and soil erosion management. One farmer displayed a portion of her farm that used to be washed off whenever there was run-off during heavy rains. Due to tied ridging that part of the farm became highly productive. Tied ridging is very effective in Mauche to contrast the sloping terrain in most areas which are prone to soil erosion. The tied ridges facilitate water retention and enhanced soil moisture as a result of slow seepage. This ensures continued water availability for the crop in the event of rainfall scarcity. It is a relatively cheap and farmer friendly technology that may be adopted by farmers under rain-fed systems. Plate 17 demonstrates the effectiveness of tied ridging in water management intensification.

Plate 17: A farmer's healthy potato crop due to tied ridging – photo by Amos Sareto on 19/6/2015

Use of farm yard manure was popular due to its availability in Mauche where every household had livestock. The farmers expressed the need for training in compost making which is a good complement to farm yard manure. Green manure in the form of *leucaena triandra* was not popular due to low availability.

Water harvesting was an area of focus particularly in Mauche which is a high rainfall zone. The project promoted water harvesting as a climate change adaptation measure, for domestic use, livestock consumption and irrigation of kitchen gardens particularly during the dry season when vegetables fetch good prices. The aim was to ensure household food security as well as improved household income. During the intervention period, some farmers made an effort to harvest water for domestic use. This was achieved through rehabilitation of old dams (Plate 18a) or use of tanks for roof catchment (Plate 18b). One farmer innovatively harnessed roadside water run-off into her dam using canals (Plate 19) for domestic use, livestock, vegetable gardening and irrigation of a tree nursery.



a. b.

Plate 18: A rehabilitated dam (a) and roof catchment (b) – photos taken by Amos Sareto on 19/5/2015

a. b.

Plate 19: Use of canals (a) to harvest rain water into a dam (b) – photos taken by Amos Sareto on 20/5/2016

Household energy sources was discussed as it is related to environmental degradation in the study area. Despite its scarcity in Mauche, fuel-wood was still a major source of energy for cooking in all households. Mauche area had experienced a lot of deforestation yet there was minimum effort to restore the tree cover. Many families were experiencing scarcity of fuel-wood as dependence on government forest had declined in the recent past due to increased surveillance by forest guards. Charcoal was very scarce to find and expensive as Charcoal vendors preferred to take their goods to the market centres where they fetched better prices. Rural Mauche was yet to get electricity connection; hence paraffin was still a common source of lighting. However some families had taken advantage of solar energy availability and purchased solar panels as illustrated in Plate 20.

a.  b. 

Plate 20: A housewife displays her kerosene lamp (a) which she replaced with a solar panel (b) - Photos taken by Rael Taiy on 16/8/2016

4.6.2 Clean seed quality improvement through positive selection

Inadequate clean seed was identified by the study as a challenge to climate change adaptation in potato production in Mauche Ward, where the potato seed system was dominated by open-air market supply, self-supply or neighbour supply. This concurs with Okello et al (2014) that a major cause of the low potato yields in sub-Saharan Africa is the use of poor quality seed potato, yet potato is a major food staple and source of income to the predominantly smallholder growing households in the region. Furthermore, Gildemacher et al. (2011) asserted that in Kenya, Uganda and Ethiopia, the proportion of seed potatoes originating directly or indirectly from quality-controlled multiplication was less than 3% of the total seed requirement. This implies that majority of potato producers cannot access commercial high-quality seed.

Improving potato quality through positive selection is known to increase potato yield by 3.5 metric tonnes per hectare above the Kenyan average of 7.8 tons per hectare (FAO, 2015a). In recognition of this, a training on seed potato quality improvement through positive selection was carried out by SMACC project in collaboration with the International Potato Centre (CIP) and the Department of Agriculture in Mauche, targeting 30 Chomosa Group farmers. The baby trials provided the farmers with the opportunity to conduct positive selection of potato seed, hence gaining the skills that enabled them to produce clean potato seed. Other neighbouring farmers who depended on Chomosa group for clean seed also had a chance to learn from the practical trainings offered in the baby trial plots.

The seed borne diseases to watch out for included fusarium wilt (caused by *Fusarium solani*), bacterial wilt (caused by *Ralstonia solanacearum)*, and viruses. This agrees with Gildemacher et al. (2011) that Seed quality degeneration is the combined result of increasing percentage of seed tubers infected with multiple viruses and an increasing concentration of particles of these viruses in the seed tubers.

Positive selection is a farmer led process and a valuable technology for smallholder producers (Ogutu, Okello & Jakinda, 2016). It began with pegging of the best potato plants in a field before flowering, roughly 10 weeks after planting. Two weeks later, the farmers inspected the field and removed pegs from plants with newly developed disease symptoms. The pegged plants served as mother plants and were harvested individually as seed for the next season's potato crop. Plants with few, small or misshaped tubers were rejected.

In the subsequent seasons, negative selection was done to remove the diseased crops from the field and maintain clean tubers for selection as seed. The farmers reported an increase of potato yield by up to 30% as a result of adopting the technology. The yield increase was obtained through farmer management, under circumstances very much representative of Kenyan smallholder potato farming, without any additional cash investment. Positive selection is recommended where access to high-quality or certified seed is not guaranteed. Plate 21 is a pictorial representation of positive selection of potato seed by the CLC of which Chomosa farmer group is a core member.

Plate 21: Positive selection of potato seed by the CLC - Photo taken by Peter Kiprotich on 14/10/2015

4.6.3 Potato Marketing

The study focused on capacity building of farmers for collective marketing through the CLC, in order to improve income from potato for enhanced adoption of climate change adaptation strategies. Lack of a structured market for potato was a key issue in Mauche. Potato traders moved around in lorries with teams tasked with extending the bags and packaging the potatoes which were then loaded into lorries and transported to city markets or across the Kenyan borders to Tanzania and Uganda.

The extended 50 kg bag at Mauche went for ksh 800 to 1500 depending on supply. One trader confided that the same bag sold at Ksh 2500 to 3000 in Nairobi but quickly justified that she had to meet the levies by traffic police on the road and packing charges for her lorry by the County Government of Nairobi. Plate 22 (a, b, c), is the extended potato bag ready to be being loaded into a lorry (Plate 23).

Plate 22a: Extended 50kg potato bag
Photo taken by Rael Taiy
on 31/7/2016

Plate 22b: Extended 110kg potato bag
Photo taken by Abraham Onyango
on 1/7/2016

Plate 22c: The 50kg extended bag commonly known as Soya or Mkorino – photos taken by a farmer on 24/5/2016

Plate 23: Loading of the extended potato bags into a lorry – photo taken by Rael Taiy on 15/6/2016

Through the CLC intervention, Chomosa farmer group members started marketing their potato as a group and lobbying other potato farmer groups to join in. Plate 24 captures Chomosa farmer group members sorting their seed and ware potatoes which they later weighed and stored as they awaited to sell (Plate 25). However, inadequate storage was a major challenge facing the group, which hired and rehabilitated a store. However, the store was still inadequate and the group had to resort to using farmers' stores which were multipurpose and inappropriate for potato storage.

Plate 24: Sorting and grading of potato seed – photo taken by Amos Sareto on 21/7/2015

Plate 25: Weighing and storage of potatoes – photo taken by Amos Sareto on 21/7/2015

4.7 The opportunities and challenges of establishing and maintaining a Collective Learning Community for climate change adaptation

This section presents results for the sixth objective:

To establish the opportunities and challenges of maintaining a Collective Learning Community for climate change adaptation in smallholder potato production in Mauche Ward of Nakuru County.

Establishing the challenges and opportunities of maintaining a collective learning community for climate change adaptation was achieved through continuous observation and documentation, which culminated in a workshop attended by 50 CLC stakeholders comprising of 30 farmers, 2 input suppliers, 2 transporters, 2 traders, 1 processor, 2 Non-Governmental Organizations representatives, 1 representative of faith based organizations, 3 local administrators, 3 extension workers, 2 social workers and 2 researchers. The methodology applied in the workshop was a combination of the nominal group discussion and the brainstorming techniques, which ensure active participation by all participants (Jones, 2007). The SMACC team introduced the subject and divided the stakeholders into two groups. Each group was tasked with addressing one of the following questions:

i) What are the opportunities of establishing a collective learning Community for climate change adaptation?

ii) What are the challenges of establishing a collective learning community for climate change adaptation?

One group brainstormed on the opportunities while the other focused on the challenges. In each group, everyone first wrote down their opinions on the given questions individually, followed by discussions in smaller sub-groups of about eight people. The ideas considered most important were then reported by one group at a time to allow for joint discussion among all group participants. The ideas were recorded in a flip chart to allow everyone to see and consider their importance as the discussions progressed. Each team later presented its outcomes at the plenary. The dialogue in a brainstorming session allows for instant feedback and raising of novel, opposite or supporting perspectives (Himanen et al, 2016). It presents the results of the workshop as a group communication process rather than a collection of individual opinions. The workshop findings are discussed below in relation to the opportunities and challenges of establishing a CLC for climate change adaptation in potato production in Mauche Ward of Nakuru County.

4.7.1 Opportunities of establishing a Collective Learning Community for climate change Adaptation

The Collective Learning Community for climate change adaptation brought in the following opportunities: i) Enhanced stakeholder networking and collaboration ii) CLC leadership iii) Enhanced access to technologies iv) Improved access to clean potato seed v) Expanded access to potato market

i) Enhanced stakeholder networking and collaboration

The CLC enhanced formation of stakeholder networks to promote continuous interaction and communication among the members. Bringing on board all potato value chain stakeholders from the beginning of the research process created a forum to apply trans-disciplinarity. It ensured optimal knowledge integration, mutual learning processes, and the best conditions for dissemination, applying and adopting results in practice. It also enabled the stakeholders to identify failures in existing strategies to cope with climate change and develop strategies to address them. As noted by CIP (2011), climate change adaptation entails formation of information-sharing platforms that would enable different actors to come together and analyze shared constraints, promote dialogue, access new technologies, collaborate, engage in joint innovation and investment.

ii) CLC leadership

The leadership of the CLC was very important in creating linkages with sources of information and resources needed to run the CLC. A good leadership also inspired trust among CLC members and even motivated non- members to accept interventions championed by the CLC. By bringing potato stakeholders together, the CLC leadership enabled them focus on a common goal, hence avoiding duplication, competition and overlapping for efficient and effective allocation of resources. The CLC approach was intended to strengthen the ownership of project findings and secure continued use of project results.

iii) Access to technologies

The Mauche CLC enabled farmers to access CC adaptation potato value chain technologies from Egerton University, KALRO Njoro, CIP and the Nakuru County Department of Agriculture. These included soil, water and crop intensification strategies, post-harvest management, value addition, and water harvesting technologies. The Agricultural Technology Development Centre Nakuru provided CC adaptation fabricated tools. The farmers also accessed grain storage technology from the East African Grain Council.

iv) Improved access to clean potato seed

Capacity building by the CLC on positive selection to maintain clean potato seed, potato production and post-harvest management enabled Chomosa farmers to produce clean seed for their own use and sale to other farmers in Njoro Sub-County and neighbouring counties such as Baringo and Bomet. The clean potato seed initiative succeeded due to stakeholders co-funding of activities. Whereas SMACC project supported capacity building of farmers, the Department of Agriculture financed farm operations and purchase of certified seed through Njaa Marufuku programme. The group attained increase in potato yield from 40 bags per acre in 2013 to an average of 90 bags per acre in 2015.

v) Access to potato market

The CLC initiated collective action for potato marketing in Mauche and Chomosa farmers started marketing their potatoes as a group. This enabled members to get better prices for their potatoes. While other farmers were selling the extended 50kg bag for Ksh 1300, Chomosa farmers sold non-extended 50kg bag of clean potato seed for kshs 2500. The group asset base grew from ksh 50,000 to more than one million in 2015.This was due to higher potato yields and better prices.

The CLC Advocated for collective action in potato marketing in Mauche, which required participation of all potato farmers including non-members of the CLC. Chomosa farmers' cooperative society was formed to facilitate potato marketing. As noted by Sebatta et al (2014), membership in a farmer group/cooperative positively influences smallholder farmers' decision to participate in markets. Other farmer groups were being encouraged to join the cooperative society to facilitate group marketing of potato. Chomosa farmer group also purchased a plot in Mauche market at a cost of Kshs 300,000 which will house the cooperative society offices and a potato store.

4.7.2 Challenges of establishing and maintaining a CLC for climate change Adaptation

The challenges of establishing and maintaining a CLC included: i) Inconsistent participation of the private sector actors ii) Cost of maintaining the CLC iii) CLC ownership by actors

i) Inconsistent participation of private sector actors

The CLC network establishment and maintenance requires total commitment of relevant stakeholders for achievement of goals. However, inconsistent participation of the private sector value chain actors such as farm input suppliers, transporters and traders in CLC activities was evident. This was observed especially in farm related activities that they perceived as not benefiting them directly. There was overwhelming participation of input suppliers in activities such as field days which gave them an opportunity to sell their goods.

ii) Cost of maintaining the CLC

Maintaining a CLC platform can be expensive. There needs to be a budget for network maintenance and a definite and sustainable source of funding to organize group activities, whereas platform members are expected to partly pay for their own expenses. Fundraising from the stakeholders does not usually yield adequate financing. Some value chain actors may not be willing to contribute any finances if they do not see any economic benefit for them.

iii) CLC ownership by actors

It takes a while for the actors to internalize and own the platform, hence there needs to be a champion. Other than climate change adaptation, the Mauche CLC has the capacity to be instrumental in advocating for other community issues such as electricity connection, education, health, water and road network. In spite of these other functions, it has concentrated on its initial objective which was largely driven by SMACC project that acted as its Champion. The problem is that when the champion exits the CLC may not be sustained. A strategy needs to be developed for it to quickly reinvent itself to be relevant in addressing other issues affecting the community. Concerted effort has to be made to create local ownership and steering of the CLC. Recognition and support of the platform by the local leadership is important. Organizations that stand to benefit more from a cohesive CLC should use all means to ensure that the network remains strong and active.

4.8 The influence of the Collective Learning Community on integration of climate change adaptation practices in smallholder potato production

This section presents results for the seventh objective:

To evaluate the influence of the Collective Learning Community on integration of climate change adaptation strategies in smallholder potato production.

Achievement of this objective entailed the following: i) Evaluation of the CLC network ii) Integration of climate change adaptation strategies analysis iv) Determining the direction of relationship between the CLC characteristics indices and climate change adaptation index v) Hypothesis testing

4.8.1 Evaluation of the Collective Learning community network

A structured questionnaire was used to evaluate the CLC on the basis of network quality, capacity building of farmers and knowledge dissemination on integration of climate change adaptation strategies in smallholder potato production. These were the key characteristics of the CLC identified by the study as the independent variables.

i) Network quality

This study operationalized network quality as interaction between group members to enhance learning and sharing of information. In order to investigate the level of communication among the CLC for better for information sharing, the group social networking capacity was established, and was measured by the level of attendance to CLC meetings and level of interaction among group members. Table 17 summarizes the respondents' frequency of attending CLC meetings.

Table 17

Frequency of attending CLC meetings

CLC group meetings	Frequency	Percent
Twice a month	31	62.0
Once a month	17	34.0
Twice a year	2	4.0
Total	**50**	**100.0**

Group meetings were mainly held twice a month as indicated by 62% of the respondents. Through these regular meetings, farmers were expected to share climate change information and establish systems for demanding for relevant adaptation technologies from the extension service providers, researchers and other actors. These meetings came in handy following the decline of government extension services in Kenya as a result of non- recruitment of extension workers in a long time and the fact that extension services were yet to pick up after the devolution of most of the agriculture sector functions to the Counties. As noted by Kiptot et al. (2016), farmers have the ability to spread innovations effectively due to their local knowledge, use of the local language and location. These regular meetings had a bearing on the level of interaction by the respondents as presented in Table 18.

Table 18

Level of interaction by the respondents

Extent of interaction	Frequency	Percent
Very low	1	2.0
Low	6	12.0
Moderate	9	18.0
High	19	38.0
Very High	15	30.0
Total	**50**	**100.0**

A majority (68 %) of the CLC members indicated that their extent of interaction was either high or very high. This high interaction enabled the members to share technologies and work together towards achievement of group objectives including integration of climate change adaptation strategies in potato production. Through regular meeting and intense interaction, farmers were expected to access CC adaptation technologies from the researchers, extension service providers, and other potato value chain actors.

Social networks promote efficiency in society by facilitating coordinated action and attainment of goals that could not otherwise be achieved at individual levels. Communities with higher levels of participation, social networks and local organizations are more efficient in information sharing and more receptive to extension projects than those without (Chisita, 2012). On the other hand, communities with weak social networks have been shown to be more vulnerable to adverse conditions due to constrained access to locally adapted seed compared with those with strong social networks (Bezner, 2013).

ii) Capacity building of farmers

Capacity building of farmers referred to training of farmers on climate change adaptation strategies in potato production. A Likert scale was developed for the CLC members to rate their level of capacity building based on the category of activities conducted. Their responses of are presented in Table 19.

Table 19

Responses on level of capacity building received from the listed CLC activities

	Level of Capacity Building				
CLC Activities	**Very Low %**	**Low %**	**Moderate %**	**High %**	**Very High %**
Group Training	4	6	28	28	34
Farm Visits	0	4	32	48	16
Field Day/Demos	0	10	24	40	26
Tour	4	10	18	56	12
Workshop/Seminar	6	18	20	42	14
Demonstration	6	16	12	34	32

N = 50

The CLC rated tour (68%), field days and demonstrations (66%) and farm visits (64%) as the most effective in capacity building of farmers to access climate change adaptation strategies, potato seed as well as potato markets. Membership in a farmer group is likely to increase producers' income earning capabilities due to skills and joint learning among them as opposed to individual producers (Tolno et al., 2016).

In the systems perspective, where enabling innovation is the key task, capacity building options go well beyond a focus on agricultural research and extension organisations and involve strengthening the networks, interactions, and policy and institutional conditions from which innovation arises (World Bank, 2006). These include supporting the development of entrepreneurial activity as this is where innovation adds social and market value to ideas; building value chains that connect farmers to new markets and stimulating innovation in response to consumer demand (GOK 2011a).

iii) Knowledge Dissemination

Knowledge dissemination meant transfer of knowledge within and outside the CLC with the expectation that it would be utilized by the farmers. The study rated the CLC on the extent to which it facilitated exchange of knowledge using a five point Likert scale. Table 20 summarizes the responses of CLC members on extent of knowledge dissemination.

Table 20

Extent of knowledge dissemination by the CLC

Knowledge Dissemination	**Frequency**	**Percent**
Very Low	4	8.0
Low	7	14.0
Moderate	10	20.0
High	15	30.0
Very High	14	28.0
Total	**50**	**100.0**

The study found out that the level of knowledge dissemination by the CLC was high (30%) or very high (28%). Success in agricultural research and technology transfer is more likely when farmers through farmer organizations participate in its development (World Bank, 2002). The CLC emphasized on involving farmers in situation analysis and problem setting, design, implementation, training, result demonstration and dissemination of findings through brochures and leaflets as well as through local radio stations. Monitoring and evaluation of the participatory research process, outputs, outcomes and impacts of climate change adaptation in potato production was also undertaken in the CLC. Demand-driven and market-led technology development and adaptation is tied to responsiveness of researchers to the specific needs of the client (Sempeho, 2004). Access to research findings, which is enhanced in the CLC presents farmers with CC adaptation strategies.

4.8.2 Integration of Climate Change Adaptation Strategies Analysis

As a dependent variable, integration of climate change adaptation strategies in potato production was measured by enhanced knowledge on various CC adaptation strategies, access to clean potato seed and access to potato market. According to Chesterman and Neely

[Eds] (2015), overarching recommendations for outs-scaling climate smart agriculture in Kenya should take into consideration access to productive inputs and markets as well as knowledge generation and sharing, which are critical for evidence based decision making. This section presents the key findings of the study based on these indicators as related to some selected moderator variables.

i) Level of Knowledge on Climate Change Adaptation Strategies

As an indicator for integration of climate change adaptation strategies, the level of knowledge CLC members had acquired on selected CC adaptation strategies was measured on a five point Likert Scale. Their responses are presented in Table 21.

Table 21

Responses on level of knowledge of selected CC adaptation strategies

	Percent Respondents				
Knowledge item	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Potato seed production	0	0	6	46	48
Disease control	0	0	24	48	28
Crop rotation	0	0	28	44	28
Water harvesting using tied ridges	0	2	12	66	20
Intercropping	0	0	38	46	16
Soil fertility management using farm yard manure	0	0	18	54	28
Potato storage	0	4	26	50	20

(N=50)

The results in Table 21 suggest that the CLC members generally had a good understanding of climate change adaptation strategies due to the training activities carried out in the CLC. Access to information empowers households to adopt climate change coping strategies requisite for adaptation and household food security (Ali & Erenstein, 2016). It should be noted that Climate change affects food production, decreases food availability and access to food as a result of increased food prices, which further threatens food and nutrition security (Tripathi & Mishra, 2016).

ii) Access to potato seed

Access to clean potato seed is requisite for climate change adaptation in potato production. Table 22 illustrates the extent to which the CLC has empowered farmers to access potato seed taking into consideration various indicators of access to potato seed such as availability of clean seed, access to variety of choice, affordability and timeliness of acquiring potato seed.

Table 22

Extent of empowerment to access potato seed

	Percent Respondents				
Indicators of access to clean potato seed	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Availability of clean potato seed	0	10	16	40	34
Access to variety of choice	0	8	42	38	12
Affordability of potato seed	0	8	40	34	18
Timeliness of acquiring potato seed	0	2	34	42	22

(N=50)

The respondents generally had above average access to clean potato seed on all indicators when high and very high access are considered together. Capacity building of CLC farmers on positive selection of potato seed has enabled them produce clean potato seed for their own use, and also for sale to other farmers. Farmers using improved seeds often realize higher potato yields and thus are more likely to increase outputs and market surplus (Tolno et al, 2016). This technology needs to be up-scaled and out-scaled beyond the CLC membership as it is known to be a major challenge to all smallholder potato farmers in all potato growing areas in Kenya.

iii) Access to the Market

Access to the market was a key variable identified by the study that supports integration of climate change adaptation strategies in potato production. Table 23 presents how the CLC has facilitated members to access the market based on selected indicators.

Table 23

Extent of facilitation to access potato market

	Percent Respondents				
Indicators of access to potato market	**Very Low**	**Low**	**Medium**	**High**	**Very High**
Market Information	0	6	14	48	32
Transport to the market	22	32	22	18	6
Group marketing	0	6	40	32	22
Linkage to consumers	2	34	36	24	4
Linkage to processors	6	40	38	16	0

(N=50)

The results presented in Table 23 show that the CLC has not adequately enabled members access the market, except in the areas of obtaining market information (72%) and group marketing (54%). The failure of the CLC to offer access to markets to their members is associated with limited capacity among the CLC leadership in entrepreneurship and marketing. The CLC was still relatively young and marketing activities, at group level, demand stable CLCs with formalized structures for marketing and profit sharing mechanisms as well as a high degree of trust among members. There is therefore a big scope for capacity of the CLC in group marketing strategies and entrepreneurship as well as the need to link the CLC with potential potato marketing partners. This is in agreement with Chesterman and Neely [Eds] (2015) that climate smart agriculture efforts have to be supported by linkages to the market, since market-linked small farmers increase their household income (Sebatta et al., 2014).

4.8.3 Direction of Relationship between the CLC Characteristics Indices and Climate Change Adaptation Index

The Collective Learning Community was evaluated on the basis of network quality, capacity building of farmers and knowledge dissemination, which were identified as the independent variables of this study. The mean scores of responses to the items measuring network quality (NQ), capacity building of farmers (CB) and knowledge dissemination (KD) were computed to give Network Quality Index (NQI), Capacity Building Index (CBI) and Knowledge Dissemination Index (KDI) respectively.

Integration of climate change adaptation strategies was evaluated based on knowledge acquired by the respondents on climate change adaptation strategies (KAS), access to clean potato seed (CPS) and access to potato market (APM). The mean scores for responses to these variables were computed to give knowledge on climate change adaptation index (KASI), access to clean potato seed index (CPSI) and access to potato market index (APMI) respectively. These indices were compounded into the Climate Change Adaptation Index (CCAI).

To determine the general direction of relationships between the independent variables and the dependent variable, scatter diagrams of CLC characteristics indices (NQI, CBI and KDI) against the Climate Change Adaptation Index were generated as illustrated in Figures15, 16 and 17.

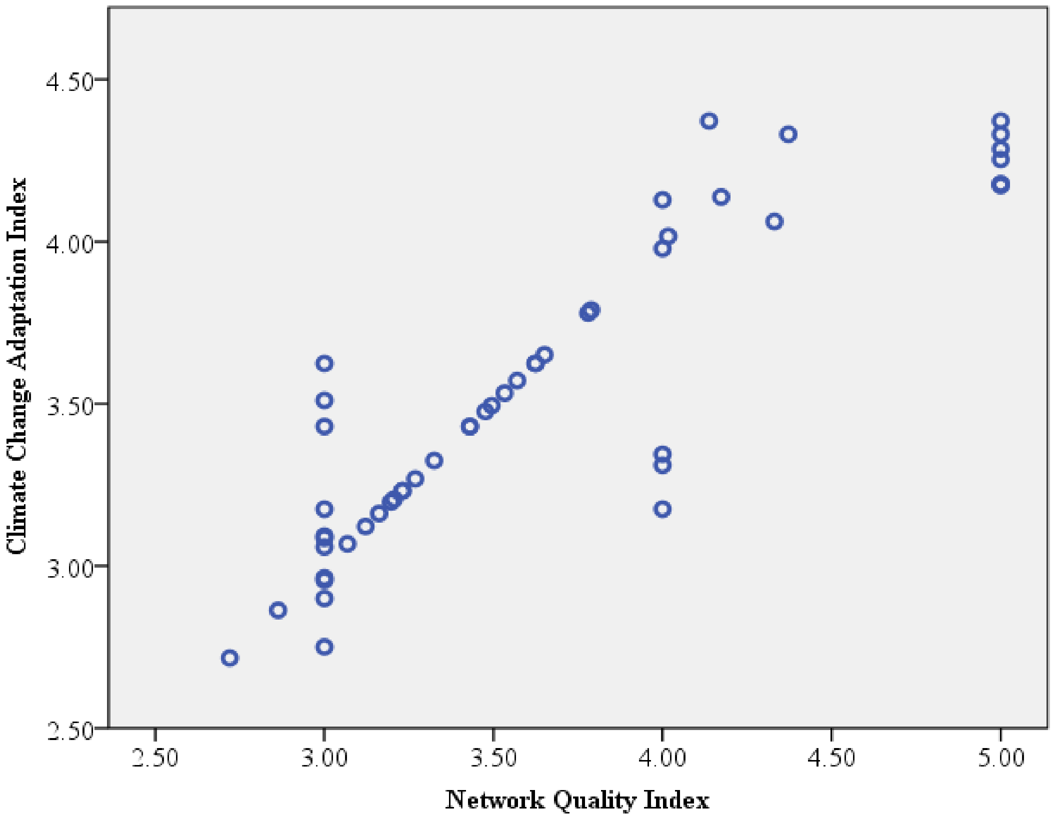


Figure 15: Scatter plot of the Network Quality Index against the Climate Change Adaptation Index

A positive correlation between Network Quality Index and Climate Change Adaptation Index was obtained. The underlying idea is that wider knowledge and information are embodied in different actors and interaction among them enhances their innovation behavior and performance (Mekonnen, Gerber & Matz, 2016). The Collective Learning Community facilitates interaction among stakeholders to innovate for climate change adaptation through generation and dissemination of climate change adaptation strategies, availability of clean potato seed for better yields and collective marketing of potato -hence ensuring better returns for the farmers.

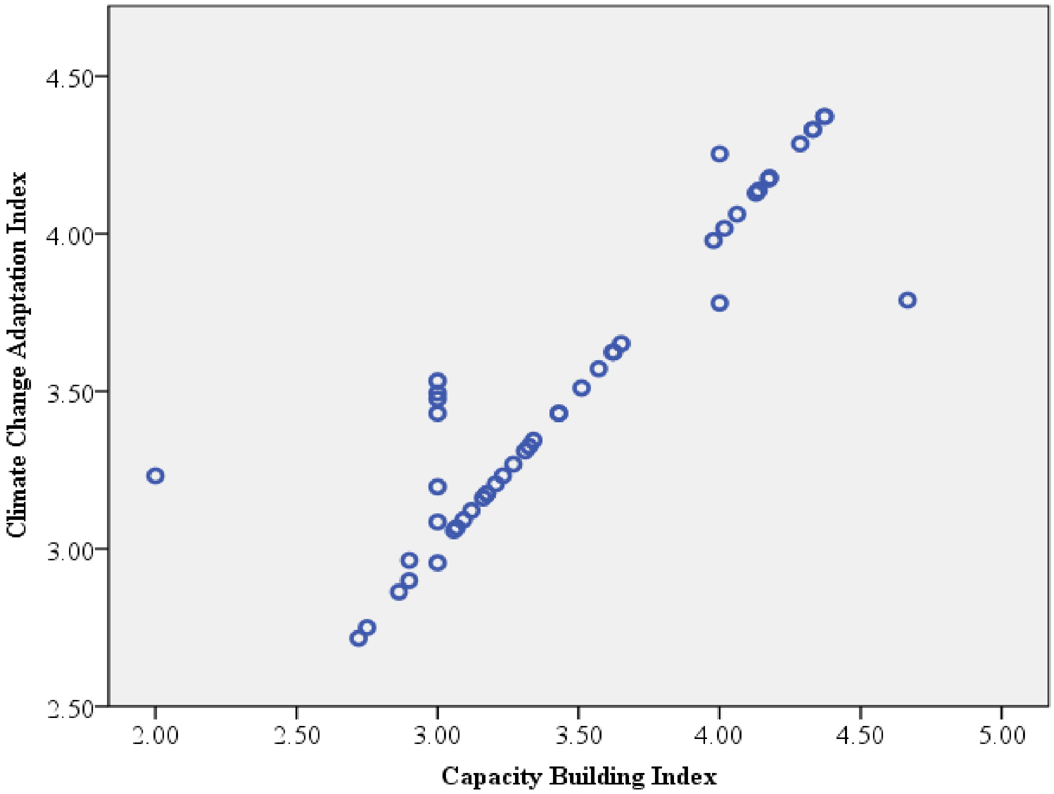


Figure 16: Scatter plot of the Capacity Building Index against the Climate Change Adaptation Index

Capacity Building Index was positively correlated to Climate Change Adaptation Index. Capacity building activities in the CLC included training of farmers and their involvement in research through management of the baby trial plots and data collection. The process of learning by doing enabled them acquire knowledge and skills required to adapt climate change adaptation strategies on their farms. It also ensured ownership and sustainable utilization of research outcomes.

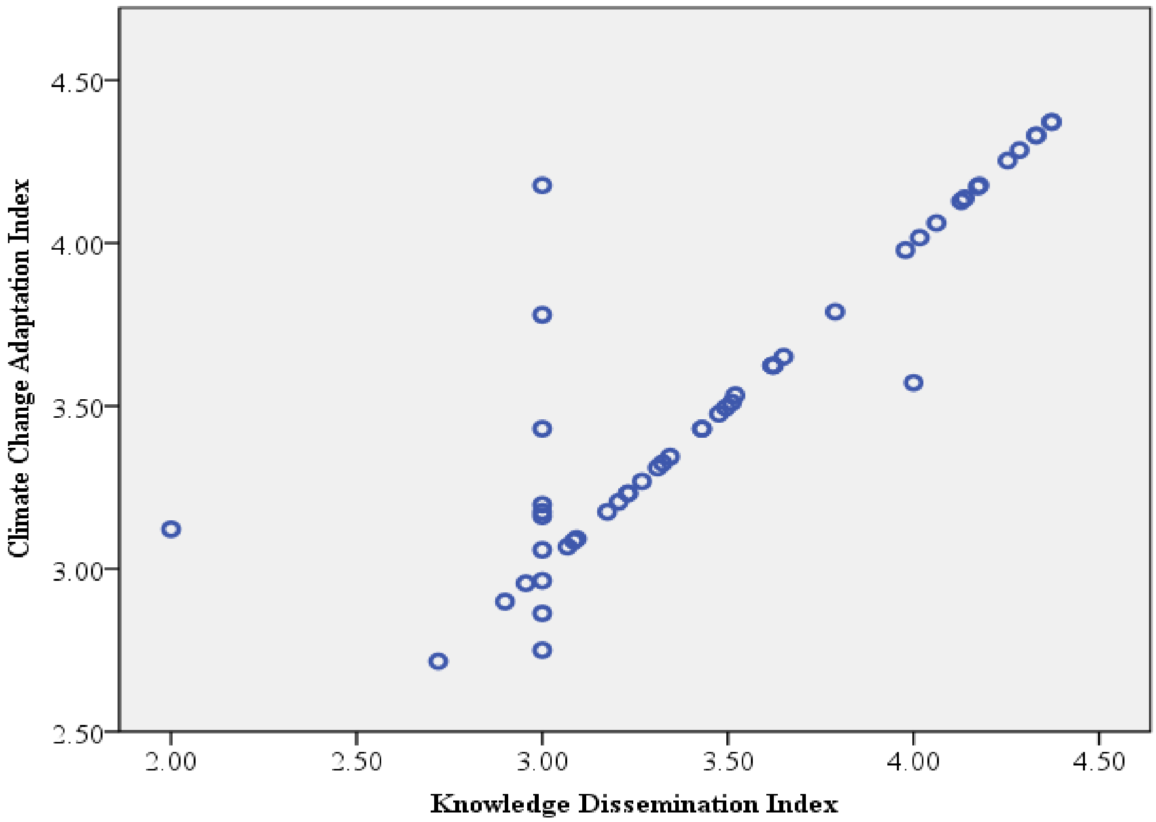


Figure 17: Scatter plot of the Knowledge Dissemination Index against the Climate Change Adaptation Index

There was a positive correlation relationship between Knowledge Dissemination Index and Climate Change Adaptation Index. The Collective Learning Community facilitated generation and transfer of climate change knowledge within and outside the CLC, with the expectation that it would be utilized by the farmers. The methodologies used by the CLC to disseminate knowledge to a wider audience within and outside the study area included field days, print media, brochures and conferences.

4.8.4 Hypothesis Testing

The study further investigated the influence of the Collective Learning Community on integration of climate change adaptation practices in smallholder potato production by testing the hypothesis that:

Ho: *The Collective Learning Community has no statistically significant influence on integration of climate change adaptation strategies in smallholder potato production.*

The Collective Learning Community was evaluated on the basis of network quality, capacity building of farmers and knowledge dissemination, which were identified as the independent variables of this study. To predict the influence of each CLC characteristic on integration of climate change adaptation strategies in potato production, a stepwise Multiple Linear Regression of the form $y = a+b_1x_1+b_2x_2+b_3x_3$ was used to evaluate whether network quality Index (NQI), capacity building Index (CBI) and knowledge dissemination Index (KDI) mean scores could predict climate change adaptation index (CCAI). Multiple regression determines the overall fit (variance explained) of the model and the relative contribution of each of the predictors to the total variance explained (Higgins, 2005). The results of the model are summarized in the series of tables as follows:

Table 24 presents the results of linear regression between moderator variables namely: age, gender, education level, farm size, land tenure, house hold income from livestock and household income from crop farming and CCAI.

Table 24

Results of linear regression between selected moderator variables and CCAI

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.019	.431		9.315	.000
	Age of Respondent	-.087	.098	-.137	-.889	.379
	Gender of Respondent	-.271	.144	-.280	-1.877	.068
	Relationship to household head	-.056	.075	-.113	-.746	.460
	Education Level of Respondent	-.156	.098	-.261	-1.592	.119
	Farm Size (ha)	.121	.122	.157	.990	.328
	Land Tenure System	-.123	.083	-.203	-1.482	.146
	Yearly income from livestock farming	.100	.062	.279	1.622	.112
	Yearly income from crop farming	.023	.055	.058	.414	.681

The moderator variables namely: age, gender, education level, land tenure and household income from crop farming had no significant influence on the CCAI. Farm size (0.157) and yearly income from livestock farming (0.279) were the only moderator variables found to have some influence on CCAI. The respondents had nearly similar land sizes (86% owned between 0.1 to 2 hectares), which automatically controlled for its effect on CCAI. There was no major disparity in earnings from livestock farming since a majority of the respondents (62%) earned Kshs 50,000 - 70,000 annually. These moderator variables were therefore naturally controlled for in the study.

Following is Table 25 which presents the model summary of multiple linear regression between CLC characteristics indices and CCAI.

Table 25

Model summary of multiple linear regression between CLC characteristics indices and CCAI

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.894[a]	.800	.796	.21826	.800	191.897	1	48	.000	
2	.939[b]	.882	.877	.16904	.083	33.025	1	47	.000	
3	.959[c]	.919	.913	.14206	.036	20.550	1	46	.000	1.369

a. Predictors: (Constant), Capacity Building Index

b. Predictors: (Constant), Capacity Building Index, Knowledge Dissemination Index

c. Predictors: (Constant), Capacity Building Index, Knowledge Dissemination Index, Network Quality Index

d. Dependent Variable: Climate Change Adaptation Index

Table 25 shows the multiple linear regression model summary and overall fit statistics. The adjusted R^2 of Capacity Building Index, Knowledge Dissemination Index and Network Quality Index in model is .796, .877and .913. This means that the linear regression between Capacity Building Index, Knowledge Dissemination Index and Network Quality Index against Climate Change Adaptation Index explains 79.6%, 87.7% and 91.3% of the variance in the data respectively.

Table 26 is the Analysis of Variance (ANOVA) table for multiple regression which tests whether the overall regression model is good at predicting the outcome of the data.

Table 26

ANOVA table for multiple linear regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.142	1	9.142	191.897	.000[a]
	Residual	2.287	48	.048		
	Total	11.428	49			
2	Regression	10.085	2	5.043	176.477	.000[b]
	Residual	1.343	47	.029		
	Total	11.428	49			
3	Regression	10.500	3	3.500	173.441	.000[c]
	Residual	.928	46	.020		
	Total	11.428	49			

a. Predictors: (Constant), Capacity Building Index

b. Predictors: (Constant), Capacity Building Index, Knowledge Dissemination Index

c. Predictors: (Constant), Capacity Building Index, Knowledge Dissemination Index, Network Quality Index

d. Dependent Variable: Climate Change Adaptation Index

Table 26 presents the ratio of improvement in prediction that results from fitting the models (labelled 'Regression' in the table) relative to the inaccuracy that exists in the models (labelled 'Residual' in the table). In each of the 3 models, the regression value is greater than the residual value. If the improvement due to fitting the regression model is much greater than the inaccuracy within the model, then the value of F will be greater than 1.In the 3 models, the F-ratio is 191.897, 176.477 and 173.441, which is highly significant in each case ($p < 0.001$). This means that the three independent variables (Capacity Building Index, Knowledge Dissemination Index and Network Quality Index) significantly improve the ability to predict the Dependent Variable (Climate Change Adaptation Index).

The next part of the output is concerned with the parameters of the model. Table 27 presents regression coefficients that show the significance of each independent variable in predicting the Dependent variable.

Table 27

Regression coefficients

Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1 (Constant)	.908	.192		4.721	.000
Capacity Building Index	.755	.054	.894	13.853	.000
2 (Constant)	.506	.165		3.076	.003
Capacity Building Index	.476	.064	.564	7.404	.000
Knowledge Dissemination Index	.395	.069	.438	5.747	.000
3 (Constant)	.530	.138		3.830	.000
Capacity Building Index	.321	.064	.380	5.021	.000
Knowledge Dissemination Index	.296	.062	.328	4.793	.000
Network Quality Index	.235	.052	.335	4.533	.000

The results in Table 27 indicate the individual contribution of each predictor to the model. The B values indicate relationships between the outcome, Climate Change Adaptation Index (CCAI) and each predictor – Capacity Building Index (CBI), Knowledge Dissemination Index (KDI) and Network Quality Index (NQI). The B value in each case is positive indicating a positive relationship between the predictors and the outcome. The smaller the value of p (sig.) and the larger the value of t, the greater the contribution of the predictor. Since the standardized /beta values provide a better insight into the contribution of each predictor in the model (Field, 2009), CBI (0.894) has the highest contribution to CCAI, followed by KDI (0.438) and NQI (0.335).

From the results above, the following model was constituted for the influence of the Collective Learning Community on integration of climate adaptation strategies in smallholder potato production.

$$CCAI = 0 + 0.894CBI + 0.438KDI + 0.335NQI$$

Capacity building is the most significant independent variable as it is an important means for farmers to gain information on new technologies. Capacity is the ability to fulfill a task or meet an objective effectively (Chikaire et al., 2015). In a systems perspective capacity building is not a one-off intervention, but a continuous process of upgrading and change (Mbaabu & Hall, 2012). Relatedly, it reveals learning-by-doing, reflection and adaptation as key elements of capacity building. It also entails establishing innovation platforms to connect ideas with opportunities (Nederlof et al., 2011). Capacity building in the CLC by Egerton University, KALRO and the Nakuru County Department of Agriculture enabled farmers to access climate change adaptation technologies, get linked to seed sources and institute processes towards collective marketing of their potato.

Knowledge dissemination within and outside the CLC is the second most significant characteristic in climate change adaptation. It popularizes the innovation by providing necessary information, knowledge and skills in order to enable farmers to apply the innovation (Bauer & Karki, 2004). Furthermore, it brings in the aspect of modern science meshed with indigenous knowledge in order to come up with appropriate climate change adaptation strategies.

Network Quality plays a significant role in climate change adaptation. Potato farmers are more likely to adopt climate change adaptation strategies when other farmers in their social network have adopted because they expect to share information, learn from each other and solve problems together. Farmers communicate with others within their social network to strengthen their perception of these practices, and then adopt them to improve their conditions (Feng et al., 2017). The underlying idea is that wider knowledge and information are embodied in different actors and interaction among them enhances their innovation behavior and performance (Mekonnen, Gerber & Matz, 2016). Social networks are the channels for such interactions and for social learning to occur. This is supported by the inherent farmer-to-farmer dissemination which accompanies enhanced social networks. This implies that farmer groups or cooperatives could be important tools for better delivery of agricultural extension and advisory services.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This Chapter presents a summary of the study and the conclusions made from the study. It also highlights on the recommendations for integrating climate change adaptation in potato production as well as recommendations for further research.

5.2 Summary of the Study

Potato is a food security crop for many smallholders in Mauche Ward of Nakuru County. However, its production is affected by variability in rainfall patterns, increased pests and diseases and post-harvest loses associated with rain fed systems highly vulnerable to climate change. This study formed a Collective Learning Community in Mauche Ward of Nakuru County to enhance climate change resilience and adaptation capacities of smallholder potato producers through multi-stakeholder interaction in the potato value chain. The Collective Learning Community characteristics identified were capacity building of actors, social network quality and knowledge dissemination. The Collective Learning Community approach facilitated integration of climate change adaptation strategies in smallholder potato production. It facilitated capacity building of actors, knowledge dissemination and enhancing of network qualities that enhanced access to climate change adaptation strategies, clean seed production and marketing.

The study adopted both Survey Research and Participatory Action Research designs. Simple Random Sampling was used to select 150 smallholder potato farmers to participate in a survey. One active potato CIG comprising of 30 farmers was purposively selected to implement the CC adaptation strategies. Data collection was done using a structured questionnaire, checklists and topic guides. Survey data was analyzed using SPSS version 22 whereas qualitative data was obtained and synthesized through problem tree analysis, stakeholder analysis, multi-criteria analysis, the net-map toolbox and brainstorming. Multiple Linear Regression was used to evaluate the magnitude of relationship between the Collective Learning Community characteristics – capacity building of farmers, knowledge dissemination and network quality and integration of climate change adaptation strategies.

The study revealed that smallholder potato farmers are vulnerable to the negative effects of climate change. Inadequate knowledge on climate change adaptation strategies, limited access to clean seed and lack of collective marketing were major challenges affecting the potato VC. However, resilience could be enhanced by integrating soil, water and crop intensification strategies developed collaboratively in the Collective Learning Community. This process entailed capacity building of actors on climate change adaptation technologies, supported by access to clean potato seed and better potato marketing systems.

The collective Learning Community was found effective means for actors to enhance stakeholder networking and collaboration for joint innovation and investment towards achievement of a common goal. It taps into the many resources and expertise held by various stakeholders to address societal issues collaboratively. It guarantees effective and efficient utilization of resources, hence avoiding duplication, competition and overlapping. Participating in the Collective Learning Community for climate change adaptation enables farmers to access technologies, clean potato seed and the market.

Capacity building was found to be the most significant independent variable as it is an important means for farmers to access climate change adaptation strategies, get linked to seed sources and institute processes towards collective marketing of their potato. Knowledge dissemination within and outside the CLC was found to be the second most significant characteristic in climate change adaptation. It popularizes the innovation by providing necessary information, knowledge and skills in order to enable farmers to apply the innovation. Network quality plays a significant role in climate change adaptation by enabling actors to share information, learn from each other and solve problems together.

The study recommends participatory research and joint innovation in a CLC to enhance capacity building of farmers, stakeholder networking, knowledge generation and dissemination for sustainable utilization of research findings. Positive selection to improve availability of clean potato seed and streamlining of potato marketing are requisite to integration of CC adaptation strategies in potato production.

5.3 Conclusions

From this study, the following conclusions can be made:

i. Smallholder potato farmers earn low income if they depend on on-farm activities alone.

ii. Climate change and climate variability negatively affect smallholder potato production in Mauche Ward through intermittent rainfall, rampant incidence of potato pests and diseases which lead to reduced yields. Increased rain causes soil erosion leading to reduced soil fertility, as well as damage to the road network thereby hampering market access. Farmers in Mauche Ward have limited climate change training lack of a clear perception of the indicators of climate change. This renders them unable to adequately apply available climate change adaptation options to reduce their vulnerability.

iii. A majority of the farmers obtain potato seed from unknown sources such as open air markets or other farmers, which complicated control of potato diseases such as bacterial wilt and viral infections. Inadequate storage and lack of collective action in potato marketing render the farmers vulnerable to exploitation by potato cartels.

iv. A Collective Learning Community brings in multi-disciplinarity and application of local knowledge in addressing climate change and contributing to the science discourse through sharing of the research findings beyond the confines of the study area.

v. Integration of climate change adaptation strategies in potato production is achieved by facilitating farmers to acquire and apply knowledge and skills in crop, soil and water intensification technologies through training activities and farmer participation in research. Implementation of climate change adaptation strategies must be supported by availability of clean potato seed through positive selection for increased yields as well as collective marketing of potato for improved incomes.

vi. A Collective Learning Community enhances networking, collaboration among stakeholders and linkages with information sources. The main challenges include inconsistent participation of the private sector actors, maintenance cost and low level of ownership by participating stakeholders. The Collective Learning Community requires shared goals, ownership and resources to implement planned activities. It must be dynamic and vibrant in order to be relevant in addressing emerging issues in the society.

vii. The Collective Learning Community positively influences integration of climate change adaptation strategies in potato production. Capacity building in a Collective Learning Community is an important means for farmers to gain information on climate change adaptation technologies. Knowledge dissemination within and outside the Collective Learning Community popularizes climate change adaptation innovations in potato production by providing farmers with the necessary information, knowledge and skills to enable them apply the innovations. Network Quality plays a significant role in climate change adaptation as it enables potato value chain actors to share information, learn from each other and solve problems together.

5.4 Recommendations

The study came up with recommendations for integrating climate change adaptation strategies in potato production.

i. The County Government of Nakuru should support farmers in Mauche Ward to engage in profit oriented off-farm activities such as value addition so as to attain product diversification, higher keeping quality, employment creation and enhanced household incomes. In addition, developing of more recipes from potato improves acceptability of potato as a major food item in the households, hence creating higher demand.

ii. There is a need for coordinated effort by all agriculture sector stakeholders to enhance climate change awareness and improve farmers' capacities to reduce risk or make optimal use of climate variability for increased production by applying crop, soil and water management intensification strategies developed collaboratively by actors in a Collective Learning Community. Any efforts to address climate change challenges in smallholder potato production must be complemented by investments in rural infrastructure such as market access roads, water dams and water pans to facilitate irrigation as well as storage facilities. This can be achieved through collaboration between the National Government, County Government of Nakuru, partners and stakeholders.

iii. To bridge the existing deficit in certified potato seed, the Nakuru County Department of Agriculture, Egerton University, KALRO and CIP need to continue training smallholder farmers on clean potato seed production techniques such as positive selection to enable them to produce clean seed at a more affordable cost for their own use and income generation.

iv. Smallholder farmers need to form cooperatives and engage in contract farming in order to overcome technological and market constraints. Collective marketing of farm produce and acquisition of inputs enable the farmers to negotiate prices in order to benefit from the economies of scale. Cooperatives facilitate bulking of farm produce for access to niche markets.

v. There is need for researchers to engage in participatory action research and joint innovation through effective collaborative linkages with farmers and other stakeholders in a Collective Learning Community, with the view of making technology generation demand led and also to ensure ownership and sustained utilization of research outcomes.

vi. The Collective Learning Community leadership should be developed based on dimensions of group dynamics, entrepreneurship, fund raising, lobbying and advocacy to ensure its effectiveness in spearheading climate change adaptation in smallholder potato farming. Organizations that stand to benefit more from a cohesive CLC should use all means to ensure that the network remains strong and active.

vii. Policy makers should ensure integration of climate change adaptation strategies in design and implementation of agricultural extension programmes through capacity building, knowledge dissemination and social networking in collective learning processes.

5.5 Recommendations for further research

The study came up with the following recommendations for further research:

i. Factors affecting attraction to and retention of the potato value chain actors in a Collective Learning Community.

ii. Strengthening of CLC structures, their functions and sustainability in innovating for climate change adaptation.

iii. A gender differentiated study on the impacts of CLC participation in empowerment of smallholder farmers.The impacts of collective learning on specific segments of the potato value chain.

REFERENCES

AGRA (2014). Climate Change and Smallholder Agriculture in Sub-Saharan Africa. Africa Agriculture Status Report. Issue No. 2. ISSN 2313- 5387

Ali A. and Erenstein O. (2016). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Elsevier.

Ali S., Liu Y., Ishag M., Shah T.,Iiyas A.A. and Din I.U. (2017). Climate Change and its Impact on the Yield of Major Food Crops: Evidence from Pakistan. *Foods, 6(6):34.*Accessed on 10/9/2017

Anandajayasekeram P. and Berhanu G. (2009*).* Integrating innovation systems perspective and value chain analysis in agricultural research for development: Implications and challenges. Improving Productivity and Market Success of Ethiopian Farmers *Project Working Paper 16.* International Livestock Research Institute, Nairobi, Kenya. 67 pp.

Ansuategi A.,Greño P., Houlden V.,Markandya A.,Onofri L.,Picot H.,Tsarouchi G.,Walmsley N. (2015). The impact of climate change on the achievement of the post-2015 sustainable development goals. https//sustainabledevelopment.un.org/focusdgs.html. Accessed on 6/8/2017.

Apata T. G. Samuel, K. D. and Adeola, A. O. (2009) Analysis of Climate change perception and Adaptation among Arable Food Crop Farmers in south Western Nigeria *paper presented at the conference of International Association of Agricultural Economics pp. 2-9.*

Arumungan s., Ashok K.R., Kushereshtha S.N., Vallengany I. and Govindasamy R. (2014). Adapting to climate change through crop choice by small and medium farmers in Southern Zone of Tamil Nadu, India. *SAARC J. Agri., 12(1), 139-149 (2014).* Accessed on 19/7/2017.

Ayanwuyi E., Kuponiyi F. A., Ogunlade I. and Oyetoro J. O. (2010). Farmers Perception of Impact of Climate Changes on Food Crop Production in Ogbomoso Agricultural Zone of Oyo State, Nigeria. *Continental J. Agricultural Economics 4: 19 – 25*

Baum F., MacDaugall C. and Smith D. (2006). Epidmiol Community Health. BMJ Publishing Group Ltd.U.K.

Barbour R. (2008). Introducing Qualitative Research: A Student Guide to the Graft of Doing Qualitative Research. London: Sage.

Bartolini F. and Viagi D. (2010). Recent Developments in Multi-Criteria Evaluation of Regulations. Presentation during the 2nd MoniQA International Conference, Krakow, Poland, 8 June, 2010.

Bauer S. and Karki L.H. (2004). Technology Adoption and Household Food Security. Analyzing Factors Determining Technology Adoption and Impact of Project Intervention: A Case of Smallholder Peasants in Nepal. Paper Presented in the Deutscher Tropentag on 5-7 October, 2004, Humboldt-University, Berlin.

Beddington J., Asaduzzaman M., Clark M., Fernandez A., Guillou M., Jahn M, Erda L, Mamo T.,Van Bo N., Nobre C.A., Scholes R., Sharma R. and Wakhungu J.(2012). *Achieving food security in the face of climate change: Final report from the Commission on Sustainable Agricultureand Climate Change. CGIAR Research Program on Climate Change, Agriculture and FoodSecurity (CCAFS).* Copenhagen, Denmark.

Berg B.L. (2007). Research Methods for the Social Sciences, Sixth Edition. Pearson Education Inc. USA.

Bett B., Kiunga P., Gachohi J. and Sindato C., Mbotha D., Robinson T., Lindahi J., and Grace D. (2016). Effects of climate change on the occurrence and distribution of livestock diseases. Elsevier (2016), http://dx.doi.org/10.1016/j.prevetmed.2016.11.019. Last accessed on 6/8/2017.

Bezner K.R. (2013). Seed struggles and food sovereignty in Northern Malawi. *Journal of Peasant Studies, 40, 867-897*.

Bie S.W., Mkwambisi D. and Gomani M. (2008). Climate Change and Rural Livelihoods in Malawi. Review study report of Norwegian support to FAO and SCC in Malawi with a note on some regional implications. Noragric, Norwegian University of Life Sciences.

Biniam, M.G., Githiri S.M., Tadesse, M. and Kasili, R.W. (2014) Potato Seed Supply, Marketing and Production Constraints in Eritrea. *American Journal of Plant Sciences, 5, 3684-3693.* http://dx.doi.org/10.4236/ajps.2014.524384

Bonabana-Wabbi J. (2002). Assessing Factors Affecting Adoption of Agricultural Technologies: The Case of Integrated Pest Management (IPM) in Kumi District, Msc. Thesis Eastern Uganda.

Chaveller J.M. and Buckles D.J. (2013). Participatory Action Research: Theory and Methods of Engaged Inquiry. Rutledge, UK.

Check J. and Schutt R.K. (2012). Survey Research, In: Check J. and Schutt R.K. [Eds]. Research Methods in Education. Thousand Oaks, CA. Sage Publications, PP 159-185

Chesterman, S. and Neely, C. [Eds] (2015). Evidence and policy implications of Climate--smart agriculture in Kenya. CCAFS Working Paper no. 90. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Retrieved from www.ccafs.cgiar.org on 1/6/2017.

Chikaire, J.U., Ani, A.O., Atoma, C.N. and Tijjani, A.R. (2015). Capacity Building: Key to Agricultural Extension Survival. *Scholars Journal of Agriculture and Veterinary Sciences, Agric Vet Sci 2015; 2(1A):13-21*

Chisita C.T. (2012). Knotting and networking agricultural information services through Web 2.0 to create an informed farming community: a case of Zimbabwe. Session 205, Social networking for agricultural research, education, and extension service: an international perspective —Agricultural Libraries Special Interest Group. Retrieved from http://conference.ifla.org/ifla78 on 6/8/2017.

Connoly-Boutin L. and Smit B. (2015). Climate change, food security, and livelihoods in Sub-Saharan Africa. *Environ Change (2016) 16:385–399, Springer.*

Conroy R.M. (2016). Sample Size Handbook. Royal College of Surgeons, Ireland. www.rcsi.ie/files/research/docs/2016 0811111051 Accessed on 14/6/2017

Cooper J.M., Stern R.D., Noguer M..and Gathenya J.M. (2013). Climate Change Adaptation Strategies in Sub-Saharan Africa: Foundations for the Future Chapter 13. Retrieved from http://dx.doi.org/10.5772/55133 on 4/5/2015.

Cullen B.R., Johnson I.R., Eckard R.J., Lodge G.M., Walker R.G., Rawnsley R.P. and McCaskill M.R. (2009). Climate change effects on pasture systems in south-eastern Australia. *Crop & Pasture Science, 60, 933–942*

Dalice A. (2010). The sampling issues in Quantitative Research. Egitim Danismanligi Ve Arastivmalari Ilatism Hizmatlari Tic. Ltd. Istanbul, Turkey

Damisa M.A. and Yohanna M. (2007). The Role of Women in Farm Management Decision Making Process: Ordered Probit Analysis. *World Journal of Agricultural Sciences 3 (4): 543 – 54*

Darkwa S. and Darkwa A.A. (2013). The use of Indigenous Green Leafy Vegetables in the Preparation of Ghanaian Dishes. *Journal of Food Processing and Technology. 4:286.doi.10.4172/2157-7110.1/000286.* Accessed on 13/7/2017

Dickenson M., Pedler M. and Burgoyne J. (2009). Action Learning, what’s going on? Hanley Business School, University of Reading, UK.

Diiro, G. (2013). Impact of Off-farm Income on Technology Adoption Intensity and Productivity: Evidence from Rural Maize Farmers in Uganda. International Food Policy Research Institute, Working Paper 11.

Din N., Yahya S. and Kassim S.R. (2012). Online Social Networking for Quality of Life. Elsevier.

Donald M. (2009).Small Farmers’ Access to Higher-value Markets. What can we learn from the Malawi Pigeon Pea Value Chain? Center for Agricultural Research and Development, University of Malawi.

Eastern and Central Africa Programme for Agricultural Policy Analysis (2006). Promoting Agricultural Value Chains: The Case of Kenya. *ECAPAPA Newsletter Vol.9 No. 24*

Easterling W.E., Aggarwal P.K., Batima P., Brander K.M., Erda L., Howden S.M., Kirilenko A., Morton J., Soussana J.F., Schmidhuber J.and Tubiello F.N.(2007). Food, fibre and forest products, In Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry M.L., Canziani O.F., Paluti kof J.P., Van der Linden P.J. & Hanson C.E. (eds), Cambridge University Press, Cambridge, United Kingdom, 273-313.

Elum Z.A., Modise D.M. and Marr A. (2017). Farmers' Perception of Climate Change and Responsive Strategiesin Three Selected Provinces of South Africa. Elsevier.

Feng X., Liu M., Huo X. and Ma W., (2017). What Motivates Farmers' Adaptation to Climate Change? The Case of Apple Farmers of Shaanxi in China. Sustainability 2017, 9, 519; doi:10.3390/su9040519. Accessed on 6/8/2017.

Field A.P. (2009). Discovering Statistcs using SPSS: and sex and drugs and rock 'n' roll (Third Edition). London: Sage.

Finlay A. and Adera E. eds. (2012). Application of ICTs for Climate Change Adaptation in the Water Sector: Developing country experiences and emerging research priorities Association for Progressive Communications (APC) and the International Development Research Centre (IDRC), South Africa.

Food and Agriculture Organization of the United Nations (2008). International Year of the Potato. Retrieved from www.potato2008.org. on 14/11/2012

Food and Agriculture Organization (2013). A policymakers' guide to crop diversification: The case of the potato in Kenya. FAO, Rome.

Food and Agricultural Organization (2014a). Tanzania Mainland country profile: gender inequalities in rural employment in Tanzania Mainland, an overview. FAO, Rome

Food and Agricultural Organization (2014b). I identifying the "family farm". An informal discussion of the concepts and definitions. FAO, Rome.

Food and Agriculture Organization (2015a). FAO Statistical Yearbook 2015. FAO, Rome.

Food and Agriculture Organization of the United Nations (2015b). The economic lives of smallholder farmers. An analysis based on household data from nine countries. FAO, Rome.

Food and Agriculture Organization of the United Nations (2016a). Climate Change and Food Security, Risks and Responses. FAO, Rome.

Food and Agriculture Organization of the United Nations (2016b). Eastern Africa Climate Smart Agriculture Scoping Study: Ethiopia, Kenya and Uganda. FAO, Addis Abbaba.

Flato M., Muttarak R. and Pelser A. (2017). Weather and Woes: The Triangular Dynamics of Female-Headed Households, Economic Variability and Climate Variability in South Africa. *World Development Vol. 90 pp. 41-62.*

Fraenkel, J.R and Wallen, N.E (2000). *How to Design and Evaluate Research in Education.* New York, NY: McGraw Hill Publishing Co.

Freyer B., Asch F., Birech R., Malinga J., Dessalegn Y. and Alemayehu G. (2012). Smallholder Farmer Strategies to cope with Climate Change (SMACC) proposal applied to ERA ARD II Net call 2012.

Gathumbi M. (2009). Mainstream the potato. Paper Presented to the Irish Potato Round Table Meeting at Silver Springs Hotel Nairobi on May 8, 2009.

Gaur P. (2010) Constraints of Potato Seed Production in Developing Countries. In: Cromme N., Prakash A.B., Lutaladio N.B. and Ezeta, F., Eds., Strengthening Potato Value Chains: Technical and Policy Options for Developing Countries, The Food and Agriculture Organization of the United Nations and the Common Fund for Commodities, Rome, 61-70.

Gebru H., Mohammed A., Dechessa N. and Belew D. (2017). Assessment of Production Practices of Smallholder Potato (*Solanum tuberosum L.)* Farmers in Wolaita Zone, South Ethiopia. Agriculture and Food Security 2017. Retrieved from https://doi.org/10.1186/s40066=017-0106-8 on 2/9/2017.

Georgopoulos G. (2008). Knowledge Dissemination from the European Institute of Innovation and Technology. Centre for Economics and Policy Working Paper 2008/2. University of Cambridge.

Gibbs G. R. (2007). Analyzing qualitative data. In U. Flick (ED.).The sage qualitative research kit. London: Sage.

Gildemacher, P.R., Schulte-Geldermann, E., Borus, D. et al. Potato Res. (2011) 54: 253. doi:10.1007/s11540-011-9190-5. Last accessed on 8/6/2017

Gildemacher, P.R. (2012) Innovation in Seed Potato Systems in Eastern Africa. PhD Thesis, Wageningen University, Wageningen.

Golder B. (2005). Cross Cutting Tool Stakeholder Analysis. Retrieved from https://intranet.panda.org/documents/folder.cmf? U folder ID=60976. Last accessed on 7.10.2013

Government of Kenya (2004). Strategy for Revitalizing Agriculture. Kilimo House; Nairobi, Kenya.

Government of Kenya (2007). Kenya Vision 2030 – The Popular Version. Government of the Republic of Kenya, Government Printer, Nairobi.

Government of Kenya (2010). National Climate Change Response Strategy. Government Printer, Nairobi.

Government of Kenya (2011a): Agricultural Sector Development Support Programme – Programme Document. Government Printer, Nairobi.

Government of Kenya (2011b): Food and Nutrition Policy. Government Printer, Nairobi.

Government of Kenya (2012). National Climate Change Action Plan 2013-2017. Government Printer, Nairobi.

Government of Kenya (2014). Ministry of Agriculture, Livestock Development and Fisheries: Annual Report for Njoro Sub-County – 2013/2014 Financial Year.

Himanen S.J.,Mäkinen H., Rimhanen K. and Savikko R. (2016). Engaging Farmers in Climate Change Adaptation Planning: Assessing Intercropping as a Means to Support Farm Adaptive Capacity. *Agriculture 2016, 6, 34; doi: 10.3390/agriculture6030034*. Accessed on 19/7/2017

Hoeffler H. (2005). Promoting The Kenyan Potato Value Chain: Can Contract Farming Help Build Trust and Reduce Transaction Risks? Paper prepared for presentation at the 99th EAAE Seminar 'Trust and Risks in Business Networks, February 8-10, 2006, Bonn, Germany.

Höffler H. and Ochieng B.W.O. (2008). High commodity prices – who gets the money? A case study on the impact of high food and factor prices on Kenyan farmers. Berlin, Heinrich-Boell Foundation (available at http: //www. boell.de/downloads/worldwide. Last accessed on 30/5/2015.

Higgins J. (2005). Introduction to Multiple Regression.www.biddle.com/documents/bcg-comp- chapter 4. Accessed on 17/5/2017.

International Potato Center (CIP). 2011. Roadmap for investment in the seed potato value chain in eastern Africa. Lima, Peru, 27pp

International Resources Group (2008). Impacts of Climate Change on Rural Livelihoods in Madagascar and the Potential for Adaptation- Quarterly Report. United States Agency for International Development (USAID), Washington DC.

Jahn T. (2012). Transdisciplinarity as a Research Practice to Approach Sustainability Challenges – A Social-Ecological Perspective. Institute for Socio-Ecological Research, Lueneburg University, Frankfurt.

Jones R.W. (2007). Learning and teaching in small groups: Characteristics, benefits, problems and approaches. Anaesth. Intens. Care 2007, 35, 587–592.

Kabanza A.K. and Rwehumbiza F.B.R. (2007). Assessment of the Contribution of Tied Ridges and Farm Yard Manure Application to Sorghum Production in Semi-Arid Areas of Tanzania. In Batimo A. (Ed): Advances in Integrated oil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities, 723-729. Springler.

Kaguongo W.P., Gildemacher P., Demo P., Wagoire W., Kinyae P., Andrade J., Forbes G., Fuglie K. and Thiele G. (2008**).** Farmer practices and adoption of improved potato varieties in Kenya and Uganda. International Potato Center (CIP) Lima, Peru. Social Sciences Working Paper 2008-5. 85p.

Kaguongo W.P., Maingi G. and Gienke S. (2014). Post-harvest losses in Potato Value Chains in Kenya. GIZ, Frankfurt.

Kamau P.W., Kimani E. and Wamue-Ngare G. (2014). Gender relattions in utilization of Micro-finance resources among women in Kiharu Constituency, Murang'a County, Kenya. Merit Research Journal of Art, Social Science and Humanities, Vol. 2(7) pp.095100

Kaplinsky R. and Morris M. (2003). A handbook for Value Chain Research. International Development Research Centre, UK.

Karfakis, P., Knowles, M., Smulders, M. and Capaldo, J. **(**2011). Effects of global warming on vulnerability to food insecurity in rural Nicaragua. *ESA-FAO Working Paper Series No. 11–18.* Rome.

Karfakis P., Lipper L. and Smulders M. (2012). The assessment of the socio-economic impacts of climate change at household level and policy implications. Food and Agriculture Organization of the United Nations, Rome.

Kassie M., Ndiritu S.W. and Stage J. (2014). What determines Gender Inequality in household Food Security in Kenya? Application of Switching Treatment Regression. World Development Vol 56 pp. 153-171

Katelyn R (2016). Climate change impact on agriculture expected to have multi sector effect. 50 CMMYT 1966 to 2016.

Kathuri, N.J. and Pals, A.D. (1993*). Introduction to Educational Research*. Njoro:Egerton Education Book services, Kenya.

Kemmis, S. and McTaggart, R. (2007). Participatory Action Research. Retrieved from www.corwin.com/upm- data/21157. Last accessed 4/6/2014

Kenya National Bureau of Statistics (2008). Economic Survey 2008. Herufi House, Nairobi, Kenya

Khai, H.V., Yabe, M., Yokogawa, H., and Sato, G. (2008). Analysis of Productive Efficiency of Soybean Production in the Mekong River Delta of Viet Nam. Journal of Agriculture, Kyushu University. 53(1):271-279.

Kimiywe J., Waudo J., Mbithe D. and Maundu P. (2017). Utilization and Medicinal Value of Indigenous Leafy Vegetables Consumed in Urban and Peri-urban Nairobi. *African Journal of Food, Agriculture, Nutrition and Development. Vol.7. No.4, 2017.*

Kiptot E., Karuhanga M.,Franzel S. and Nzigamasabo P.B. (2016) Volunteer farmer-trainer motivations in East Africa: practical implications for enhancing farmer-to-farmer extension. *International Journal of Agricultural Sustainability, 14:3, 339-356, DOI: 10.1080/14735903.2015.1137685*

Krasny M.E. and Lee S.K. (2002). Social learning as an approach to environmental education: Lessons from a program focusing on non-indigenous, invasive species. *Environmental Education Research 8(2):101-119.*

Kristjanson P., Neufeldt H., Gassner A., Mango J., Kyazze F.B., Desta S., Sayula G., Thiede B. , Förch W., Thornton P.K. and Coe R. (2012). Are food insecure smallholder households making changes in their farming practices? Evidence from East Africa. Springerlink.com. Last accessed on 1/8/2013

Laibuni, N.M., Omiti, J.M. (2014). Market Structure and Price: An empirical analysis of Irish potato markets in Kenya; Future Agricultures Consortium: Nairobi, Kenya, 2014.

Lang D.J.,Wiek A., Bergmann M., Stauffacher M., Martens P., Moll P. and Swilling M., Thomas C.J. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. Springer

Lasco R.D., Habito C.M.D., Delfino R.J.P., Pulhin F.B. and Concepcion R.N. (2011). Climate Change Adaptation for Smallholder Farmers in Southeast Asia. World Agroforestry Centre, Philippines.

Lingard L., Albert M. and Levinson W. (2008).Grounded Theory, Mixed Methods, and Action Research". *British Medical Journal*.337 (2008): 567-567. Retrieved from http://works.bepress.com/loreleilingard/65.

Maatman A., Wongtschowski M., Heemskerk W., Sellamna N., Davis K., Nahdy S., Ochola W. and Kisauzi D. (2011). Dynamic Networks of Interactive Learning and Agricultural Research for Development .Three Critical Roles for Agricultural Advisory Services Conference Working Paper 11 prepared for the ASTI/IFRI-FARA conference, Accra, Ghana.

MacDonald C.(2012). *Understanding Participatory Action Research: A Qualitative Research Methodology Option. Canadian Journal of Action Research Volume 13, Issue 2, pages 34-50*

Mahendra D. S. (2011). Climate Change, Rural Livelihoods and Agriculture (focus on Food. Security) in Asia-Pacific Region. Indira Gandhi Institute of Development Research (IGIDR), India.

Maina I., Newsham A. and Akoti M. (2013). Agriculture and Climate Change in Kenya: Climate Chaos, Policy Dilemmas. Working Paper 070.Future Agricultures. p16 Marshall

Marshall N.A. (2009) Understanding social resilience to climate variability in primary enterprises and industries, *Global Environmental Change.*

Marshall N.A., Marshall P.A., Tamelander J., Obura D., Malleret-King D. and Cinner J.E. (2009). A Framework for Social Adaptation to Climate Change; Sustaining Tropical Coastal Communities and Industries. Gland, Switzerland, IUCN. v + 36 pp.

Mbaabu A.N. and Hall A. (Eds.) (2012). Capacity Building for Agricultural Research for Development: Lessons from Practice in Papua New Guinea. 274pp. United NationsUniversity-Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), Maastricht: The Netherlands.

McCarthy N., Lipper L. and Branca G. (2011). Climate-Smart Agriculture: Smallholder Adoption and Implications for Climate Change Adaptation and Mitigation. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Mekonnen D.A., Gerber N. and Matz J.A., (2016). Social Networks, Agricultural Innovations and Farm Productivity in Ethiopia. African Development Bank Working Paper series number 235, April, 2016.

Morton J. F. (2007).The impact of climate change on smallholder and subsistence agriculture Proceedings of the National Academy of Scienceswww.pnas.org vol. 104 no. 50

Michura E.G. and Njuguna T.K. (2017). Climate change and its influence on adoption of conservation agriculture by female smallholder farmers, Nakuru County, Kenya. *Sky Journal of Soil Science and Environmental Management Vol. 6(1), pp. 001 - 010, January, 2017*. Accessed on 19/7/2017.

Ministry of Agriculture (2009). Ministry of Agriculture Strategic Plan 2008-2012. Ministry of Agriculture. Nairobi. p.18

Ministry of Agriculture, Livestock and Fisheries (2015). Economic Review of Agriculture, 2015. Ministry of Agriculture, Livestock and Fisheries. Nairobi. p.15

Moore D.S. (2000). *The Basic Practice of Statistics (2nd Edition).* New York: W.H. Freeman and Company.

Mugenda O.M. and Mugenda A.G. (1999). Research Methods: Quantitative and Qualitative Approaches. Acts Press, Nairobi, Kenya.

Mutekwa V.T. (2009). Climate Change Impacts and Adaptation in the Agricultural Sector: The Case of Smallholder Farmers in Zimbabwe**.** *Journal of Sustainable Development in Africa, Volume 11, No.2*

Muthoni J. and Nyamongo D. O. (2009). A review of constraints to ware Irish potatoes production in Kenya. *Journal of Horticulture and Forestry Vol. 1(7) pp. 098-102*

Muthoni J., shimelis H., and Melis R. (2013). Potato Production in Kenya: Farming Systems and Production Constraints. Journal of Agricultural Science Vol.5 No. 5

Nakashima, D.J., Galloway M.K., Thulstrup H.D., Ramos C. A. and Rubis, J.T. (2012). Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation. Paris, UNESCO, and Darwin, UNU, 120 pp.

Nederlof, S., Wongtschowski M. and van der Lee F. (Eds): 2011. *Putting heads together. Agricultural innovation platforms in practice*. Bulletin 396, KIT Publishers.

Ng'eno V., Muiruri E.J., Nyangweso P.M. and Kipsat M.J. (2011). Farmers' Inaccessibility to Agricultural Credit in Nyandarua District, Kenya. *Asian Journal of Agricultural Research Vol.I (6) pp. 64-68.*

Ngo T. Q. (2016). Climate experiences in the Mekong River Delta, Vietnam. *African Journal of Agricultural Research Vol. 11(15), pp. 1361-1372, 14 April, 2016 DOI: 10.5897/AJAR2015.10756.* Accessed on 19/7/2017.

Nyangaka D.O., Obare G.A. and Nguyo W. (2009). Economic Efficiency of Smallholder Irish Potato Producers in Kenya: A Case of Nyandarua North District. Contributed Paper prepared for presentation at the International Association of Agricultural Economists' Conference, Beijing, China, August 16-22, 2009.

Ogutu S.O., Okello J.J., Jakinda D.O. (2014). Impact of information and communication based market information services on smallholder farm input use and productivity: The case of Kenya. *World Dev. 2014, 64, 311–321.*

Ojwang' G.O., Agatsiva J. and Situma C. (2010). Analysis of Climate Change and Variability Risks in the Smallholder Sector: Case Studies of the Laikipia and Narok Districts Representing Major Agro-ecological Zones in Kenya. FAO, Rome, Italy.

Okello J.J., Zhou Y., Kwikiriza N. 1, Ogutu S.O., Barker I., Schulte-Geldermann E., Atieno E. and Justin Taj Ahmed J.T. (2016). Determinants of the Use of Certified Seed Potato among Smallholder Farmers: The Case of Potato Growers in Central and Eastern Kenya. *Agriculture 2016, 6, 55; doi: 10.3390/agriculture6040055.* Last accessed on 3/6/2017.

Okonya J.S., Kroschel J. (2016). Farmers' knowledge and perceptions of potato pests and their management in Uganda. *Journal of Agriculture and Rural Development in the Tropics and Subtropics Vol. 117 No. 1 (2016) 87–97*. Last accessed on 17/7/2017.

Ongusumi L.O. (2007). Socio-economic Conditions of Peasant Farmers: The Case of Agricultural Technologies Sustainability in South-West Nigeria. *African Journal of Agricultural Research Vol 2 (9) pp. 441 – 446, September 2007.*

Osumba J. and Rioux J. (2015). Scoping study on climate-smart agriculture in Kenya Smallholder integrated crop-livestock farming systems. Food and Agriculture Organization of the United Nations, Rome.

Overseas Development Institute (2009). Planning Tools: Problem Tree Analysis. https//www.odo.org>publications 525. Accessed on 17/4/2015

Pandey S.K. (2009) Potato Research Priorities in Asia and the Pacific Region. In: Papademetriou, M.K., Ed., Proceedings of the Workshop to Commemorate the International Year of Potato—2008, Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok, 30-39.

Patton, M. Q. (2002). Qualitative research and evaluation methods (3rd Ed.). Thousand Oaks, CA: Sage.

Rafisura K. and Srinivasan G. (2010). Integrating Disaster Risk Reduction and Adaptation into Rural Livelihood Programming. A guide for Oxfam Staff and Patners in Southeast Asia.Oxfam, Hong Kong.

Rahman M. A. (2008). Some Trends in the Praxis of Participatory Action Research. In Reason P. and Bradbury H. (Eds.). The Sage Handbook of Action Research. Sage Publications, London pp 49-62.

Random House Dictionary (2013). Random House inc.

Ratnadass A., Fernandes P., Avelino J. and Habib R. (2012). Plant Species Diversity for Sustainable Management of Prop Pests and Diseases in Agro-ecosystems: a review. *Agronomy for Sustainable Development, Volume 32, Issue 1, pp. 273-303.*

Reason, P. and Bradbury H. (Eds.) (2008). The Sage Handbook of Action Research: Participative Inquiry and Practice (2nd Ed.).Sage Publications, London.

Ringler C. (2011). The Impact of Climate Variability and Climate Change on Water and Food Outcomes - A Framework for Analysis in Ringler C.,Bryan E., Hassan R.M.,Alemu T., and Hillesland M. (eds). How Can African Agriculture Adapt to Climate Change? Insights from Ethiopia and South Africa. International Food Policy Research Institute, Washington DC.

Rogers E.M. (1983). Diffusion of Innovations, Third Edition. Macmillan Publishing Co. Inc. New York.

Roncoli C., Okoba B., Gathaara V., Ngugi J. and Nganga T. (2010). Adaptation to Climate Change for Smallholder Agriculture in Kenya: Community-Based Perspectives from Five Districts.University of Georgia, Griffin.

Schiffer E. (2007). Net-Map Toolbox: Influence Mapping of Social Networks pp.3–4. International Food Policy Research Institute. Presented at the Sunbelt Conference of the International Network of Social Network Analysis, 01-06 May 2007, Corfu, Greece.

Scholz R. (2012). The Global TraPs Project Transdisciplinary Processes for Sustainable Phosphorus Management (2010–2015). Internal paper, ETH Zurich.

Sebatta C., Mugisha J., Katungi E., Kashaaru A. and Kyomugisha H. (2014) Smallholder Farmers' Decision and Level of Participation in the Potato Market in Uganda. *Modern Economy, 5, 895-906.http://dx.doi.org/10.4236/me.2014.58082.* Last accessed on 8/6/2017.

Sempeho G. (2004). Reforms of Agricultural Research and Technology Dissemination Systems in Eastern Africa: Tanzania Experience. Paper Presented at ASARECA/NARS/World Bank Retreat, Addis Abbaba, Ethiopia, 26 -28 February, 2004.

Shibabaw A., Alamayehu G., Desalegn Y., Adgo E., Tewodoros Y., Germer J., Asch F., Merene Y. and Freyer B. (2014). Exploratory Survey on Climate Change Effects, Value Chain Processes and Supportive Services: Case Study from Potato Based Farming System of Awi-Zone, Ethiopia. International Journal of Agriculture Innovations and Research Volume 2, Issue 4, ISSN (Online) 2319-1473. Last accessed on 16/7/2017.

Singleton R.A. and Straits B.C. (2009). Approaches to Social Research. Oxford University Press.

Sullivan *E., (2010)* Agriculture, Health, Technology. *Retrieved from* http://www.earthzine.org. Last accessed on 6/11/2013

Thompson A. (2016). Africa faces hotter future. Global warming hits the African continent soonest and hardest. Climate Central May 2016. Retrieved from https://www.scientifiamerican.com.Afri. on 30/7/2017.

Thornton P.K., Van de Steeg J., Notenbaert A. and Herrero M. (2008). *The livestock climate poverty nexus: A discussion paper on ILRI research in relation to climate change* Discussion Paper No. 11, ILRI, Nairobi, Kenya, p 76.

Tolno E., Kobayashi H., Ichizen M., Esham M., and Balde B.S. (2016). Potato Production and Supply by Smallholder Farmers in Guinea: An Economic Analysis. *Asian Journal of Agricultural Extension, Economics & Sociology 8(3): 1-16, 2016; Article no.AJAEES.21726.*

Trochim W.M. (2006). *The Research Methods Knowledge Base, 2nd Edition*. Retrieved from http://www.socialresearchmethods.net/kb/> on 15/4/2014

Tripathy A. and Mishra A.K. (2016). Knowledge and passive adaptation to climate change: An example from Indian farmers. Elsevier.

Tubiello F. (2012). Climate change adaptation and mitigation: challenges and opportunities in the food sector. Natural Resources Management and Environment Department, Food and Agriculture Organization of the United Nations, Rome.

United States Agency for International Development (2007). Adapting to climate variability and change. A guidance manual for development Planning. USAID, Washington DC.

United Nations Framework Convention on Climate Change (2007).The Bali Action Plan.United Nations Framework Convention on Climate Change. Retrieved from http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf. Last accessed on 14/7/2015

United Nations Development Programme (2017). Coherence of Sustainable Development Goals, Climate Change Adaptation and Sendai framework on Disaster Risk Reduction at the International Perspective. Speech by Ms. Beate Trankmann, Resident Coordinator, United Nations, Mongolia

University of Reading Statistical Centre (2000). *Guidelines for Planning Effective Surveys*. Statistical Services Centre, University of Reading, U.K.

Van Aelst K.V. & Holvoet N. (2017). Climate change adaptation in the Morogoro Region of Tanzania: women's decision-making participation in small-scale farm households, Climate and Development, DOI: 10.1080/17565529.2017.1318745. Last accessed on 3/6/2017.

Wani S. A, Chand S, Najar G. R and Teli M. A. (2013). Organic farming: as a Climate Change Adaptation and Mitigation Strategy. Curr Agri Res 2013; 1(1):45-50. doi http://dx.doi.org/10.12944/CARJ.1.1.06. Last accessed on 14/8/2015.

Wangai A.W., Redinbough M.G., Kinyua Z.M., Miano D.W., Leley P.K., Kasina M., Mahuku G., Sheets K. and Jetters D. (2012). Plant Disease. *American Phyto Pathological Society Journal. Volume 96* Number 10 Page 1582. Retrieved from http://dx.doi.org/10.1094/PDIS-06-12-0576-PDN. Last accessed on 2/10/2014

Warnecke A., Tänzler D. and Vollmer R. (2010). Climate Change, Migration and Conflict: Receiving Communities under Pressure? The German Marshall Fund of the United States.

Weiss, C.H. (1995). Nothing as Practical as Good Theory: Exploring Theory-based Evaluation for Comprehensive Community Initiatives for Children and Families. In Connel J.P., Kubish A.C., Schorr L.B. and Weiss C.H. [Eds] (1995).New Approaches to Evaluating Community Initiatives: Concepts, Methods, and Contexts. Washington, DC: Aspen Institute.

Were H.K., Kabira N.J., Kinyua Z.M., Olubango F.M., Karinga J.K., Aura J., Lees A.K., Cowan G.H. and Torrence L. (2013). Occourance and Distribution of Potato Pests and Diseases. Springer.

Wolf J., Mandryk M., Argyris Kanellopoulos A., Van Oort P., Schaap B., Reidsman P. and Van Ittersum M. (2011). Integrated assessment of adaptation to Climate change in Flevoland at the farm and regional level. Agri Adapt Project Report no. 4 & 5 Wageningen UR, Wageningen

World Bank (1989). Women and Food Security in Kenya. Population and Human Resources Department: The World Bank, Washington D.C.

World Bank (2002). Empowerment and poverty reduction source book. The World Bank: Washington DC

World Bank (2006). Enhancing Agricultural Innovations: How to go beyond the Strengthening of Research Systems. Economic Sector Work Report. The World Bank: Washington, DC.

Yin, R. K. (2009). Case study research: Design and methods (4th Ed.). Thousand Oaks, CA: Sage Publishing.

Zomer R.J., Trabucco A., Bossio D.A. and Verchot L.V. (2008). Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation. *Agriculture, Ecosystems and Environment 126 (2008) 67–8*

APPENDICES

APPENDIX A: QUESTIONNAIRE FOR SMALLHOLDER POTATO FARMERS

Introduction

This survey is aimed at finding out the challenges to potato production under climate change pressure and analysis of household practices among smallholder farmers in Mauche Ward of Njoro Sub-County, Kenya. Your honest answers are very vital to this study, will be treated with utmost confidentiality and will not be used for any purpose other than this study.

SECTION I: SOCIO-ECONOMIC BACKGROUND OF THE RESPONDENTS

Date of interview---

Name of Respondent--

County ______________________Sub-County ________________ Ward _________________

1. Age of Respondent __________________________ (years)

2. Gender of the Respondent

   Male ☐ Female ☐

3. Relationship of respondent to household head

   Self ☐ Wife ☐ Son ☐ Daughter ☐ Relative ☐

   Other (specify) ___________________________________

4. Level of formal education

   None ☐ Primary ☐ Secondary ☐ Post-secondary ☐

   Other (Specify) ___________________________________

5. Farm Size (Acres)

   Below 1 ☐ 1-5 ☐ 5.1-10 ☐ Over 10 ☐

6. Land tenure:

   Owned with title deed ☐ Owned without title deed ☐ Rented ☐

7. Indicate the main enterprises you have on your farm

Crop enterprises	Size (Acres)	Livestock enterprises	Numbers
1. Maize 2. Potato 3. Beans 4.Vegetables 5. Garden peas		1. Cattle 2. Sheep 3. Goats 4. Chicken 5. Bee hives	

8. Indicate your sources of household income and total earnings per year

Source of income	**Yearly earnings (Ksh)**
Livestock farming	
Crop. farming	
Salary from employment	
Small scale business (Hawking, kiosk, hotel, shop, bar)	
Assistance by relatives/lenders	
Others (specify)	
TOTAL	

SECTION II: CLIMATE CHANGE RELATED CHALLENGES EXPERIENCED BY SMALLHOLDER POTATO FARMERS

9. Have you noted any significant changes in rainfall pattern and temperature in recent years?

Yes ☐ No ☐

10. If yes, rate the common indicators of climate change according to how they have affected you or your area using the following Likert scale:

Indicator of climate change	**1 Very Low**	**2 Low**	**3 Moderate**	**4 High**	**5 Very High**
Changes in rainfall seasonality					
Observed changes and trends in temperature					
Water resources – changes in quality, quantity					
Forest Cover – changes in extent, wood supply					
Soil fertility, extent of erosion, runoff					
Effects on human health					
Increased Pests/Diseases					
Reduced crop yields					
Reduced availability of fodder					
Incidence of bush fires					

11. What strategies have you used to cope with climate change?

12. Which is your main source of information on climate change?

Ministry of Agriculture ☐ Other GoK Organizations ☐ NGOs/CBOs ☐

Media ☐ Internet ☐ Other Farmers ☐

Others, specify ______________________________

13. Have you attended any training related to Climate Change and potato production?

Yes ☐ No ☐

14. If yes, who trained you? ______________________________

15. Which topics were you trained on?

____

16. Please indicate the level of knowledge you have acquired on the listed climate change adaptation strategies for potato production.

Technology	**Level of Knowledge**				
	1 **Very Low**	**2** **Low**	**3** **Moderate**	**4** **High**	**5** **Very High**
Use of organic fertilizer					
Crop rotation					
Relay cropping					
Inter cropping					
Water management by use of tie ridges					
Potato disease control					
Post-harvest management					

SECTION III: ANALYSIS OF HOUSEHOLD PRACTICES

17. Where is your main Source of potato seed?

Cooperative Society ☐ Other farmers ☐ ADC ☐ Research Centre ☐

NGO/CBO ☐ Private suppliers ☐

Other (specify) ____________________________

18. What is the price of potato seed per 50kg?

18. Do you always get potato seed in the quantities that you need every year

Yes ☐ No ☐

If no, what is the reason?

Not available ☐ Too expensive ☐

I am not sure of benefit ☐ Not available on time ☐

19. Are there any market related opportunities that motivate you to produce potato?

Yes ☐ No ☐

If yes, which ones?

____

____

____

20. How do you store your potato seed?

____

21. How do you store your ware potato?

____

22. Do you use potato as a major food item in the household?

Yes ☐ No ☐

23. If no, what is the main reason?

Lack of knowledge/skill on how to prepare food recipes from potato ☐

Low level of production ☐ Low preference as food ☐ I prefer to sell it ☐

Others (specify)____

24. Do you have sufficient food in your household throughout the year?

25. Are there any problems you face in potato marketing?

Yes ☐ No☐

25. If yes, what are the problems?

Lack of market information ☐ Poor linkage to the market ☐ Low consumer demand ☐

Limited access to market ☐ Inadequate transportation ☐

Others (specify)____

26. Are there marketing cooperatives/ farmers' organization working on potato?

Yes ☐ No ☐

27. If yes, what services do they provide?

____

____

28. Indicate your general opinion about the listed constraints to potato marketing using the following key:

Strongly Agree (SA) ☐ Agree (A) ☐ Undecided (U) ☐ Disagree (D) ☐ Strongly Disagree (SD) ☐

Constraint to potato marketing	**5 SA**	**4 A**	**3 U**	**2 D**	**1 SD**
Low quality of produce					
Low market prices					
Unavailability of markets					
Lack of market information					
Difficulties in processing					
Difficulties in storage					
Poor transport to the market					
Farmers are not organized to market collectively					

29. What is the main energy source in your household?

Firewood ☐ Biogas ☐ Solar ☐ Gas ☐ Electricity ☐ Charcoal ☐

***** THE END – THANK YOU*****

APPENDIX B: FOCUS GROUP DISCUSSION GUIDE FOR POTATO VALUE CHAIN ACTORS

1. Agro-chemical input suppliers

i. Which potato production inputs do you supply?
ii. Where is your source of inputs?
iii. Which products are most demanded by farmers?
iv. Are you able to meet the farmers' demands?
v. What are your challenges as an agro-dealer?

2. Traders

i. What are the preferred potato varieties?
ii. What are the available potato varieties?
iii. What are your sources of Potato?
iv. Are your sources of potato reliable throughout the year?
   If not reliable, which months of the year do you have deficiencies?
v. What are the market outlets for your potatoes?
   Are you able to meet the demand for tomatoes for your market outlets?
vi. What factors do you take into account when you negotiate prices with people who sell potatoes to you?
vii. What factors do you take into account when you negotiate prices with people who buy potatoes from you?
viii. How do potato prices vary?
ix. When selling potatoes do you receive higher prices for potatoes of higher quality
x. What quality attributes of potatoes receive the best prices?
xi. Are you able to obtain Potatoes with the desired quality attributes?
xii. What is the source of potatoes with the desired quality attributes?
xiii. On average, for how long do you store your potatoes before selling?
   Do you experience potato storage losses?
   If yes, what are the major causes of potato storage loses?
   (both in terms of quality and quantity)

3. Transporters

i. Where is your source of potato?
ii. Is potato available throughout the year?
iii. If not, which months do you have a deficit?
iv. How do you package potato during transportation?
v. What are the main destinations of the potatoes you transport?
vi. What challenges do you face as a transporter?

4. Hotels/Restaurants/ Supermarkets

i. What is your source of potato?
ii. Which potato varieties do you prefer? Why?
iii. Are potatoes available throughout the year?
iv. If not, which months do you have a deficit?
v. What quality attributes do you consider when buying potatoes?
vi. Are you willing to pay more for higher quality potatoes?
vii. Would you be interest in buying tomatoes from smallholder farmers on Contractual basis?
viii. How do you store potato?
ix. Do you have any challenges with potato storage?

5. Processors

i. What are your sources of potato?
ii. Do you prefer specific potato varieties? Why?
   Are you willing to pay higher prices for better quality potatoes?
iii. How do potato buying prices vary?
iv. Would you be interest in buying potatoes from smallholder farmers on Contractual basis?
   Please state your terms of business

APPENDIX C: FOCUS GROUP DISCUSSION GUIDES FOR FARMERS

APPENDIX C-1: CLIMATE CHANGE IMPACTS ON LIVELIHOODS AND COPING STRATEGIES

No.	Items	Main Observation	Remark
1.	**Local awareness and perception of climate variability and trends related to climate change and associated impacts on natural resources**		
i	Changes in rainfall seasonality, abundance		
ii	Observed changes and trends in temperature		
iii	Floods – frequency and severity		
iv	Droughts – frequency and severity		
v	Water resources – changes in quality, quantity		
vi	Forest Cover – changes in extent, wood supply		
vii	Soil fertility, extent of erosion, runoff		
viii	Wildlife/Fisheries/Other natural products		
2	**Consequences and impacts of climate related changes and trends, with particular attention to livelihoods and socio-economic impacts**		
i	Impacts on human health		
ii	Changes in food security		
iii	Changes in principal sources of income, livelihoods		
iv	Changes in crop yields, productivity of rural production systems		
v	Changes in land use mix changes in labor/time devoted to secure water supply		
vi	Changes in availability of fodder, fuel-wood, non-timber forest products (NTFPs)		
vii	Changes in incidence of bush fires or other consequences		

3	**Expectations of future changes and perceptions of vulnerability**		
i	Expectations for rainfall		
ii	Anticipated patterns for floods, drought		
iii	Anticipated changes in land use		
iv	Anticipated situation regarding food security		
v	Observations on major drivers of observed changes in rainfall, temperature, food production		
vi	Other sources of major impacts on local livelihoods and the conservation of biodiversity		
4.	**Observations on Responses and Adaptation**		
i	Local initiatives and adaptations adopted in terms of mix of crops planted		
ii	Adoption of soil/water conservation practices		
iii	Measures taken to intensify agricultural production		
iv	Measures taken to diversify agricultural production		
v	Other major changes in use of natural resources or shifts in relative importance of local livelihoods		
5	**Observations about barriers or principal constraints to adaptation to climate change**		
i	Implementation of interventions to reduce vulnerability		
ii	Principal interventions that could be implemented to reduce risks and negative impacts associated with climate change		
iii	Major constraints or barriers to implementing recommended interventions		
6	**Main Options (alternatives) during climate change pressure**		
i	Migration		
ii	Selling Assets		
iii	Claiming to relatives to get remittances		
iv	Contracting land		

v	Shifting dietary pattern		
vi	Allowing children to work for others on daily payment basis		
vii	Getting credit from local providers		
viii	**Possible Solutions as Suggested by Farmers for Climate Change Pressure**		

C-2: CLIMATE CHANGE ADAPTATION AT HOUSEHOLD LEVEL

i. What climate change adaptation measured have you adopted on your farm?

ii. What challenges are you facing in adopting the strategies?

iii. How do you obtain your potato seed?

iv. How do you store your seed potato?

v. How do you store your ware potato?

vi. Do you use potato as a major food item?

vii. How do you market your potato?

viii. Do you have any constraints in potato marketing?

ix. Do you practice water harvesting?

x. What are your sources of household energy?

APPENDIX D: KEY INFORMANT INTERVIEW CHECKLISTS

1. Climate Change Unit of the State Department of Agriculture

i. What are the Climate Change related challenges to agriculture in Kenya?
ii. Is there a policy framework for climate change mitigation and adaptation in Kenya?
iii. What specific interventions is the State Department of Agriculture undertaking to address climate change?
iv. What are the major achievements, gaps and challenges in ensuring adequate attention to climate change adaptation in agriculture?

2. National Potato Council of Kenya/KALRO Tigoni

i. What is your area of intervention as far as the Potato is concerned?
ii. Comment on the potato policy environment
iii. What are the effects of climate change along the potato value chain in Kenya?
iv. What adaptation strategies are the farmers employing to cope with climate change?
v. To what extent is research integrating indigenous knowledge in climate change adaptation innovations?

3. Kenya National Farmers' Federation (KENAFF)

i. Comment on the potato policy environment
ii. What are the key issues with regard to the Kenyan potato by-law (Legal notice number 44 of 2005) on potato packaging?
iii. What are the main constraints to implementation?
iv. How is climate change affecting smallholder potato farmers?
v. What are the climate change adaptation strategies (including indigenous knowledge) employed by farmers?

4. Agricultural Technology Development Centre (ATDC, Nakuru)

i. Which potato production implements do you fabricate?

ii. Are there any implements that enhance climate change adaptation?
If so, are potato farmers demanding for these implements?
Are you able to meet farmers' demands?

iii. What are your challenges as a fabricator of agricultural implements?

5. Agricultural Development Corporation (ADC), Molo

i. What are the climate change related challenges to potato seed production in this area?

ii. What strategies do you employ to cope with climate change?

iii. Which potato seed varieties do you multiply?

iv. Are there any potato seed varieties for adaptation to climate change?

v. Do you meet demand for potato seed?

vi. What challenges do you encounter as a seed multiplier?

APPENDIX E: COLLECTIVE LEARNING COMMUNITY EVALUATION TOOL

Introduction

The purpose of this survey is to evaluate the Collective Learning Community for climate change adaptation in Mauche Ward of Njoro Sub-County, Kenya. Your honest answers are very vital to this study, will be treated with utmost confidentiality and will not be used for any purpose other than this study.

SECTION I: SOCIO-ECONOMIC BACKGROUND OF THE RESPONDENTS

Date of interview---

Name of the Respondent---

County ______________________Sub-County ________________ Ward _________________

1. Age of the Respondent ___________________________ (years)
2. Gender of the Respondent

   Male ☐ Female ☐
3. Relationship of respondent to household head

   Self ☐ Wife ☐ Son ☐ Daughter ☐ Relative ☐

   Other (specify) ____________________________________
4. Level of formal education

   None ☐ Primary ☐ Secondary ☐ Post-secondary ☐

   Other (Specify) _____________________________________
5. Farm Size (Acres)

   Below 1 ☐ 1-5 ☐ 5.1-10 ☐ Over 10 ☐
6. Land tenure:

   Owned with title deed ☐ Owned without title deed ☐ Rented ☐

7. Main enterprises you have on your farm

Crop enterprises	Size (Acres)	Livestock enterprises	Numbers
1. Maize 2. Potato 3. Beans 4.Vegetables 5. Garden peas		1. Cattle 2. Sheep 3. Goats 4. Chicken 5. Bee hives	

8. Sources of household income and total earnings per year

Sources of income	**Yearly earnings (Ksh)**
Livestock farming	
Crop. farming	
Salary from employment	
Small scale business (Hawking, kiosk, hotel, shop, bar)	
Assistance by relatives/lenders	
Others (specify)	
TOTAL	

SECTION II: EVALUATION OF THE COLLECTIVE LEARNING COMMUNITY

9. Network Quality

i. What is the level of attendance to scheduled meetings by CLC members?

1. Very low ☐ 2. Low ☐ 3. Moderate ☐ 4. High ☐ 5. Very high ☐

ii. To what extent do the members of your CLC interact at individual level?

1. Very low ☐ 2. Low ☐ 3. Moderate ☐ 4. High ☐ 5. Very high ☐

10. Capacity building of farmers

Please indicate the level of capacity building you have received from the listed CLC activities

CLC Activity	Level of Capacity building				
	1 Very Low	2 Low	3 Moderate	4 High	5 Very High
Group Training					
Farm Visit					
Field Day					
Tour					
Workshop/Seminar					
Demonstration					

11. Knowledge Dissemination

Rate the CLC on the level of knowledge dissemination using the following key.

1. Very Low ☐ 2. Low ☐ 3. Moderate ☐ 4. High ☐ 5. Very High ☐

SECTION III: INTEGRATION OF CLIMATE CHANGE ADAPTATION STRATEGIES

12. Knowledge acquired on climate change adaptation strategies

Please indicate the level of knowledge you have acquired on the listed Climate Change Adaptation strategies through CLC training.

Climate Change Adaptation Strategy	Level of Knowledge				
	1 Very Low	2 Low	3 Moderate	4 High	5 Very High
Potato seed production					
Potato disease control					
Crop rotation					
Use of tied ridges					
Inter cropping					
Use of farm yard manure					
Use of green manure					
Potato storage					

13. Access to potato seed

Please rate your level of access to potato seed using the listed criteria

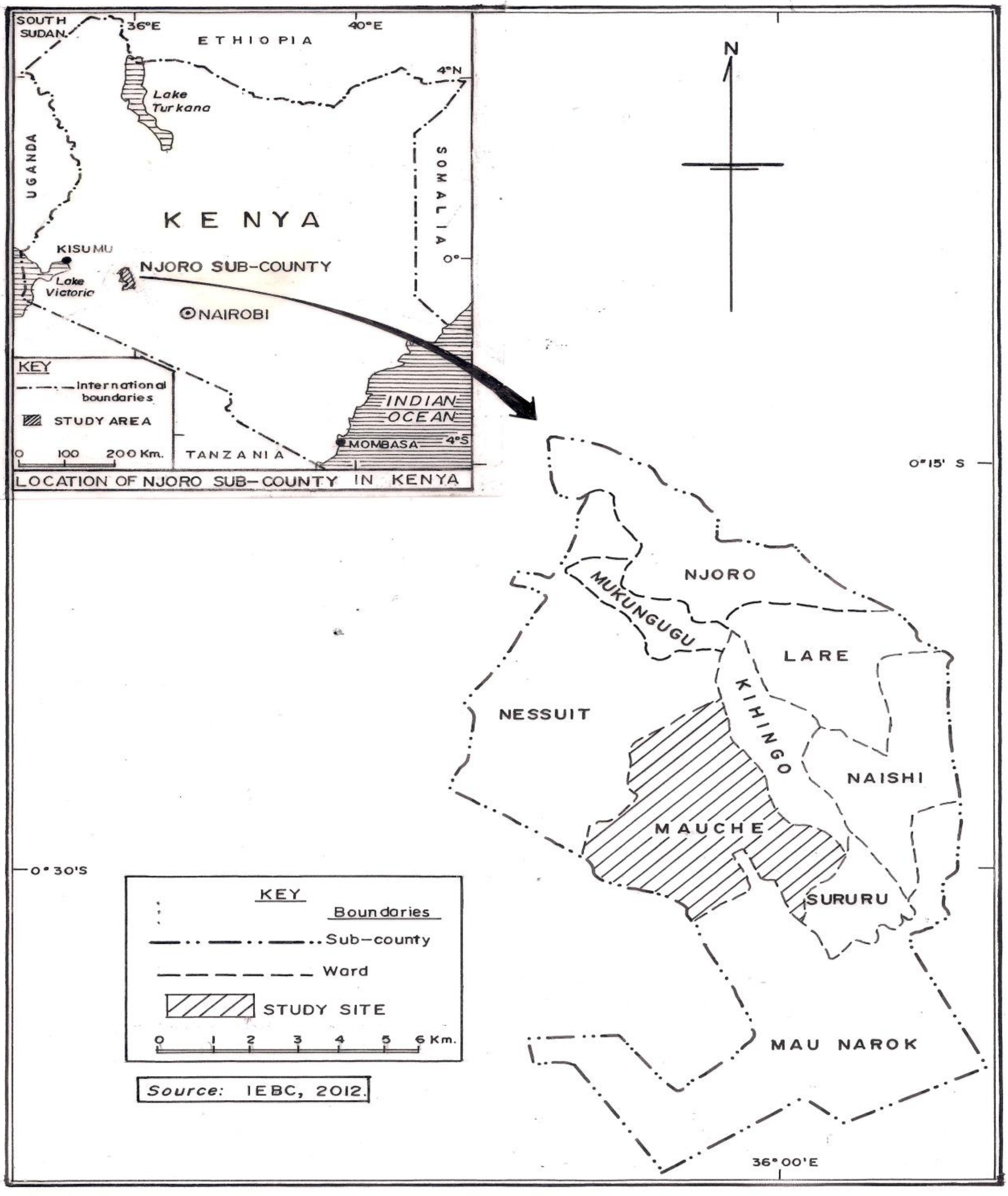
Criteria for access to potato seed	Level of Access				
	1 Very Low	2 Low	3 Moderate	4 High	5 Very High
Availability of clean potato seed					
Access to variety of choice					
Affordability of potato seed					
Timeliness of acquiring potato seed					

14. Access to potato market

Please rate your level of access to the market using the listed criteria

Criteria for access to the market	Level of Access				
	1 Very Low	2 Low	3 Moderate	4 High	5 Very High
Market Information					
Transport to the market					
Group marketing					
Linkage to consumers					
Linkage to processors					

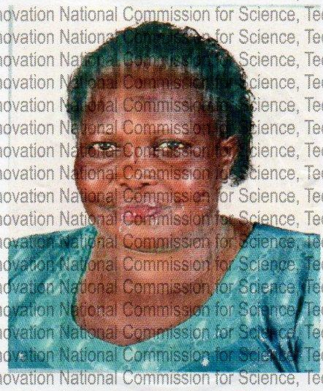
APPENDIX F: MAP OF KENYA SHOWING LOCATION OF THE STUDY AREA



APPENDIX G: COPY OF THE RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MS. RAEL JEPKEMEI TAIY
of EGERTON UNIVERSITY, 0-30100
eldoret,has been permitted to conduct
research in *Nakuru County*

Permit No : NACOSTI/P/16/92413/9876
Date Of Issue : 22nd March,2016
Fee Recieved :Ksh 2000



on the topic: *INTEGRATION OF CLIMATE CHANGE ADAPTATION STRATEGIES IN POTATO PRODUCTION THROUGH A COLLECTIVE LEARNING COMMUNITY IN MAUCHE WARD OF NJORO SUB-COUNTY, KENYA*

for the period ending:
21st March,2017

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 8221

CONDITIONS: see back page