ASSESSING INFLUENCE OF POSITIVE DEVIANCE AND COLLABORATIVE LEARNING ON IMPROVING CASSAVA PRODUCTION AND MARKETING IN NYANDO CLIMATE-SMART VILLAGES, KISUMU COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Doctor of Philosophy Degree in Agricultural and Rural Innovation Studies of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND RECOMMEDATION

Declaration

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

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DEDICATION

This work is dedicated to my loving wife Shirley Tana and my children, Philip, Silvia, Peter, Stephanie and Patrick, for the support they gave throughout the study period. To my late beloved mother, Abigael for her sacrifice in providing for my education single-handedly and to my late father John, for his true love and precious gifts he gave me a few months before his passing on.

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ABSTRACT

The Nyando Climate Smart Village (CSV) is a multi-stakeholder Collaborative Learning Platform facilitated co-testing and co-development of a portfolio of climate smart technologies to empower farmers to respond to changing and variable climate risks. However, field surveys suggested that majority of the farmers have abandoned the technologies, suggesting that only a few could be benefiting with the worsening exposure to climate risks. Though collaborative learning may have failed to empower farmers, a phenomenon pointing to positive deviance behaviour is emerging, indicating possibility of viable solutions being present within local communities by positive deviant farmers who outperform positively compared to the typical majority. This study aimed to understand the influence of positive deviance and collaborative learning on fostering cassava production and marketing in Nyando CSVs of Kenya. The specific objectives were to determine how different typical farmers are compared to positive deviant farmers in adopting, abandoning and knowledge gained from climate smart cassava production and marketing; and how functions of innovation systems and collaborative learning have fostered climate smart cassava production and marketing in Nyando CSVs . The study implemented Participatory Action Research that integrated a household survey, Focus Group Discussion, Key informant interviews and collaborative learning forum (CLF). A sample of 150 farmers were reached out of which, six farmers were identified by peers as positive deviants (PDs) in climate smart cassava innovations. Data analysis was descriptive and inferential with Chi-square tests, logistic regression and best-worst score computation. Positive deviant farmers were distinctively different from typical farmers in adopting, abandoning and realising gains from climate smart cassava production and marketing. Compared to typical farmers, positive deviant farmers replaced local cassava varieties, allocated more land to improved varieties, and improved postharvest handling and cassava value addition. Unlike typical farmers, positive deviant farmers were less likely to abandon climate smart cassava innovations. They also attained relatively higher production, diversification, adaptability, productivity, marketable surplus and food security. Fostering of cassava production and marketing was relatively more important with knowledge development (19.17%), knowledge diffusion (18.86%) and resource mobilisation (14.88%). Collaborative learning had greatest improvement in knowledge about viable cassava seed cuttings, use of inputs, intercropping cassava with other crops, value addition and linkage to processors. These results demonstrate that positive deviance and collaborative learning can foster cassava production and marketing in Climate-Smart Villages. The study recommends strengthening extension service linked to farmer networks and proactively involving positive deviant farmers in promoting climate smart cassava innovations to empower farmers better against climate related risks.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACIAR	The Australian Centre for International Agricultural Research
AIS	Agricultural Innovation System
AR4D	Agricultural Research for Development
CCAFS	Climate Change and Food Security
CGIAR	Consultative Group on International Agricultural Research
COMCEC	Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation
CSA	Climate Smart Agriculture
CSV	Climate Smart Village
FAO	Food and Agricultural Organization of the United Nations
GHG	Green House Gas
GLCA	Global Leadership for Climate Action
IP	Innovation Platform
IPCC	Intergovernmental Panel on Climate Change
NACOSTI	National Commission for Science Technology and Innovation
NARS	National Agricultural Research Systems
ODI	Overseas Development Institute
OIC	Organization of Islamic Cooperation
PD	Positive Deviance
PAR	Participatory Action Research
RELMA	Regional Land Management
SEI	Stockholm Environment Institute
SSA	Sub-Saharan Africa
ULAMP	Uganda Land Management Programme

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Climate Smart Villages (CSV) is a multi-stakeholder-facilitated collaborative learning effort aimed at enabling local communities in areas prone to extreme and variable weather events to address chronic climate threats, food insecurity, poverty, and disease outbreaks. The CSV strategy is part of the Agriculture Research-for-Development (AR4D) agenda across Africa, Asia, and Latin America to address climate change problems for food security and improved livelihoods (Campbell *et al.,* 2016). The CSV approach is implemented by collective action groups that are mobilized locally. Functionally, these are forums for inventive collaboration to deliver new information and skills, produce innovations, and intentionally build farmer capacity to modify farming practices (Ojango *et al.,* 2016).

Among the approaches used by the multi-stakeholder collaborative learnings are the participatory approaches which are used by multi-stakeholders to engage local farmers in experimenting with a portfolio of promising weather-smart, water-smart, carbon-smart, knowledge-smart, crop-smart, or livestock-smart solutions. Climate-Smart Agriculture (CSA) is a portfolio of promising interventions that farmers can use to increase agricultural productivity and income, adapt to and build resilience to climate change, and, where possible, contribute to reducing or eliminating greenhouse gas (GHG) emissions (Steenwerth *et al.,* 2014). As a result, successful CSA innovation helps to the achievement of sustainable development goals such as food security (SDG: 2), poverty reduction (SDG: 1), and adaptation and mitigation of climate change (SDG: 13), all of which compose the CSA triple wins.

households experiencing one to two months of hunger per year, and another 17% experiencing Subsistence and rain-fed agricultural systems in the Nyando Climate Smart Village suffer from extreme droughts, flood events, unpredictable commencement of rainfall, widespread land degradation due to soil erosion and growing disease and insect occurrences (Macoloo *et al.,* 2013; Mango *et al.,* 2011). As a result, agricultural productivity is dismally poor, as seen by average maize yields of 100 kg/ha, a primary food crop in the Nyando Climate Smart Village (Njogu, 2020). Food insecurity is widespread, with 81% of three to four months of hunger per year (Mango *et al.,* 2011). Up to 45% of children under the age of five are malnourished, and many households rely on food aid during floods and extended dry spells (Kinyangi *et al.,* 2015; Ojango *et al.,* 2016). HIV/AIDS is prevalent in the Nyando

Climate Smart Village, with 7.5% adult infection, leading to more widows and widowers and orphaned headed households and resulting in low productivity and agricultural labour shortages (Njogu, 2020). As a result, half of the population lives below the national poverty level.

Since 2011, the Nyando basin in Western Kenya has been adopting CSA innovations through a multi-stakeholder facilitation approach that includes collaboration with local farmers. National Agricultural Research Systems (NARS), extension agents, development agents, the commercial sector, and farmer organizations are among the multi-stakeholders assisting implementation. Each of these partners brings with them distinct experience when it comes to solving climate risk challenges. In particular, the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) collaborated with local farmers, the International Centre for Agroforestry (ICRAF), the Kenya Agricultural and Livestock Research Organization (KALRO), the Ministry of Agriculture and Livestock Development (MOALD), the Swedish Cooperatives Vi Agroforestry program, Maseno University, and World Neighbours to implement CSA innovations (technologies, innovations, practices, and institutional frameworks).

Farmers have been testing, co-developing, adopting, and promoting a portfolio of CSA innovations with several stakeholders. Since the baseline and livelihood surveys revealed that agricultural households were especially exposed to the effects of periodic climate change and extreme events, the Nyando basin was selected as a target beneficiary of CSV for CSA improvements. Among the CSA improvements encouraged in the Nyando CSV to alleviate food insecurity and reduce the consequences of climate change are improved cassava cultivars.

Smallholder farmers in the region have experimented with food diversification strategies in order to stabilize their food supply status while producing marketable excess to earn income for household cash needs. Improved cassava varieties were recognized as a prospective diversification crop with CSA features, important for Nyando CSV, being a staple food crop alongside maize and sorghum in a community participatory process facilitated by multi-stakeholders (Ojango *et al.,* 2016; Recha *et al.*, 2015). Improved cassava varieties (e.g., MH95/0183) with mosaic viral disease resistance, high yielding, early maturing, and low cyanide content were introduced as CSA innovation with the potential to increase productivity for home consumption and surplus for sale to earn income for households. With its characteristics of tolerance to high water stress and low input demand (water, fertilizer, herbicides, and insecticides), improved cassava is well adapted to the existing climate risk. Cassava is also suitable for intercropping with a variety of crops, and as a perennial crop that can be harvested over a long period of time while still under soil cover, it increases soil carbon sequestration, which helps to reduce GHG emissions. Furthermore, cassava has the ability to stimulate rural agro-processing by providing economic opportunities (NEPAD, 2004; Taiwo *et al.,* 2014).

Household surveys conducted in the Nyando CSV between 2011 and 2015 by Recha *et al.* (2017) revealed increased crop diversification with households growing improved crop varieties increasing from 34% to 93% and households growing at least three new crops increasing from 32% to 90%. Improved cassava variety is among the new and improved crop varieties, which would suggest that the crop plays a role in farm livelihood diversification. However, there was a sudden large decline in crop diversification to 23% after 2015, indicating that some of the new and improved crop varieties failed during the innovation process of on-farm testing, co-developing, adopting and promoting CSA innovations. Recent analyses further reveal weak and general declining uptake of many CSA innovations (Campbell *et al.,* 2014; Westermann *et al.,* 2015). Some of the household surveys associate CSA innovations in Nyando CSV with positive livelihoods outcomes (Kinyangi *et al.,* 2015; Njogu, 2020).

However, the same studies observe a general low and decline in farmer application of CSA innovations, less livelihood diversification on the farms, low productivity in staple food crops, and high dependency on relief aid and markets for food supplies during climate related shocks. These observations are thus inconsistent, not innovation specific and do not associate farmer use of CSA innovation with improvement in livelihood outcomes. The studies fail to demonstrate the extent to which a particular innovation may be limiting farmers to realize the expected triple wins of CSA (increase crop productivity and income, better manage climate risk, and possibly contribute to reducing GHG emissions). Whether improved cassava varieties are among those failing innovations has not been documented, yet it is a prioritized crop to fight poverty, enhance food and income security and support Africa's development, building on the unique attributes of the crop as a CSA innovation (Jarvis *et al.,* 2012; NEPAD, 2004). The studies' findings could also suggest that some households were dis-adopting cassava while some were benefiting from the cassava innovation.

The innovation process of on-farm testing, co-developing, and adopting and promoting CSA innovations involves (Spielman *et al.,* 2009) sharing, accessing, and exchanging knowledge among interactively engaged actors that form Agricultural Innovation System (AIS). AIS can be an individual or a collective act that initiate, import, modify, and diffuse knowledge turned into innovation, with social and economic benefits, when put into productive use. This implies that an individual using the same innovation can perform differently, but innovation studies (Hekkert *et al.,* 2006) have provided an explanation for those observed individual disparities in performance based on a comparison of the macro-level social structure of actors, their relationships, and institutions. In the middle of group operations on the AIS platform, some farmers conduct their business at the micro level and turn out to be outstanding entrepreneurs above the average peer farmers. Through experimenting, they engage in a dynamic process of learning and acquiring more knowledge about the functioning of the technology under different conditions (Hekkert *et al.,* 2006). This makes presence of active entrepreneurs to be an important indicator of performance of an AIS.

These outstanding performers (Positive Deviants) distinguish themselves by their innovativeness, connecting science with practice and deviating in a positive direction from the average, to find better solutions than the others (Typical farmers). This unique attribute positions them (positive deviance) to inspire other farmers and in that way can contribute to development of the CSA innovation and help in scaling up and out the same. Therefore, knowing how some few farmers successfully innovate, can better inform how to foster innovation process towards realizing greater social benefits and economic growth, especially for improved cassava varieties.

1.2 Statement of the Problem

A multistakeholder collaborative learning in the Nyando climate smart villages facilitated co-testing and co-development of a portfolio of climate smart technologies to empower farmers to adequately respond to persistently changing and variable climate risks. However, collaborative learning may not have been effective. Household surveys indicate that only a few farmers may be getting empowered and benefiting. A majority are not and are abandoning the technologies while exposure to climate risks is worsening. When climate smart technologies were introduced in 2011, adoption increased up to 2015 and thereafter has been sharply declining, suggesting that majority of the farmers are abandoning the technologies. The research observations have not documented whether cassava, a drought tolerant crop suited to recurring variable and extreme climate events, is among those technologies that farmers are abandoning. The high demand for improved cassava varieties in both local and urban markets, could imply stagnation in cassava production and marketing caused by a sharp decline in adoption of climate smart technologies. Despite the indications that only a few farmers do derive benefits of adopting climate smart cassava technologies, supportive empirical evidence is lacking. The differential gain between positive and typical farmers from climate smart technologies is a phenomenon likely pointing to positive deviance behaviour. Emergence of positive deviance behaviour is a situation that suggests the presence of viable solutions within the local communities to foster cassava production and marketing. This corresponds to positive deviant farmers outperforming positively compared to the typical majority.

1.3 Purpose of the Study

The purpose of this study is to contribute to food security, poverty alleviation, and sustainable livelihoods under climate change risks through improved cassava production and marketing by learning from positive deviance behaviour and collaborative learning in the Nyando Climate Smart Villages of Kenya.

1.4 The Study Objectives

The specific objectives of this study were:

i. To characterise trends in use of climate smart cassava innovations by typical and positive deviant farmers in the Nyando Climate Smart Villages
ii. To identify climate smart cassava production and marketing practices that typical and positive deviant farmers are abandoning in the Nyando Climate Smart Villages
iii. To determine cassava production gains realised by positive deviant farmers and typical farmers in the Nyando Climate Smart Villages
iv. To determine relative importance of functions of innovation systems in fostering cassava production and marketing in the Nyando Climate Smart Villages
v. To identify climate smart cassava production and marketing innovations that can be improved through a collaborative learning forum in Nyando Climate Smart Villages.

1.5 Research Questions

The research questions of this study were:

i. Has use of climate smart cassava innovations since 2011 been markedly different between typical and positive deviant farmers in the Nyando Climate Smart Villages?

ii. Are the abandoned cassava production and marketing practices different between typical and positive deviant farmers in the Nyando Climate Smart Villages?
iii. Are the realised cassava production gains different between typical and positive deviant farmers in the Nyando Climate Smart Villages?
iv. What is the relative importance of the seven functions of innovation systems in fostering cassava production and marketing in the Nyando Climate Smart Villages?
v. Which improvements in cassava production and marketing can be initiated through a collaborative learning forum in Nyando Climate Smart Villages?

1.6 Significance of the Study

The empirical evidence on the influence of positive deviance on benefits gained from climate smart cassava innovations is relevant to informing development practitioners on fostering cassava innovation, while empirical evidence on what improvements collaborative learning can initiate in cassava production and marketing is relevant to designing delivery of benefits of climate smart cassava innovations (including improved cassava varieties).

The knowledge evidence would be valuable to farmers, development agencies and policy makers in promoting climate smart agriculture for the vulnerable communities exposed to high climate induced risks in the Nyando CSV. A positive deviance approach should reveal innovations that work for the local communities, which then informs targeting extension messaging. Thus, explaining how positive deviant farmers have fostered cassava innovation from perspectives of the "seven functions of innovation systems" is to deepen the understanding of how farmers manage inherent uncertainties with new technologies and inform the innovation processes that lead to fostering and scaling up and out climate smart agriculture innovations. For these reasons, the study makes contributions to understanding pathways through which climate smart agriculture interventions deliver the so-called triple wins: productivity, food security and greenhouse gas mitigation to households.

1.7 Scope of the Study

The scope of this study was confined to cassava agricultural innovation systems within the Jimo East Ward of the Nyando climate smart villages. The identification of positive deviant farmers is informed by snowballing sampling and perception of the peer farmers. Data collection and analyses was comparative between positive deviant farmers and typical farmers, with the latter being all other farmers in sample not singled by peers as outstanding in climate smart cassava innovation.

1.8 Assumptions of the Study

This study was implemented with the assumptions that:

i. Climate smart cassava innovation system initiatives was functional in Jimo East Ward of Nyando climate smart villages.
ii. That farmers singled by peers as demonstrating outstanding practice of climate smart cassava practices represent the local positive deviant farmers in Jimo East Ward of Nyando climate smart villages.

1.9 Limitations of the Study

The limitations of the study were:

i. Small sample of positive deviant farmers growing improved cassava varieties in the Nyando climate smart villages restricted inferential statistical analysis.
ii. A likelihood of low reliability of data collected from respondents who are not decision makers of agricultural activities on the individual farms.
iii. A likelihood of wrong answers to questions in the process of translating from English into local language for the respondents not able to speak and understand English.
iv. Biased responses to questions by respondents where on-farm observation to aid validation of the response was not possible.

1.10 Operational Definition of Terms

Agricultural Innovation System (AIS): This is a network of institutions, firms, and people with the common goal of advancing the adoption of new organizational structures, processes, and products in the social and economic spheres, as well as the institutions and laws that shape the behaviour and performance of innovative persons.

Climate Change: Weather averages or weather ranges that have undergone long-term, consistent change (increase or decrease).

Climate Smart Agriculture (CSA): These are methods, tools, and inventions that alter and realign agricultural systems in order to raise output and incomes, improve food security, and lower greenhouse gas emissions in support of the Sustainable Development Goals.

Climate Smart Cassava Innovation: The AIS network and its actors are supporting the adoption of improved cassava varieties, as well as the multiplication of improved cassava variety seeds, the certification of improved cassava variety seeds, and the distribution of improved cassava variety seeds.

Climate Smart Village: A village recipient of a multi-stakeholder facilitated platforms to pilot climate smart interventions to address persistent vulnerability to climate risks due to high incidences of poverty; insecure food, nutrition and income; and poor health outcomes.

Climate Variability: the degree to which the climate deviates annually from or above a long-term average.

Innovation: An innovation is a new concept, information, or technology developed through participatory learning involving multiple stakeholders and implemented for socioeconomic benefits (Baregheh *et al.*, 2009; Spielman *et al*., 2009).

Innovation Platform: An innovation platform is an environment that will promote information exchange between producers and market participants in order to jointly identify obstacles and possibilities to improve agricultural produce production and marketing.

Positive Deviant: These are farmers from within the target group having the same information as other farmers but use it differently, making them demonstrate innovation capacity which enables them to act and employ strategies that deviate from typical way of doing things to emerge as out-performers above the others under similar constraining factors.

Food Security: The state when individuals or households have access to enough and preferred food that is safe and nutritious to enable them meet their dietary needs for healthy life (FAO, 2006).

Productivity: In this study, productivity was defined as quantity of cassava output per unit land area (acre) planted, as well as per quantity of planted materials. This definition reflects improvements in cassava production efficiency influenced by innovations and technological progress since 2011.

Farm Diversity: The count of crops grown and livestock kept by targeted farmers within a given reference period. This definition captures both perennial and annual crops. Crop level diversity is cassava diversity, which entails varieties of cassava planted and types of products harvested and processed.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This literature review chapter is a synthesis to inform improvements in smallholder cassava production and marketing under changing and variable climate risks. Firstly, the literature review contributes to better understanding of relevance of cassava as a climate smart agriculture innovation. Subsequently, the review is extended to application of several concepts including positive deviance, agricultural innovation systems, climate smart agriculture, innovative climate smart “best bet” practices, seven functions of innovation systems and collaborative learning to improving cassava production and marketing. The outcome of the review was used to inform a conceptual framework deployed in this study to investigate the influence of positive deviance on benefits gained from climate smart cassava innovations and what improvements collaborative learning can initiate in cassava production and marketing, using the Nyando Climate Smart Village as a case study.

2.2 Cassava Attributes as Climate Smart Agriculture Technology

Cassava (*Manihot esculenta*) is Kenya's second-most significant food root crop, behind Irish potato. The cassava crop was placed 36 out of 50 in the 1991 national priorities due to its limited production base. Strong droughts, little rainfall, little soil moisture, and poor soils don't harm the crop (Aggrawal *et al.,* 2018). The country's cassava production is increasing, according to the data that is currently available. According to the Kenya Agricultural Research Institution (KARI), 2009, the country's cassava production is mostly focused in the Western, Coastal, and Central areas, with the Western and Coastal regions accounting for more than 80% of the output. 60%, 30%, and 10%, respectively, of the nation's cassava production are produced in the Western (Western and Nyanza Provinces), Coastal (Coast Province), and Central (Central and Eastern Provinces) areas.

The majority of the cassava crop is grown by smallholder farmers for subsistence, making it a crucial crop for food security. In the majority of growing regions, utilization of fresh roots is restricted to roasting and boiling for eating. Before eating, the roots are either boiled or fried. Additionally, cassava leaves are a common vegetable in the diets of rural communities, while the tubers are used as both human food and animal feed. However, in the Nyanza and Western regions, roots are also peeled, chopped into small bits (cassava chips), dried, and ground into flour for ugali (traditional bread). The cereal (maize or sorghum) is typically combined with the cassava to make the ugali. While raw cassava roots are chewed as a snack in other Central regions (Machakos and Kitui), cassava leaves are consumed as a vegetable in coastal regions.

Typically, cassava is cultivated alongside beans, maize, and bananas as an intercrop. Abiotic and biotic conditions in the area limit the cultivation and output of the cassava crop. Crop output is impacted by the use of unhealthy planting materials, poor agronomic methods, and a narrow variety of enhanced processing technologies. Cassava mosaic disease has been the most destructive biotic factor in recent years. Yields of fresh tubers decreased from 6 to 3 tons in the research area's Western region. For instance, the area used for cassava production decreased from 3000 ha to 1000 ha annually in Busia County (Teso sub county) (MoA and RD, 1997/1998). The reduction was mostly attributed to the yield loss in 1998 brought on by Cassava Mosaic Virus Disease (CMVD), which was estimated to have cost 150,000 tons of crop and cost US$ 10 million (IITA, 1990). Therefore, a crucial intervention in the cassava production and marketing is to stop the spread of CMVD. Intervention strategies include the introduction and assessment of germplasm with anti-CMVD and other advantageous physiological properties.

According to studies, cassava yield can be raised by using the right varieties and management techniques (Githunguri *et al*., 2018). Additionally, studies have indicated that while cassava offers significant income to farmers in rural areas, its perishability, mass, poor base of use, and limited village marketplaces prevent its commercialization and profitability. Despite the existence of a potential export market, there is currently no framework in place for cassava export marketing. It is important to remember, nevertheless, that the rise in demand for cassava is mostly due to its superior nutritional and health benefits (rich in fibre and gluten-free) when compared to processed wheat flour.

Cassava chips (dry, chopped, and sun-dried cassava) are produced by 38% of processors in the western region, and composite flour (cassava combined with other grains) is produced by 38% of the processors. Crisps, chapati, and starch at 13% are additional products (Githunguri *et al*., 2018). The cassava business is a potential source of ethanol, sweeteners, native and modified starches, and high-quality cassava flour for the baking sector. Having a purpose for cassava would help with product development as well as raise market demand and industry focus on the issue of post-harvest losses. For market-oriented farmers who are able to build a business venture out of their agricultural production, increased cassava demand can also make it easier for them to move from subsistence-level production.

In Kenya, there is a rising demand for starch and other starch-based goods including glucose and dextrin. The livelihoods of farmers will improve as a result of the establishment and development of local starch industries in Kenya to replace imported starch, since farmers will increase cassava production to supply these enterprises. Therefore, when they sell fresh cassava to cassava processing firms, their income may grow. The development of the starch sector would also aid in reducing Kenya's predicted 9.3% unemployment rate (KNBS, 2019). Due to the low labour and financial returns in agriculture, which are mostly a result of market volatility, young people are not drawn to it as a business.

In this study, market research was done on cassava and cassava by-products in the nearby City of Kisumu. In Kisumu, there are many bakeries and animal feed manufacturers that can absorb farmers produce in large quantities thus avoiding post-harvest losses. Research and product testing have shown that bread containing up to 20% cassava flour indicate that the blend could be as high as 35%, tastes the same as 100% wheat flour bread – without compromising texture, appearance and shelf life (Nginya 2015). Some consumers actually rate bread baked with 10% to 20% composite flour higher than 100% wheat flour in aroma, colour, flavour and texture. From a product development viewpoint these are impressive attributes since increasing consumption of cassava through composite breads is not dependent on changing consumer behaviour. Besides, by processing cassava into other products reduces GHG emissions as post-harvest losses are brought to check.

2.2.1 Economic Importance of Cassava

Cassava is a key component of Sub-Saharan Africa's (SSA) food security. According to estimates from the FAO (1990), Africa accounts for around 42% of the crop's global tropical production. Over 90,000 acres in Kenya are used to grow cassava, with a yearly production of about 540,000 tons. Cassava is tolerant of pests and drought, can thrive on marginal soils, and requires little in the way of inputs (Githunguri *et al*., 2018; Nweke *et al*., 2002). Although it has significant potential to help rural poor people on marginal lands secure their food supply and generate cash, Kenyan farmers seldom ever use this crop. Additionally, it can be planted, safely left in the ground for 7 to 24 months, and then harvested as needed.

After the Irish potato, cassava is the second-most significant food root crop in Kenya. However, in KARI's 1991 priority setting exercise, it is ranked 36th out of 50 due to its limited production base (KALRO, 1995). The country's cassava production is increasing, according to the data that is currently available. The three primary regions of the country—

the coastal, central, and western regions—are where cassava is primarily produced. Over 80% of the country's recorded cassava output is produced in the Western and Coastal parts of the country (KARI, 2009). However, cassava's importance as a food and commercial crop in central Kenya is rising. Both as human food and as animal feed, cassava tubers are used. Locals love the leaves as a vegetable as well. Before eating, the roots are either boiled or fried.

Kenya's output falls across the western (Western and Nyanza Provinces), coastal (Coast Province), and eastern (Central and Eastern Provinces) regions, with respective shares of 60%, 30%, and 10%. Smallholder household farmers that lack resources produce the crop as a food security crop for subsistence. In Kenya, the majority of growing regions only allow for the roasting and boiling of fresh roots for ingestion. However, roots are peeled, sliced into small bits (cassava chips), dried, and ground into flour for ugali in the Nyanza and Western provinces of Kenya. This is typically prepared alongside a cereal (such as sorghum or maize). While raw cassava roots are chewed as a snack in the Eastern area (Machakos and Kitui), cassava leaves are utilized as a vegetable in the Coast area.

2.2.2 Cassava Production in Kenya

In Kenya, cassava is widely cultivated in Western and Coastal regions for food and nutrition security and any excess roots are sold to earn income for the farm household (Kidasi *et al.*, 2021). Compared to maize and wheat, which are staple crops in the country, cassava productivity per unit of the land area is high. Planting materials are own seed, from neighbours, local markets and KALRO.

The Western, Eastern/Central, and Coastal regions of Kenya are where cassava is farmed. 9% of Kenyans' daily caloric intake comes from this crop (Republic of Kenya, 1990). 60% of the nation's cassava production is grown and consumed in the western area of Kenya. Cassava is a staple crop in many parts of Kenya's Western region. Lamu and Kisumu are two of Kenya's top cassava-producing counties, and the crop contributes 6% of all family incomes (MOALF 2018). Typically, cassava is cultivated alongside beans, maize, and bananas in intercrops. Abiotic and biotic conditions in the area limit the cultivation and output of the cassava crop. Crop productivity is impacted by the use of unhealthy planting materials, poor agronomic techniques, and a narrow variety of enhanced processing methods. Cassava mosaic disease has been the most destructive biotic factor in recent years.

Cassava cultivation and its improved food, nutritional, and industrial positioning as a climate smart crop face a number of challenges, including diseases, late maturing varieties, pests, a lack of climate smart adaptable varieties, low yields, brittle seed systems, a lack of value addition, a lack of market connections, and an inadequate mapping of gendered roles in cultivation and marketing. Due to a scarcity of clean planting materials, it has been noted that fewer agricultural producers are generating enhanced kinds, which has decreased root output and quality. Githunguri *et al*. (2014) pointed out that 93% of Kenya's cassava farmers plant cassava seedlings from their own or nearby farms, which contributes to a constant rise in diseases and pests. As noted by Mukiibi *et al*. (2019), recycling of cassava planting materials from the previous crop by farmers is contributed by the unavailability of planting materials. This assertion concurs with that of Le *et al.* (2019) who noted that preferred planting material for local and improved cassava varieties, experience scarcity. Kidasi *et al.* (2021) noted that demand for cassava planting materials cannot be met by both informal and formal seed sources, which according to Osei *et al.* (2009); Mwango'mbe *et al.* (2013), leads to insufficient quantities of good quality cassava planting materials as the potential to increase cassava acreage and production is limited. Sadly, the government's efforts to promote cassava as a useful, commercially viable crop have been severely hampered by the idea that it should only be used for subsistence cultivation, crude processing, and limited consumption (Githunguri *et al*., 2017). Cassava production is now dominated in the research area by low-yielding cultivars that are prone to pests and diseases and have extremely subpar crop and pest management techniques.

The cassava mosaic disease may have contributed to the drop in fresh tuber yields in Nyanza, the study location, from 6 to 3 tons. According to the MoA and RD Annual Report for 1997/98, the area used for cassava production in Teso Sub County decreased from 3000 hectares per year to 1000 ha. According to IITA (1998), the yield loss brought on by CMD in 1998 was projected to be 150,000 tons, worth $10 million. It became absolutely essential to stop the epidemic given the implications of the illness. The introduction and assessment of germplasm for resistance to CMD and other advantageous physiological traits were regarded vital intervention measures to lessen the epidemic.

The farming communities in Western Kenya received cassava clones that were deemed desirable, adaptive, and acceptable. In order to determine whether the measures used to restart cassava production in Western Kenya actually had a significant impact on it, this study set out to explore them. For the development of new varieties that will meet farmers' various needs in various places, it is essential to comprehend farmers' perspectives of improved cassava varieties. In addition to higher fresh tuber yields, farmers also consider harvest duration, the quality of the food-processed product, labour requirements, and the overall economics of the improved variety in their particular local contexts.

Numerous factors were taken into account before desirable, adaptable, and acceptable cassava clones were rapidly multiplied and distributed to farming communities in Western Kenya, including (a) the region's vegetation and its suitability for growing other crops; (b) population density and the associated cassava food demand; and (c) tribal preferences that limit cassava cultivation to smaller farmers with less land and less money to expand the crop High-density cassava consumer populations nearby; local presence and capacity of organizations that can provide small-scale farmers with enhanced planting supplies; and farmers' perceptions of the overall advantages of improved cassava varieties compared to local varieties. Because they prevent pests, animals, and thieves, some farmers frequently favour the bitter cassava cultivars. Cassava breeders must work with food and nutrition experts and technologists to find and create novel cassava products for local, national, and international markets in addition to recognizing the needs of farmers.

2.2.3 Cassava Market Potential

According to studies, cassava yield can be raised by using the right varieties and management techniques (Githunguri *et al*., 2018). Furthermore, research (Nginya, 2015) has revealed that while cassava offers significant income to rural farmers, its commercialization and profitability are hampered by its perishability, bulkiness, poor base of use, and limited village markets. Despite the existence of a potential export market, there is currently no framework in place for cassava export marketing. However, it is worth noting that the increase in demand for cassava is largely on account of its proven superior health and nutritional benefits (high in fibre and gluten free) when compared to processed wheat flour.

Cassava chips, which are dried, chopped, and sun-dried cassava, are made by 38% of processors in the western region, and composite flour, which is cassava combined with other grains, is made by 38%. Crisps, chapati, and starch at 13% are additional products (Githunguri *et al*., 2018). The cassava business may provide high-quality cassava flour for the baking industry, native and modified starch, sweeteners, and ethanol. Existence of a cassava end use will encourage higher market demand and industry attention to the issue of post-harvest losses in addition to aiding product development. For market-oriented farmers who are able to build a business venture out of their agricultural production, increased cassava demand can also make it easier for them to move from subsistence-level production.

Cassava has the potential to be used in the paper and textile sectors in East Africa (Abbas *et al*., 2013; Mufumbo *et al*., 2011). The enormous demand from these sectors could encourage higher cassava output at the farm level (ibid). According to FAO, developing nations in Africa might begin using cassava starch for many industrial uses. Cassava can assist meet the rising industrial demand for starch while easing supply strain on other staple crops like maize and wheat (FAO, 2006). Wheat and maize have large fertilizer input requirements, which increases greenhouse gas emissions. Because cassava requires so little fertilizer, replacing them lowers GHG emissions. Additionally, because cassava is cultivated as a second crop, it can take advantage of the fertilizer that is left in the soil after producing first crops, which again reduces GHG emissions. In Kenya, there is a rising demand for starch and other starch-based goods including glucose and dextrin. The livelihoods of farmers will improve if starch industries are established and strengthened in Kenya to replace imported starch because farmers will increase cassava production to feed the starch businesses. Selling fresh cassava to the industries involved in processing cassava will thereby improve their income. The development of the starch sector would also aid in reducing Kenya's predicted 9.3% unemployment rate (KNBS, 2019). Due to the low labour and financial returns in agriculture, which are mostly brought on by market instability, young people are not drawn to it as a business.

In this study, market research on cassava and its by-products was carried out in the adjacent City of Kisumu. There are lots of bakeries and animal feed producers in Kisumu which can take in a lot of the produce from farmers, which could help in preventing post-harvest losses. According to research and product testing, bread made with up to 20% cassava flour, with a potential blend of up to 35%, has the same flavour as bread made with 100% wheat flour without sacrificing texture, appearance, or shelf life (Nginya, 2015). Some consumers really prefer the scent, colour, flavour, and texture of bread made with 10% to 20% composite flour to that made with 100% wheat flour. These qualities are impressive from the perspective of product development because boosting cassava consumption through composite breads does not require altering customer behaviour. Additionally, converting cassava into other products lowers GHG emissions by reducing post-harvest losses. Because cassava is a climate-smart crop, its profile will rise significantly as a result of modifications to locally available processing equipment and a concentrated marketing and promotion campaign. Food security, incomes, and community resilience will all improve as a result.

2.3 Strengthening Smallholder Farmers Capacity

Over 1.5 billion people worldwide live in smallholder households in rural areas where their means of subsistence depend on agricultural operations, making them disproportionately vulnerable to the effects of climate change (World Bank, 2021). To improve their ability to offset the consequences of climate change and generate markets for their produce, it is necessary to find strategies that may boost their adaptive capacity. This necessitates action from concerned parties, who must devise strategies for modifying how smallholder farmers currently carry out their operations to take into account the consequences of climate change and the sale of their produce. It is crucial to increase people's ability, particularly that of the poor in developing nations (Rola-Rubzen & Gabunada, 2003), who typically own relatively few resources and frequently rely on their own labour as their primary source of income. People won't be able to take advantage of economic opportunities that will help them escape poverty if they don't have the appropriate education and skills (Rola-Rubzen & Gabunada, 2003).

The development of different societies or individuals is significantly influenced by capacity building and human capital development. Building organizational capacity is crucial for enhancing governance, leadership, vision, and missions, as well as for improving administrations and the formulation and execution of strategic decisions. Capacity building is a continual improvement method aimed at creating a sustainable and effective organization rather than a one-time effort to increase short-term effectiveness.

A component that improves farmers' engagement in the innovation platform is using a plurality strategy to involve numerous and pertinent stakeholders in increasing smallholder farmers' ability in market development and mitigating the consequences of climate change. The institutions that entered the climate smart villages throughout the intervention period to enable resolving the effects of climate change and better livelihoods in the study region did not prioritize smallholder farmers' capacity building on market development.

The goal of the study was to increase the ability of farmers in the study area to produce in a market-oriented manner. Market-oriented production should begin with an assessment and awareness of the resource base and market-producibility potential of communities (Gebremedhin *et al*., 2012). To remain competitive in the market, productivity and production efficiency improvements are required. They also stated that the commercial transformation of subsistence farmers depends on the adaption and adoption of better technologies and methods. Farmers from the study region may have difficulty calculating profitability and organizing their businesses, so it is necessary to increase their capability in these areas in order to help the farmers organize their production for their market. Farmers' marketing capacity is frequently reported to be weak in Kenyan farming communities as a whole.

Farmers in the study area must have their capacity built on cassava production and marketing related issues in order to be able to make independent decisions about when and where to sell, how to negotiate, and other marketing-related matters. Farmers must also learn how to sell their farm products collectively in order to outwit brokers in their game of exploitation. Since they carry out their market-oriented production operations, buy inputs, and market their outputs, farmers need a reliable source of technical and market-related information (Gebremedhin *et al.*, 2012). As a result, it is critical to organize a source of information that farmers in the research region can access with ease. The Learning Platform was utilized in this project to allow information exchange between farmers and market participants in order to jointly identify obstacles and opportunities to improve agricultural produce production and marketing in the study area. In order to increase the production and marketing of the cassava crop in the research region, the identified stakeholders in the cassava value chain jointly identified problems and possibilities of offering solutions to the identified problems regarding the cassava crop using the Learning Platform. They also individually highlighted their points of entry with the aim of empowering the farmers.

2.4 Market Development Capacity

Market development refers to the growth of a product's overall market through the entry into new market categories, the conversion of nonusers into users, and/or the increase in consumption per user. In the case of climate smart villages, there is need for strengthening farmers’ capacities on market development for their various produce. Capacity building on market development was not emphasized in the climate smart villages during the period of intervention by the institutions that entered the villages for purposes of solving effects of climate change and food insecurity in the area. To remain competitive in today's fast-paced business world, firms must be nimble and adaptable. Market development ability enables businesses to stay ahead of the competition by spotting new market possibilities and trends before they become mainstream (Mohammadali & Abdulkhaliq, 2019). This enables farmers to take a proactive strategy and achieve a competitive advantage. Svensson (2010) state that smallholder farmers, who are typically located in rural areas, frequently lack access to information about prices in urban areas and typically sell to local traders at farm-gate prices who, in turn, have access to price and market information prevalent in other markets.

Robinson *et al.* (2011) highlighted that small-scale production methods are used in Africa, and that when farmers operate independently, they are unable to participate in new marketplaces like supermarkets where higher volumes and product standardization are frequently required. Individual farmers typically sell tiny quantities of food, as is the case in the study area. As a result, they have little leverage when negotiating with traders and frequently accept the lowest price possible, which exposes them to exploitation. When smallholders market their produce individually, they encounter a number of marketing challenges, many of which can be resolved through collective marketing (Gebremedhin *et al*., 2012).

Bingle *et al*. (2013) concluded in a review of a case study that investments in the development of human capital could affect a rural community's capacity to effectively engage in markets. They also claim that while human capital investments can be sluggish, a community's ability to obtain inputs and market produce after a project has ended is frequently determined by its marketing prowess. Agricultural research and development organizations are reportedly coming under increasing pressure to switch their focus from increasing the productivity of food crops to boosting the profitability and competitiveness of small-scale farming and connecting smallholder farmers to more lucrative markets. The study intends to enhance the capacity of smallholder farmers from the climate smart villages to make them engage effectively in markets in a more sustainable manner.

Among the key challenges facing market development capacity is keeping up with the rapid developments in technology and consumer behaviour (Manda & Dhaou, 2019; Rutsaert *et al.*, 2021). To keep ahead of the ever-changing agricultural environment and competition, farmers must be agile and adaptive. This necessitates a strong innovation culture, as well as the ability to experiment and learn quickly. Another difficulty that farmers tend to face in choosing between adopting and dis-adopting CSA, is matching short-term outcomes with long-term objectives. Market development capacity necessitates a long-term outlook, but farmers and stakeholders must also generate results in the short term to keep investors and stakeholders satisfied (Rutsaert *et al.,* 2021). Finding the correct balance is critical for long-term growth.

2.4.1 Action Research and Collective Action to address Market Failures

According to Avison *et al.* (1999) action research (AR) which originated from the work of Kurt Lewin during the 1940s, is an approach that brings researchers and practitioners together to combine theory from researchers and practices from practitioners to address a prevailing problem through change and reflection, in a mutually acceptable ethical framework. As a result, AR involves both action and research. Due to its adaptable, flexible, and interactive nature, action research is applicable to and helpful in domains including agricultural research and extension as well as community development (Fisher, 2004). Action research is a method that involves learning (research) to improve the effectiveness of action. This implies that learning happens by doing, through practitioners applying the lessons they have learnt as they try new tasks.

Fisher (2004) defined action research as a process where individuals with a common issue join together to collectively, cooperatively, methodically, and purposefully plan, execute, and evaluate actions. Action research, then, incorporates both action and study, and the investigation informs the action, which the researchers then learn from through critical reflection on the action. Therefore, the goal of action research is to address social issues by using the scientific approach. It is focused on a logical issue that locals are facing, one whose solution calls for local study. It lacks the same level of control seen in other research categories since it is not concerned with whether the findings can be applied to other contexts.

The impoverished in Africa have employed collective action through formal and informal groups to improve their wellbeing (Mwangi *et al*., 2011). This has been demonstrated to be true when more vulnerable groups, such as women, racial minorities, and the poor, participate in collective action. Small-scale farmers can benefit from collective action by being better positioned in the market, receiving inputs and training, taking advantage of economies of scale, and having more negotiating power (Sally, 2013). It's frequently a minimum condition for drawing customers and maintaining bargaining leverage to be able to sell produce in large quantities. Therefore, it is crucial for smallholder farmers who want to commercialize to collaborate as a recognized legal body in order to increase their voice for articulating their demands, for lobbying, for buying, bulking up, and selling, and for doing so, to take advantage of economies of scale (Mendez *et al.*, 2017).

The most popular type of collective action is the co-purchase of inputs and co-promotion of goods. In the value chains for agroforestry tree products, group marketing has been employed as a tactic to improve ties and foster trust among farmers, traders, and the private sector (Facheux *et al*., 2012). When farmers pool their financial and human resources, they are better able to collect the information they need, meet quality requirements, and work on a bigger scale. Farmers that sell their produce individually in the study region leave room for intermediaries to take advantage of them.

Collective action is a type of organizational arrangement that was created to better effectively connect producers, merchants, and the private sector to various organizations and development professionals. According to Penrose Buckley (2007) the act of cooperating with others to achieve a common goal can foster a sense of community and build trust among smallholder farmers, empowering them to take on the dangers and difficulties of the market and exert more influence over local policies. Farmer organizations may be able to strengthen their bargaining power, secure better pricing, and potentially have more influence in the supply chain by meeting the precise requests of purchasers (Frank *et al.*, 2012). According to ODI (1997) economies of scale may enable investments in shared resources, such as storage, transportation, and processing facilities, allowing farmer organizations to contribute. The ability to wait for better pricing rather than selling to the first buyer results from having access to the appropriate market knowledge.

The study aims to train smallholder farmer producer groups in value chain and market development methods, group dynamics, financial management, marketing, conflict management, and group marketing through the use of the collective action approach as an intervention. This could lead to the development and consolidation of group activities, enhanced leadership and entrepreneurial capabilities of producer groups, improved bargaining and negotiating skills, and ultimately an increase in the unit price of the products produced by group members whose capacity will have been enhanced in comparison to non-group members whose marketing capacity have not been enhanced. Higher produce pricing, better produce quality, and a rise in the number of producers involved are anticipated outcomes of this intervention, as well as innovations that will benefit smallholders and improve the standard of living in the research region.

2.5. Collaborative Learning

According to Grey (1989), collaboration is a technique that enables people who perceive various facets of a problematic situation to constructively explore their differences and look for answers that go beyond their own constrained understanding of what is feasible. A observed that addressing issues and fostering change in complex social-ecological systems might be possible through collaborative learning involving a number of actors. There is a lack of knowledge about how to enhance learning that encourages change in relation to sustainability challenges, despite the fact that learning among interconnected actors, sometimes also referred to as stakeholders, is seen as a crucial component to address difficult problems that society as a whole faces (Leeuwis & Pyburn, 2002).

When it comes to sustainability concerns, there is a shortage of information about how to enhance learning in a way that promotes change (Tschakert & Dietrich, 2010). Lang *et al.* (2012) and Cundill *et al.* (2014) explicitly advocate comparative analysis of learning approaches in different circumstances in order to enhance approaches that support learning processes among multiple actors who share a shared challenge. It is anticipated that through cooperating, exchanging, and combining information and experiences, different actors will be more likely to collaboratively achieve relevant outcomes than each of them individually. However, it's likely that not all of the participants are in agreement or have the same objectives. Instead, for the contact to be fruitful, all parties must be willing to participate in a process that may be especially created to accommodate a variety of opinions and perspectives, some of which may be in conflict with one another and seem irreconcilable.

The advantage of collaboration is that by asking a variety of viewpoints, significant aspects of the issue that might have gone unnoticed in the past might be revealed (Cuppen, 2012; Roloff, 2008). Due to their varied backgrounds, performers will each be familiar with some aspects of a process that others may not be. Some actors may be able to encourage or discourage the adoption of a project or idea within various organizations, institutions, or areas depending on their level of influence.

Relevant adult learning theories, such as experiential learning, transformative learning, and expanded learning with roots in sociocultural theory, describe how learning is accomplished while attempting to facilitate self-driven change in social-ecological systems. The first two learning theories emphasize a shift in cognition and behaviour. The third learning theory is predicated on the idea that learning is accomplished through social interactions and communication, and as a result, learners' behaviour and cognition as well as the activity system they are a part of change.

According to *Restrep*o *et al.* (2014) individuals can learn in two different ways, instrumentally and communicatively. Developing a task-oriented problem is referred to as instrumental learning, while comprehending the meaning of what is presented is referred to as communicative learning.

2.6 Climate Smart Agriculture Concept

Despite the current safeguards in place, the world's climate is changing quickly and will do so for the foreseeable future (Cooper, 2013). To counteract this rapidly changing climate, modern techniques must be used. Climate smart agriculture is one of the strategies used by CCAFS to mitigate the consequences of climate change in the research region. Climate-smart agriculture is defined by the Food and Agriculture Organization of the United Nations (FAO) as consisting of three main pillars: sustainably increasing agricultural productivity and incomes (food security), adapting to and constructing resilience to climate change, and lowering and/or eliminating greenhouse gas emissions. According to the definition, in order to achieve the triple co-benefits from applying CSA, an integrated approach that is responsive to local conditions is required, as well as coordinated action between various agricultural sectors (such as crops, livestock, forestry, and fisheries) and other sectors (such as energy and water).Social, economic, and environmental context are taken into account while applying the CSA idea. In this way, CSA considers the environment in which agriculture is practiced. For accomplishing food security goals and boosting resilience for the most vulnerable and underprivileged marginalized people, CSA is favoured in rural agricultural development. This illustrates how CSA is used in the Nyando basin, a center for intense and unpredictable weather. Climate-smart agriculture uses techniques and equipment to sustainably boost output, assist farmers in adapting to climate change, and lower greenhouse gas emissions. Climate smart agriculture was viewed as a key to addressing the consequences of climate change in the research area and ensuring the survival of smallholder farmers. Farmers must use crops that can withstand drought in order to live. CSA focuses on the value chain's production side, which runs the risk of requiring less intervention when creating market connections to boost farmers' incomes from their agricultural output. Additionally, the usage of CSA may not be environmentally favourable in some situations, such as when excessive pesticide and fungicide use, energy-intensive factory farming of animals, large-scale industrial monocultures, and biofuel plantations become more prevalent (Pimbert, 2015). Climate Smart Village (CSV) is a platform for innovation where multi-stakeholder facilitation is used to guide communal actions and innovation processes (Kilelu *et al*., 2017; Klerkx *et al*., 2010; Sotarauta & Pulkkinen, 2011). Farmers test and assess methods for regional adaptation to the effects of climate change on the CSV as an experimental plot. The beneficiaries collaborate to learn, explore, share knowledge, and learn from one another's experiences. Due to the possibility to interact with a variety of partners, including institutions and organizations for empowered farmers, the business sector, development agents, and research, this offers an innovation platform for the idea of agricultural innovation systems. In the Nyando basin, CSV takes a similar technique (Mango *et al*., 2011).

The Climate Smart Villages of the Climate Change, Agriculture and Food Security (CCAFS) program, in contrast, concentrate on climate change hotspots in Africa, Asia, and Latin America and work only on sustainable agricultural development (Aggarawal *et al*., 2013). The ability of farming communities is increased through utilizing specific agricultural technologies, climate information services, and interaction with pertinent organizations and policy officials. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) created climate smart villages in Lower Nyando in 2011.

CCAFS created the Climate-Smart Village (CSV) approach to agricultural research for development (AR4D) in the context of climate change to answer the demand for tested and successful CSA choices. It aims to close knowledge gaps and encourage CSA technology scaling. The CSV approach is based on participatory action research principles to ground research on appropriate and location/context-specific enabling conditions, produce more evidence of CSA effectiveness in a real-life setting, and facilitate co-development of scaling mechanisms towards landscapes, sub-national levels, and national levels.

One of the East African climate-smart villages (CSVs) under the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is Jimo East Ward, which is situated in the Nyando Basin. In order to increase smallholder farmers' food production by introducing the usage of climate smart agriculture technologies, Kenya Agricultural and Livestock Research Organization and other players approached the community with climate smart agriculture interventions. The purpose of adopting the technologies was to increase farmers' capacity for climate change adaptation, risk management, resilience building, and greenhouse gas emission reduction (Macoloo *et al*., 2013). The Nyando Basin was noted as a region with significant food insecurity as a result of climate change. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), in partnership with national initiatives, worked with rural communities to create Climate-Smart Villages as models of local actions that guarantee food security, foster adaptation, and increase resilience to climatic stresses.

The Nyando Climate Smart Villages (CSV) introduced cassava, a drought-tolerant crop, to vulnerable households as a climate smart technology to help them increase food production, adapt to variable, changing, and extreme climate, and perhaps help reduce greenhouse gas (GHG) emissions from agricultural activities. Cassava is a drought-tolerant crop that can withstand the frequent harsh weather events that occur in the CSV. Farmers can also expect to produce more food with this crop. There are no data that particularly illustrate farmers' involvement in the cultivation and selling of cassava, despite the fact that it was first introduced in this region more than a century ago and that there have been concentrated attempts by numerous stakeholders to introduce more varieties, including those that are climate smart. This revealed a knowledge gap that this study sought to fill.

Improved cassava is one of the climate-smart technologies that farming households can use to diversify their agricultural-based livelihoods, manage climate risks, boost farm productivity, and help reduce greenhouse gas emissions. Research, development partners, and extension agents have collaborated with the existing local community institutions and organizations to do this. The research, development, and extension partners have pushed improved cassava variety as a climate smart technology to empower farming households by collaborating with the already-existing neighbourhood institutions and organizations.

Researchers, local partners, farmers' groups, and policy makers worked together to choose the most suitable technological and institutional interventions based on global knowledge and local conditions to improve productivity, raise incomes, achieve climate resilience, and enable climate mitigation (Aggarawal *et al*., 2013). The formal production and marketing procedures for cassava were disorganized in Kisumu County, where this study was undertaken (Gethi *et al*., 2008).

Although many frequently fall short of this fundamental objective, producing enough tubers to meet household needs is what a significant number of farm households try to do. Due to the higher yield, an increasing number of farmers are beginning to use new cultivars. Although cassava may perform significantly better under the current conditions, they are less likely to invest additional resources to boost production due to the perception of higher returns from alternative farm and non-farm industries. Additionally, the government and private investors' interest in the production of starch and animal feed has expanded, which is encouraging cassava cultivation.

2.7 Positive Deviance Concept

It is important to direct the focus of interest at positive deviance, a phenomena that occurs in organizations and communities, in order to comprehend how innovation emerges on the micro level, that is, what generates niches for innovation. The Positive Deviance approach is centered on identifying and scaling the strategies used by positive deviants (PDs), which are people or communities that employ unusual practices to outperform their peers in spite of sharing similar circumstances and resources (Basma & Dyer, 2020). Positive deviance is described as deliberate behaviour that significantly deviates from a reference group's norms (in honourable ways) in order to develop innovations in social, technical, institutional, organizational, and policy, whether or not the referent group accepts and amplifies them.

One of the frequently cited instances of positive deviance in organizational literature and development studies is Save the Children's work on malnutrition in Vietnam in the 1990s. Save the Children found that a tiny number of families were able to feed their children despite living in places where child malnutrition was the norm and where all families had the same resources, socioeconomic level, and limitations. Positive deviance was the solution to this issue. In this small group of mothers, prawns gathered from rice fields were included to the children's meals along with greens made from the tops of sweet potatoes. Everyone had access to these foods, but traditional wisdom claimed that small children shouldn't eat them. Save the Children chose to focus on the positive deviance demonstrated by a small number of families rather than imposing external remedies to the malnutrition issue. As a consequence, 250 localities in Vietnam helped rehabilitate nearly 50,000 malnourished youngsters. There are some imaginative and creative people who can serve as role models for growth in every rural community. These people are known as "Positive Deviance" (PDs). Positively deviant people (PDs) are people who use their abilities, resources, and possessions in unconventional ways. They are able to use various approaches and strategies that result in new solutions while working with the same resources and in the face of the same obstacles (Marsh, 2004). Positive deviants are change agents who work to upset the status quo by criticizing current organizational structures and advancing fresh ideas (Pant & Odame, 2009).

According to Bruun and Hukkinen (2003), the actor's abilities, material resources, and financial resources all contribute to his or her capacity to act. The innovative processes depend heavily on the creative application of knowledge (Spielman *et al*., 2009). Because it fosters innovation, a person's ability for learning is essential. According to Lundvall (2007), Sotarauta and Pulkkinen (2011), Srinivas and Sutz (2008), learning diverse skills involves doing, looking for, interacting with, and solving problems. However, as Bruun and Hukkinen (2003) point out, agency is not something that one has or does not; rather, it can exist to varying degrees, depending on the person and the resources at hand.

When deliberate actors look for and create chances, personal agency is crucial (Biggs, 2008). Intentional actors are defined by Hung and Whittington (2011) as institutional entrepreneurs who consciously want to start changes and actively take part in their implementation. The ability to mobilize resources, talents, and power to create and transform in accordance with their vision goes along with their interest and intention to bring about change. Examples include the transformation of Kenya's public administration system and Nepal's plant breeding practices (Pant & Odame, 2009; Ochieng, 2007).

The entrepreneur does not necessarily need to start off with a clear vision of the final product in order to be intentional (Sotarauta & Pulkkinen, 2011). Because an innovation system is a self-organized, complex adaptive system that operates in a continuous process, changes in one subsystem can lead to changes in other subsystems, which can limit the ability to innovate. In some cases, changes are made because there are no other viable options for survival. The issue of adaptation is then raised. For instance, food consumption modifications were made to prevent hunger in Uganda during the African cassava mosaic virus epidemic outbreak (Hall & Clark, 2010).

Innovative ideas can also come from constrained environments. The term "scarcity induced innovations" was first used by Srinivas and Sutz (2008) to describe innovations that are driven by lack rather than abundance. This lack of support could be in the form of socioeconomic, physical, institutional, or cognitive constraints. Lack of enabling institutions, legal frameworks, and technological tools can all be considered institutional scarcity. These innovations share the trait of being robust locally, but because they are isolated, they are rarely expanded up. Because of this, it is crucial to identify them in this study in order to develop policies that will help.

Unintended consequences can result from events and actions; for example, modifications to a farming system may affect the social, biological, and economic systems.

For instance, according to Hall and Clark (2010), a viral epidemic in a staple crop altered local eating customs as well as gender relations. Because of the system's complexity, adaptive management is necessary to improve the systems' ability to reorganize themselves throughout ongoing adaptation processes (Klerkx *et al*., 2010). Nevertheless, it must be understood that innovation can occasionally depend on luck when unexpected events alter the course of events and windows of opportunity open (Biggs, 2008; Klerkx *et al*., 2010).

Institutions impose constraints on the creation, dissemination, and application of new knowledge by, for example, defining the bounds of networks (Lundvall, 2007; Sotarauta & Pulkkinen, 2011; Spielman *et al*., 2011). Individuals, however, also actively effect change. Institutional environments shape actors in a two-way interaction, but institutions themselves also undergo change as a result of the changes that actors make to their surroundings. Actors and new technologies co-evolve with institutional structure for innovation (Klerkx *et al*., 2010; Sotarauta & Pulkkinen, 2011).

The core of innovation processes is the co-evolution of organizational, technological, and institutional changes (Leeuwis, 2004; Spielman *et al*., 2011). For instance, new items will call for new regulations and production methods. In India, people built their own inexpensive bamboo tube wells to mimic the irrigation infrastructure provided by the government. Water pumping and their service sectors both evolved at the same time (Biggs, 2008). Rules and procedures, such as more contracts for land rental, were adopted in Ghana in order to lessen the uncertainties and conflicts surrounding land tenure that were brought on by pressure on land (Adjei-Nsiah *et al*., 2008). In this study, this approach was used to study the practices of various actors along the cassava value chain i.e. from production, processing, marketing to utilization.

In both industrialized and developing nations, restrictions on agricultural systems have been researched and remedies planned. There hasn't been any long-lasting change, though. Eenhoorn and Becx (2009) recommend a shift in focus toward researching strategies for getting around the obstacles in order to advance. A method called "positive deviance" can be used to learn from successful businesses and communities. A question of "what is working" serves as the foundation of this asset-based strategy. It makes use of the populace's original concepts. At its root, "inside-out" thinking assumes the existence of a project or program that produces the results. According to the guiding principle, solutions to issues will be more effective, palatable, and long-lasting if they originate from within the people (Jaramillo *et al*., 2008; Kim *et al*., 2008). As the follow-up to "technology transfer" and "participatory development" -approaches in development thinking and practice, Sherwood *et al*. (2012) proposed the approach of positive deviance. In order to investigate family and community level innovation that has surfaced in people's daily behaviours, it starts with local solutions. The objective is to comprehend how self-organization drives change.

One strategy to gain knowledge about the routes to successful livelihood outcomes is to learn from the positive deviants. Studying positive deviants' accomplishments in bringing about change and overcoming obstacles at the micro level may provide a springboard for development interventions and provide insight into potential policy initiatives that could make the larger socioeconomic environment more favourable for the actors to realize their livelihood practices (Amankwah *et al*., 2012). It is important to be aware of new small-scale innovation processes, according to many writers (Hall & Clark, 2010; Ochieng, 2007; Pant & Odame, 2009; Srinivas & Sutz, 2008). Finding strategies to create more supportive environments and encourage the marginal solutions to become mainstream would be made easier with the identification of unique ideas. However, it is still difficult to identify good deviants early on and recognize new ideas from multiple sources (Pant & Odame, 2009). In order to employ them in the learning process in the Learning Forum, the study aimed to identify the relevant positive deviancy who are involved in cassava production within the community.

2.7.1 Positive Deviance and Innovation

Zbierowski (2019), looked into positive deviance as a mediator in the relationship between high performance indicators and entrepreneurial orientation from a sample of 406 enterprises. The findings indicated that the relationship between high performance indicators and positive deviance was ambiguous in nature. The study established that making continuous improvements in the organizations, quality management of operations and openness and action oriented attitudes positively influenced positive deviance while long-term orientations and workforce quality negatively influenced positive deviance. It was further established that positive deviance had a positive impact on the three entrepreneurial orientation dimensions (risk taking, proactiveness and innovativeness) with innovativeness having the weakest effect. Recommendations drawn from the study were impactful in both research and practise and recommended that organizations in pursuit of higher entrepreneurship within, should then use positive deviance as a way to support their bid.

Steinke *et al.* (2019) investigated the prioritizing options for multi-objective agricultural development through the positive deviance approach. According to their study, agricultural development has a mandate of integrating several objectives all together with the aim of improving food security, income and livelihoods sustainability. While aiming at various households to spearhead the new innovations and developments, several factors need to be taken into picture since majority of the farming households are likely to continue prioritizing their livelihoods' practices amidst the new developments. Hence, policymakers need to identify the existing diversities in relation to resources and agricultural activities of the farming households before introducing any new technologies to them. Considering such may also come as an eye-opener to enabling better directives and changes to the developments to meet the needs of the farming households. Steinke *et al.* (2019) argued that by concentrating on the existing diversities, it is easier to pick out viable livelihood activities and practices that perform better in relation to other diverse options and make implications out of them.

Efforts to improve agricultural farming systems in resource-scarce settings proves the difficulties rural smallholder farmers often face and the numerous challenges that hinder implementation of innovations. Toorop *et al.* (2020) studied the use of positive deviance approach to inform farming systems redesign through looking at the viable solutions. The study further investigated how positive deviant farmers were performing relative to other farmers, with performance indicators being farm production, environmental and economic benefits to the farmers. A sample of 43 farms was surveyed by identifying the positive deviant farmers and recombining them into restructured farms with the help of different farmers. The study established that there was an outstanding performance on all the indicators (water usage, operating profit, dietary energy production and soil organic matter balance) which was attained through combinations in both crop and livestock farm diversification among positive deviant farmers as opposed to other farmers. The study concluded that positive deviant farms enjoyed the benefits of high production yields leading to large boost in agricultural development for rural smallholder farmers who are resource-scarce.

2.8 Use of Agricultural Innovations in Improving Productivity, Post-Harvest Handling and Marketing

The beneficiaries of agricultural innovation may see an increase in their standard of living and productivity in both direct and indirect ways. Therefore, essential interventions at many phases of the crop, including seed sowing, crop protection, harvesting, post-harvest management, and marketing, should be the emphasis of technology transfer in agriculture. This highlights the necessity of implementing innovative agricultural systems that enable more sustainable resource use, such as zero tillage, planting climate smart varieties, using pest-resistant crops, efficient irrigation, improved soil and water management, and proper post-harvest handling to help minimize GHG emission.

Since it is no longer feasible to meet the needs of an increasing population by expanding the area under cultivation, agricultural productivity growth will not be possible without developing, disseminating, and making accessible to crop farmers cost-effective farm inputs that increase yield. Research on sustainable agricultural production intensification strategies must begin at the local and national levels, with support from the global level, in order to produce novel solutions that are pertinent, acceptable, and appealing to local populations (Michele *et al.*, 2012). The first and earlier perspective holds that scientific research serves as the primary catalyst for innovation, producing new information and technology that may be applied to and modified for use in a variety of contexts. In addition to knowledge generation, the process of innovation and productivity growth encompasses the entire system of technical diffusion, adoption processes, interactions, and market adjustments. Since the market for any output is what drives production, markets increasingly drive agricultural development of any economy. Cassava processing choices, marketing channels, and connections between producers and end consumers all need improvement in order for output to increase and for producers to become more profitable.

Innovation is the introduction of anything fresh or enhanced (technologically or otherwise) in goods or services, processes, marketing, and administrative practices. In other terms, it denotes introducing fresh concepts, information, or methods into an environment in an effort to improve things and meet needs, solve problems, or seize opportunities. Accordingly, novelty and practical adjustments may be substantial (a big change or improvement) or cumulative (a number of little adjustments that together result in a significant improvement). In order to address cassava production, marketing, product processing, input intensification, and institutional engagement in the Learning Forum established in the Climate Smart Villages of Nyando, this study applied the positive deviance approach as an innovation.

2.9 Empirical Review

2.9.1 Trends in use of Climate Smart Cassava Innovations by Smallholder Farmers

Sub-Saharan Africa continues to have low adoption rates for trends in climate smart agriculture among smallholder farmers. Anbati *et al.* (2022) looked into the variables affecting Kenyan smallholder potato growers' adoption of climate wise practices. The study concentrated on farmers' entrepreneurial tendencies, an important factor in the effective adoption of climate wise agriculture practices that has been underappreciated. The study used a cross-sectional survey of 350 potato farmers. Six areas of climate smart agriculture practices-crop management, soil management, seed management, nutrient management, crop protection, water collection, and crop quality enhancement were taken into consideration based on the study. Results from the multivariate Probit indicated that farmers' innovativeness was positive and significantly related to crop management and improvement practices uptake while its correlation with water harvesting was negative.

Further, proactive farmers had a higher likelihood of adopting seed management practices while risk takers were more likely to embrace protection and water harvesting technologies. Other factors that were found to be influencing the adoption rates of climate smart agricultural practices included access to mobile-based financing, household income, farm attributes, gender, trust in extension officers and land size under cultivation.

2.9.2 Climate Smart Cassava Production and Marketing Practices among Farmers

Githunguri and Njiru (2020) studied the role of cassava and sweet potato in mitigating drought in semi-arid Makueni County in Kenya. Insights from the study indicated that in as much as improved early maturing cassava and sweet potatoes varieties have been developed, majority of the farmers still cultivated local varieties. As such, the study aimed to obtain a general overview of sweet potato and cassava farm production in Makueni County. The study utilised focussed group discussions and participatory rural appraisals with key cassava stakeholders with the aim of establishing the current status of these crops in the county.

Findings indicated that there were few adopters of the improved cassava and sweet potato variety among farmers in the county, which was attributed to lack of information dissemination hence low commercialization of the same. Additionally, the study observed that in as much as farmers had adequate experience in growing the crops for consumption purposes, they were actively searching for cultivars with a combination of both nutritional and food security qualities. Recommendations drawn from the study indicated the needs for extension service providers' engagement to help in campaigning for the adoption of the improved varieties. Also, training for farmers and awareness creation through information dissemination is necessary to enhance their adoption hence contributing to food security.

Darko-Koomson *et al.* (2020) conducted a study on the analysis of cassava value chain in Ghana: implications for upgrading smallholder supply systems. The study utilized a combination of purposive, snowball and simple random sampling to select the key players in the cassava value chain. A semi-structured questionnaire was used to collect data for analysis. During analysis, an all-inclusive value chain map was generated which indicated the different pathways for cassava crops. Findings established that cassava moved in more than four value pathways from farm gate to the market. It was revealed that cassava production is profitable in Ghana which further generated positive profit margins to its farmers. Depending on the customers' preference for cassava products, processing is majorly done for production of both dry and wet cassava products. However, despite the benefits of cassava farming, there exists a weak cassava governance system which forces most cassava traders to use spot markets in selling their products.

Steinke *et al.* (2019) looked at prioritizing options for multiple objective outcomes for agricultural development using the positive deviance approach. To test for the positive deviance adapted approach, a quantitative survey drawn from 500 rural households. 54 households were identified as having better performance in the five key developmental dimensions (income, nutrition, environment, food security and social equity). Relative to other households, positive deviant households had the best performance in terms of food security and performed slightly better on social equity. The difference was attributed to the current household priorities on the desire for more experimentation on production but not social relationships.

2.9.3 Relative Importance of Functions of Innovation Systems in Fostering Cassava Production and Marketing

Pound and Conroy (2017) looked into the innovation systems approach to agricultural research and development. As documented, innovation platforms were introduced as a means of operationalizing the innovation systems approach. While the innovation system phenomenon seems new in the agricultural sector, it comes along with various market opportunities, information dissemination, research and development and exploitation of new market opportunities. However, in as much as innovation systems seem to work perfectly, there is a need for capacity development for all those who run and operate it. These capacities; both technical and soft skills such as governance of the innovation platforms, facilitation and communication for all coordinators is essential for the smooth running of the system.

In their study Olurotimi *et al.* (2018) looked at the effects of social capital available in Innovation Platforms on the technical efficiency of cassava production in Humid tropics field sites in Nigeria. The study utilized a multistage sampling technique procedure with a sample size drawn from 100 respondents which comprised 41 innovation platform members and 59 non-innovation platform members. Data was collected with the aid of pre-tested structured questionnaires. Results indicated that farmers' technical efficiency was high and being a member of the innovation platform increased a farmers' technical efficiency in cassava production. Through membership to innovation platforms, farmers were able to learn more on cassava production and this showed that production efficiency was high among innovation platform members, with farm size under cassava, labour and stem cuttings and makings being important inputs in their production. On the other hand, for non-members, farm size and stem cuttings were their only farm inputs. This demonstrated that social capital had a significant role in enhancing cassava production. Additionally, such networks were important in enhancing collaborative learning through building contacts with researchers and experts in the cassava field.

Adekunle and Farinde (2018) carried out a study on effect of linkages and networking on role performance of stakeholders in cassava research output uptake in Oyo State, Nigeria. They alluded to the fact that research outputs are not useful unless they are embraced by end users, adapted or utilized for solving problems. The study specifically looked into the characteristics of cassava stakeholders and their roles in relation to the kinds of linkages they used in networking. A multistage sampling technique was used to select the study's sample size which comprised agricultural input suppliers, cassava producers and processors, cassava farmers, extension agents and research scientists. In order to gather innovation on the available improved variety of cassava, all the stakeholders made use of agricultural shows, exhibitions and their informal contacts as linkages for effective adoption of cassava innovations.

Bisseleua *et al*. (2018) investigated the strategic value of multi-stakeholder processes (MSP) in agricultural innovations and how it affected stakeholder platform capital dynamics for livelihood assets in West Africa. In order to assess the capital dynamics of the many stakeholders in the platform's livelihoods, the study used a multistage sample technique. The findings from the study revealed that participants of the multi-stakeholder platform had relatively higher livelihood assets as opposed to non-participants, with gains realized from participants being high.

2.10 Critique to Literature Reviewed

In as much as CSV novel technologies seem to be important towards adoption of improved cassava varieties and livelihoods in Nyando CSVs, several setbacks have derailed its achievement. From the literature reviewed, it is clear that majority of the studies reviewed, targeted the smallholder farmers as their respondents, yet this may turn out to be difficult to reconcile with the serviceable approach of multiple stakeholders who have interest in the improved cassava varieties, such as the national government and county governments, agricultural research institutions, private sector companies and community farmer groups. This insinuates that a further redesign of the cassava innovation sector is key and necessary.

Another critique arising from the reviewed literature is that stakeholder platforms are pointless if they do not lead to improved cassava innovation in Nyando CSV. Critically thinking, stakeholder platforms are key in spearheading the adoption of new improved varieties of crops, encourage information dissemination and therefore needs identification. Additionally, knowing the level of influence of each stakeholder is key in deciding who to engage and who not to engage in the stakeholder platform exercise. However, the above literature in some instances had a predetermined outcome of the local community needs which makes it futile to conduct the assessment.

2.11 Theoretical Framework

The 'Sustainable Livelihoods' approach, which offers a thorough understanding and multi-dimensionality of poverty, from global to local level (Scoones, 2009), the Agricultural Knowledge Information System (AKIS), and the technological innovation systems (TIS) theory, which offers insights into the functions and importance of the innovation systems, served as the foundation for this study. Lewin's change model theory and the 'Sustainable Livelihoods' approach are also important influences. The Lewin’s change model and the four approaches were used in this study as a guide in identifying the effects of cassava farming as a climate smart agriculture technology on farmers’ livelihoods in Kisumu County.

2.11.1 Lewin's Change Model

In the 1950s, German-American psychologist Lewin (1958) created the "Unfreeze-Change-Refreeze" concept. Lewin's change paradigm focuses on altering peoples' behaviours. Kurt Lewin proposed the unfreeze-change-refreeze model, a three-stage model of change that necessitates the rejection and replacement of earlier learning, according to Schein (1995). Three stages are identified by the model, the stage of unfreezing that gets individuals ready for a desired transformation. The desired change is accomplished during the change stage, and during the final stage, known as the refreezing stage, the desired change is hardened to prevent people from reverting to their former behaviours. The model can be used to explain the process of introduction, implementation and stable adoption of individual and organizational behaviour related to new technologies or institutional development innovations. Smallholder farmer groups must make behaviour changes as may be influenced by institutional strengthening processes.

Lewin thought that unfreezing or preparing an organization to embrace the change was the best method to help it move through transformation. Before the organization can develop a new method to function, this step requires dismantling the current modes of operation. The notion that cultural factors and earlier observational learning from the past influence human behaviour serves as the cornerstone of this developmental stage. In order to bring about change, it is necessary to introduce fresh factors or get rid of some of the ones that are now influencing the behaviour. Lewin asserts that human behaviour is based on a complex field of forces and a virtually stationary equilibrium. Lewin emphasized that for old behaviour to be abandoned (unlearned) and new behaviour to be properly acquired, the equilibrium must be disrupted (unfrozen). The study aims to improve or transform (unfreeze) smallholder farmers' existing or conventional methods of producing and marketing their produce in the climate smart villages by strengthening their capacities in a learning forum. Unlike the ice model, this one entails melting the ice in order to get it ready for a change in shape. Once the ice has been unfrozen, it must then go through the change phase, when it is moulded into the required new shape.

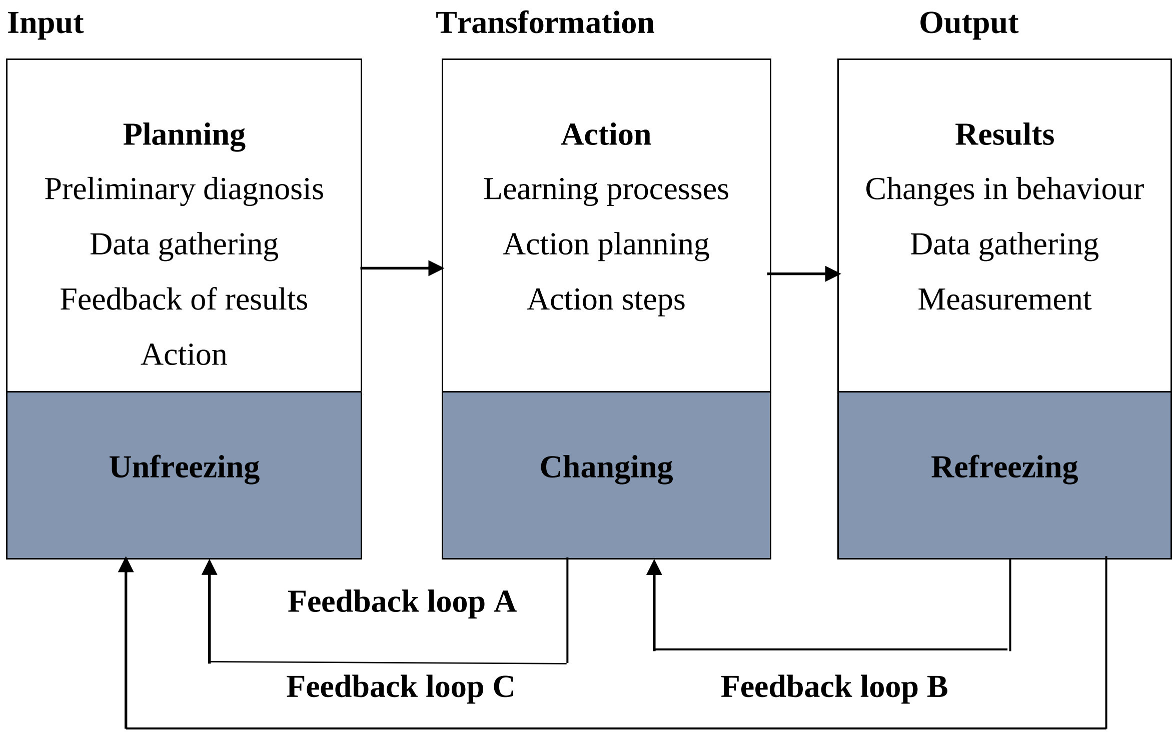

Figure 2.1: Systems model of action-research process

Source: Lewin (1958*)*

After improving on or changing the existing or traditional smallholder farmers' production and marketing of the cassava crop, there must be immediate implementation of the change (change stage). This will ensure solidification of the change (refreezing) among the smallholder farmers. Figure 2.1 shows a systems model of action-research process. With this model, after the change has been implemented in the change stage, farmers are inclined to revert to their old habits and that is why there must be refreezing of the process to ensure that whatever the smallholder farmers have been capacity built on, is adopted, hence solidification. Refreezing seeks to stabilize the group at a new quasi-stationary equilibrium to ensure that new behaviours are relatively safe from regression (Sarayreh *et al.*, 2013). To ensure this, the researcher will involve relevant actors to help with the capacity building of farmers on cassava production and marketing through a learning forum. The learning forum to be used will be the existing innovation platform which was used during the introduction of the CSA technology innovation to the village.

Apart from food production, farmers in the study area also engage in marketing of their farm produce in the local markets and even beyond. To enable the smallholder farmer's benefit from production and marketing of their produce, there is need for enhancement of their capacity in both, which makes the study to employ the use of Lewin’s change model as it focuses on behavioural modification of the people.

2.11.2 The Sustainable Livelihoods Framework Approach

In the late 1990s, the sustainable livelihoods strategy first appeared. It was first popularized by the Department for International Development (DFID), which employed it as their primary method for reducing poverty (Scoones, 2009). A livelihood is defined as "consisting of the capabilities, assets (including both material and social resources), and activities for a means of subsistence" in Chambers and Conway's 1992 working paper for the Institute of Development Studies.

A livelihood is sustainable if it is able to tolerate stresses and shocks, recover from them, maintain or increase its capabilities, and do so without jeopardizing the natural resource base. In order to understand poverty from a local viewpoint, it centers analysis on "poor" individuals and their causes. This is a crucial component of the study because it helps us understand how farmers in Kisumu County make a living. Opportunities are prioritized over requirements and limitations (DFID, 1999). It is a comprehensive strategy that encompasses and offers a way to comprehend the causes and dimensions of poverty without narrowing the attention to a select few.

The sustainable livelihoods approach seeks to provide people a clear and realistic awareness of their assets and how they convert those assets into favourable livelihood outcomes. It lists the five asset categories that form the foundation of livelihoods: human capital, social capital, natural capital, physical capital, and financial capital. Skills, knowledge, good health, and the capacity to work are examples of human assets. The development of a highly competent and creative human capital base is essential for economic progress. The capacity to create jobs in the cassava industry is enormous. Farmers can work with organizations like colleges, research centers, non-governmental organizations (NGOS), and the commercial sector to enhance their way of life, and these organizations ought to be aware of the farmer's role. Collective activity and access to knowledge are components of social capital.

Families' participation in the economy and in their communities depends on their social capital. Social capital makes it easier for the household to respond to day-to-day difficulties and enhance its welfare. By raising household incomes and enhancing access to services including water, sanitation, credit, education, health, and agriculture, it helps ensure the survival of households. In Kenya, the development of numerous cooperatives in different industries, including agriculture, is the result of the country's structured social capital. This is still lacking in the cassava sub-sector, so it is necessary to organize farmers and other stakeholders to create cassava cooperatives, whose activities will include agricultural undertakings such as input supply and marketing in order to ensure that commodities are produced on schedule to enable increasing productivity.

Farmers that work together can gain more access to markets and technologies that enhance agricultural productivity. Land, woods, water, animals, trees, crops grown, and access to common resources are all examples of natural capital. The majority of the population about 80% lives in rural areas and is reliant on agriculture for a living (Kimani, 2008). There are a number of issues with Kenya's numerous rules, laws, and regulations that control how agricultural land is used and managed. It is inappropriate to divide up agricultural land into unprofitable parts for agricultural purposes. Because of nutrient restrictions brought on by continuous cultivation, soils are becoming less sensitive to inorganic fertilizer. Poor yields that cannot support the family as a result, which is typical in the study area.

The fundamental infrastructure, access to markets and technologies, as well as the tools and equipment people use to earn a living are all examples of physical capital. Poor road conditions and lack of upkeep in Kenya's rural areas make it difficult for farmers to sell their produce because of inaccessible markets. This has an effect on people's livelihoods since money is lost. Rural transportation will contribute to improved governance and country integration, expanded markets, increased agricultural output, and lower transport costs. Using information and communication technology (ICT), ordinary agricultural practices can be replaced with intelligent ones. Farmers can use mobile phones as a financial system by using money transfer services e.g. Mpesa, M-Shwari and mobile money transfer services.

Savings (in cash or in kind), access to financial services (credit, insurance), and consistent cash inflows (trade, remittances, pension) are all examples of financial capital. Farmer access to productivity-enhancing inputs like enhanced cassava germplasms and commercial agricultural inputs like fertilizers and fungicides is restricted by a lack of operating capital and low liquidity (Nyoro, 2002). Producers with formal finance access generally have greater production efficiency levels. However, farmers have limited access to helpful financial institutions that can assist them in overcoming capital constraints and diversifying their sources of income, which prevents operational plans from being carried out.

Due to the declining farm output and the need for money for farm inputs, health care costs, and school fees, farmers are frequently forced to hunt for off-farm employment and give up their farming endeavours. Environmental deterioration may occur as a result of improvements to one livelihood. Therefore, DFID (2000) urges that in order to encourage positive change, it is necessary to look into how people's livelihood strategies and outcomes affect social, institutional, environmental, and economic aspects. The Sustainable Livelihoods Framework is employed in this study as a theoretical framework as a tool to disclose not only the locally acknowledged obstacles to sustainable livelihoods, but also the national and international context that influences their prospects for a living.

In light of this, the benefits of small-scale cassava cultivation on enhancing farmers' livelihoods in terms of income, food security, health, and household education were examined using a sustainable livelihood framework. It encourages the development of specialized knowledge and focused abilities. The livelihoods framework's practical focus enables managers and staff to pinpoint the knowledge and skills they need to acquire in order to meet community needs and the organization's own vision. To improve their ability to support themselves, smallholder farmers in climate smart villages need to increase agricultural production and marketing. For farmers to be able to attract consumers willing to pay premium prices, they must develop their capability for market production and value addition. In Figure 2.2, a redesigned livelihood framework is displayed.

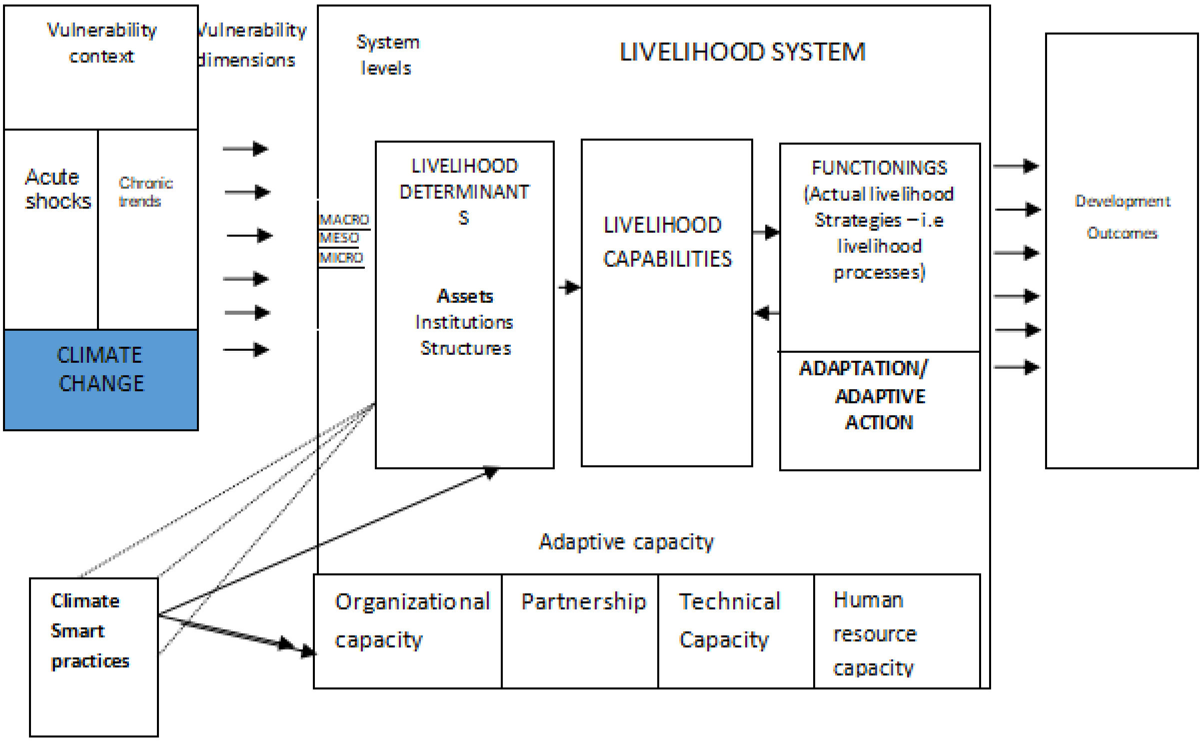

Figure 2.2: Modified Livelihood Framework adapted from Scoones (2009)

2.11.3 Agricultural Knowledge Information Systems (AKIS) Perspective

Research carried out by Aina *et al.* (1995) generally showed that there are different generators and users of agricultural information. According to AKIS, many actors comprising individuals, organizations or institutions dealing directly or indirectly with the know-how in agriculture are contained in an agricultural knowledge system (Assefa *et al.*, 2009; Roling & Engel, 1991).

The technical knowledge applied by farmers in cassava farming is developed by different actors such as Research organizations, extension actors, among others. The different technical knowledge by actors was exploited during learning in the Learning Forum. Other institutions such as Non-Governmental Organizations, Agriculture ministry, County Governments and education institutions have key roles in the AKIS, as depicted in Figure 2.3. The fundamental concern in AKIS is therefore enhancing the strength of the inter-linkages between the different actors as compared to just supporting research organizations and government support services. By carefully analysing the agricultural know-how as a system, in this study, the AKIS model was used to evaluate the effectiveness of different actors during learning in the learning Forum.

The recommendation under AKIS is that, farmers should also be regarded as important actors by the policy makers and implementers and should therefore be taken seriously in knowledge governance. Much of the AKIS literature highlights research as a major innovation motto. This AKIS perspective is relevant in this study as it explains the various sources of agricultural knowledge and information accessible to cassava farmers. In this case the model explains that cassava farmers may not entirely be blamed for poor yields as a result of obtaining misleading information.

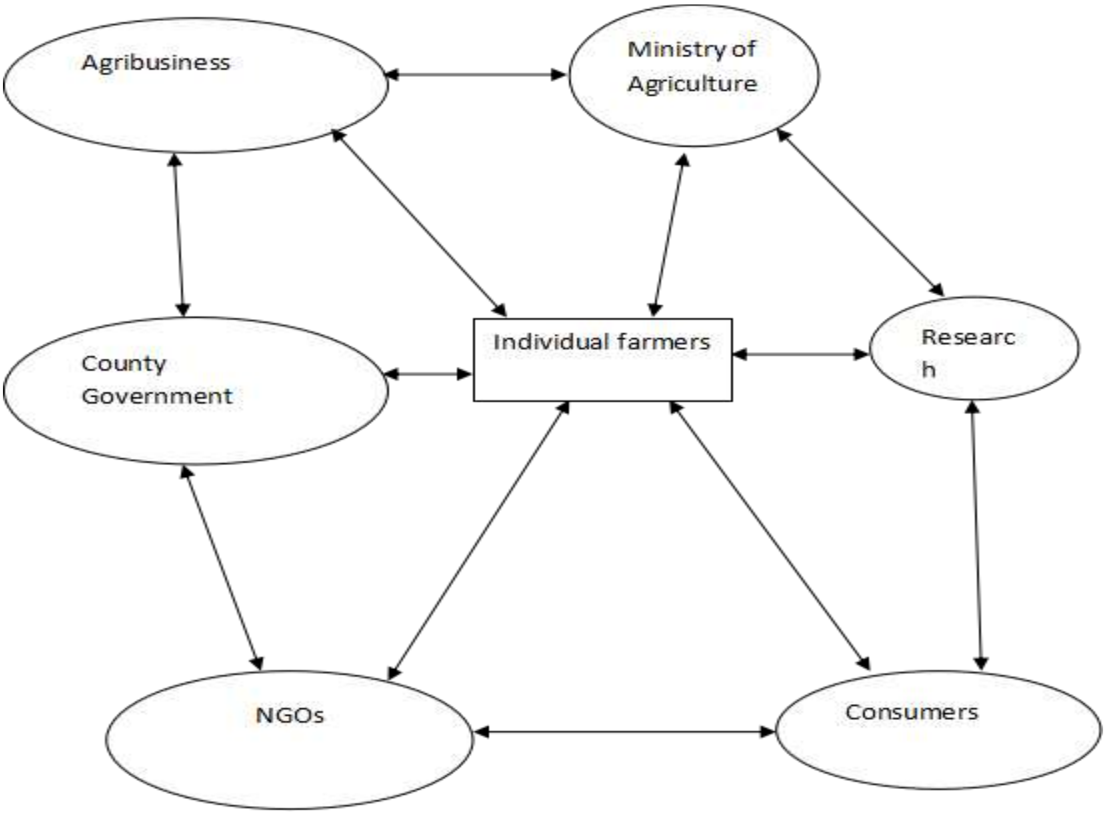

Figure 2.3: Structure of the AKIS Framework

Source: Munyua (2011)

This AKIS perspective is relevant in this study as it will explain the various sources of agricultural knowledge and information accessible to cassava farmers. In this case the model explains that cassava farmers may not entirely be blamed for poor yields as a result of obtaining misleading information.

2.11.4 The Technological Innovation Systems Theory

In recent years, the technological innovations systems (TIS) theory approach has received considerable attention for the analysis of novel technologies both within and outside the framework of sustainable transformations. It is concerned with comprehending the dynamics of an innovation system that revolves around a single technology. The approach is frequently used to evaluate the effectiveness of a TIS, detect flaws, and make suggestions for the design of policies in support of a specific technology (Jacobsson *et al*., 2011).

The TIS theory is a theory that describes the dynamics of innovation in a certain field or sector (Bergek, 2019; Planko *et al.,* 2017). It takes into account the interactions of numerous players in the development of innovations, such as corporations, research institutions, users, and government agencies. The TIS theory can be utilized to examine the elements that contributed to the successful acceptance and scaling up of improved cassava varieties in the context of cassava innovation in the Nyando CSV.

Additionally, TIS argues that innovation is a systemic process that necessitates the synthesis of multiple elements such as knowledge, actors, and institutions. Various actors play vital parts in cassava innovation, including the research institutions that developed the improved cassava varieties, smallholder farmers who tested and adopted improved varieties, both the county and national government agencies that provided policies and workable support, and the private sector. Furthermore, knowledge access in any innovation platform is critical in the innovation process since it enables all actors to better understand the gains to be realized from the improved cassava varieties and how to grow them effectively.

The institutional context is also crucial in the cassava innovation process. Government policies and programs like the Agriculture Research-for-Development (AR4D) agenda and the Climate-Smart Agriculture (CSA) approach has been at the forefront in supporting the effective adoption and scale-up of improved cassava cultivars. Furthermore, through the innovation system platform, collaboration among various stakeholders is critical in addressing the challenges that farmers in the Nyando CSV have continuously faced, such as climate change, food insecurity, and poverty.

Hekkert and Simona (2009) and Musiolik *et al.* (2012) further allude to the fact that for an innovation platform to overcome the barriers of technological adoption, they need to have willing and transformative agents, in this case, positive deviants, to help in the development and stabilization of the technology. This is key in ensuring other farmers follow suit and embrace any given technology as they would wish to be like the model farmers/positive deviants. As such, the technological innovation system theory therefore is key in this study.

2.12 Research Gaps

As facilitated in a collaborative learning initiative by multi-stakeholder Agricultural Innovation Systems (AIS) in the Nyando Climate Smart Villages (CSV), the improved cassava varieties are Climate Smart Agriculture (CSA) innovations. Using the climate smart cassava innovations, the vulnerable households were to respond to the persistently changing and variable climate risks. However, literature review of studies on the influence of positive deviance and collaborative learning on improving cassava production and marketing indicates that the main target beneficiaries has been restricted to farmers. This ignores the power and outcomes of Agricultural Innovation Systems, which justifies empirical studies incorporating different actors' roles. Participatory collaborative learning approaches through which adoption of novel technologies are enhanced are gaining in importance. The relative roles of seven functions are thus important, but empirical evidence is lacking on this, in climate smart cassava innovations promoted in climate smart villages with multi-stakeholders.

Crop diversification in the Nyando Climate Smart Village has sharply declined since 2015 after initial rising uptake from 2011, suggesting that some farmers could be abandoning some of the introduced climate smart agriculture technology innovations. Those abandoning may be not benefiting while those continuing with production could be benefitting more. This observation points to a phenomenon of positive deviant behaviour, but such studies are rare in climate smart cassava innovations. This would inform as to whether cassava is one of those climate smart innovations being abandoned.

Responding to the persistently changing and variable climate risks involves improving productivity and incomes, adapting and building resilience, mitigating the greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide), but are these also important to farmers adopting CSA practices. Field surveys have revealed that households realise gains differentially, pointing to positive deviance behaviour, because only a few farmers are observed to realise outstanding benefits while a majority are attaining gains below the average (those who can be labelled as typical average performing farmers). The positive deviants demonstrate greater innovative capacity so if identified, could support fostering cassava innovations, especially in production and marketing and realization of the benefits of climate smart agriculture.

When introducing climate smart innovations, multi-stakeholders emphasised improved agronomic practices, without integrating market participation. This could have been a disincentive for increasing production because demand for cassava increased in both local and urban markets surrounding the Nyando Climate Smart Village but cassava production, processing and marketing somehow stagnated in the Climate Smart Villages. In the Nyando Climate Smart Village, a few outstanding farmers (positive deviants) in cassava production and marketing can be found that poses innovative capacity relevant to supporting fostering cassava innovation. Collaborative learning action has been used in knowledge exchange and co-innovation to initiate improvements in agricultural systems, but application in cassava innovation is rare in documentation.

This study sought to therefore generate empirical evidence on influence of positive deviance on the benefits that can be gained from use of climate smart cassava innovations and on effectiveness of collaborative learning in initiating improvements in cassava production and marketing. The study also sought build on experiences in the Nyando Climate Smart Villages in the lake basin region of western Kenya. This is one of the climate smart villages that the Climate Change, Agriculture and Food Security (CCAFS) established together with several other partners to test a range of climate smart agriculture interventions. Cassava featured among the prioritised climate smart agriculture interventions suited in the Nyando Climate Smart Villages.

2.13 Conceptual Framework

The research conceptual framework illustrated in Figure 2.4 guided the analysis of the influence of positive deviance and collaborative learning on fostering cassava production and marketing in Nyando CSVs of Kenya. The framework shows status of the art (Context) in the Climate Smart Village and the variables which were measured and analysed to answer each of the specific research questions. The conceptual framework provides pathways through which farmers could respond climate change risks.

Multi-stakeholder collaborative learning facilitated co-testing and co-development of a portfolio of climate smart technologies to empower farmers to respond to changing and variable climate risks. Improved cassava varieties that are resistant to the mosaic virus were selected among promising climate smart agriculture practices, technologies and innovation to diversify and secure staple food crop in the Climate Smart Villages. Multi-stakeholder process established a multiplication facility to supply the planting materials. In western Kenya in 1998, Cassava Mosaic Virus Disease (CMVD) caused yield losses, estimated to reach 150,000 tons valued at US$ 10 million (IITA Annual Report 1998).

The beneficiary participating farmers in the multi-stakeholder process included the majority who have abandoned the climate smart agricultural technologies and a few who have continued to deploy those technologies. A few farmers benefiting from agricultural technologies among a majority under similar environmental and production circumstances is suggestive of a positive deviance behaviour phenomenon. The positive deviance farmers are associated with outstanding performance and so their presence is indicative of viable solutions being present within local communities. Knowing their innovative practices can inform how to address local cassava production and marketing challenges. Within a local farming environment, positive deviants (Birhanu *et al.,* 2017; Herington & van de Fliert, 2018) emerge more successful with innovation to achieve better performance than typical farmers do. The implication is that these two distinct groups of farmers – typical and positive deviance - could have differently deployed cassava innovations from the multi-stakeholder collaborative learning facilitated co-testing and co-development. The differences can be observed in the trends of using the innovation and the rates of dis adoption of the innovations.

Cassava is a selected CSA innovation to empower farmers and address impacts of climate change for realization of triple wins: productivity and incomes, adaptation and mitigation of greenhouse gases. Thus, CSA triple wins can indicate progress when diversifying livelihoods with improved cassava varieties by having diversity of products produced and processed on farm. With increased productivity, farmers produce marketable surplus to sell and earn income. Market remunerative rewards will vary with marketing innovations which an individual farmer applies, including processing and value addition and institutional arrangements.

The differences observed in cassava innovation use trends and the rates of dis adoption in turn influenced the gains in production and marketing. The differential gains between typical and positive deviance farmers gives insight into how climate smart cassava innovations have enabled households to respond to the persistently changing and variable climate risks.

Multi-stakeholder facilitated collaborative learning was through co-testing and co-development of a portfolio of climate smart technologies to empower farmers to respond to changing and variable climate risks. This is a process of fostering agricultural innovation systems. On the foregoing basis, the seven functions of the innovation systems in fostering cassava production and marketing are examined to determine their individual relative importance as was experience in the Nyando Climate Smart Villages.

A yearlong action research was specifically designed as an intervention to test for improvements in cassava production and marketing that can be initiated through a collaborative learning. This was to identify which climate smart cassava production and marketing innovations would be improved when engaging typical farmers with positive deviant farmers in a collaborative learning forum in Nyando Climate Smart Villages.

Arising from the discussed assumptions and hypothesis, the study was conceptualized to understand the influence of positive deviance and collaborative learning on fostering cassava production and marketing in Nyando CSVs of Kenya. The numbers in Figure 2.4 depict the specific relationships of focus, which were to determine how different typical and positive deviant farmers have adopted (1), abandoned (2) and gained from climate smart cassava production and marketing (3); and how functions of innovation systems (4) and collaborative learning (5) have fostered climate smart cassava production and marketing in Nyando CSVs.

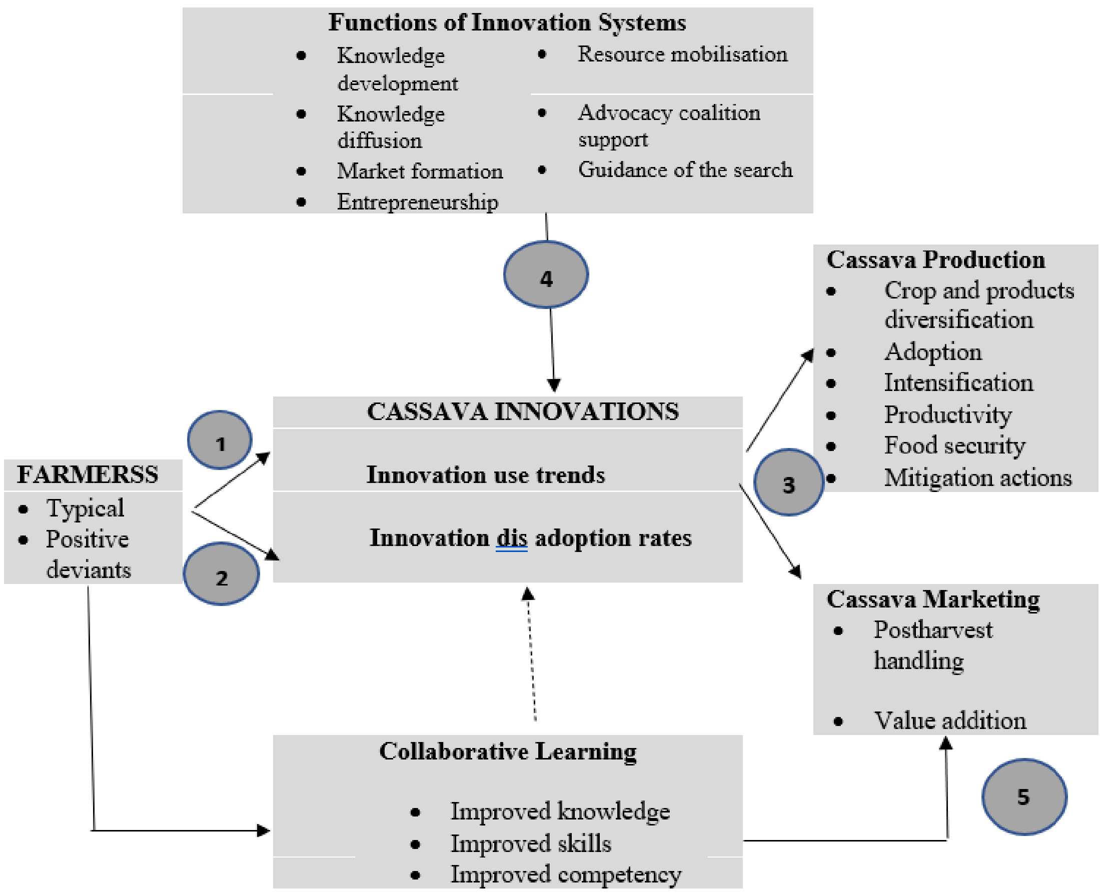

Figure 2.4: A conceptual framework illustrating relationships between variables (independent, intervening and dependent) guiding analysis of the research questions

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

The study area was the Nyando Climate Smart Villages (CSV) in the western Kenyan county of Kisumu. The Nyando Climate Smart Villages, one of the climate smart villages founded in 2011/2012 to test cassava climate innovations among other climate smart agriculture interventions, was chosen for the study. This area has been identified as a hotspot for climate change and variability that affects rural livelihoods. Because of this, Nyando CSV was created by the Climate Change and Food Security (CCAFS) in 2011–2012 to test a number of climate-smart interventions that were adapted to the needs of the neighbourhood (Recha *et al.*, 2017). The local community, through partner facilitated participatory and inclusive process, selected their preferred set of climate smart interventions with which they would be transforming to a more resilient and food secure while also contributing to climate change mitigation through practices that sequester carbon and reduce greenhouse gas emissions.

Figure 3.1 presents the location of the study area. The area lies between longitude 33° 20'-35° 20' East and latitude 0° 20' - 0° 50' South. It has a population of roughly 73,227 people and an area of about 163 km2 (KNBS, 2019). The average annual temperature is 20°C, and the average annual rainfall is 1000mm (KCID, 2013). The Nyando and Obuso rivers serve as the primary drainage waterways. The majority of the soils are black cotton, which naturally forms deep gaps in the dry season that allow rainwater to seep through at the start of the rainy season. When the rainy season begins, the earth swells, cracks shut, and water cannot penetrate the soil any further, flooding the plains results. Low ridges spread the landscape where rivers occasionally break their banks, causing loss of property and human life due to flooding (County Government of Kisumu, 2013). Waterborne, vector-borne and soil-borne disease outbreaks are associated with flooding, exposing communities to health risks, further increasing vulnerability and worsening labour for food production.

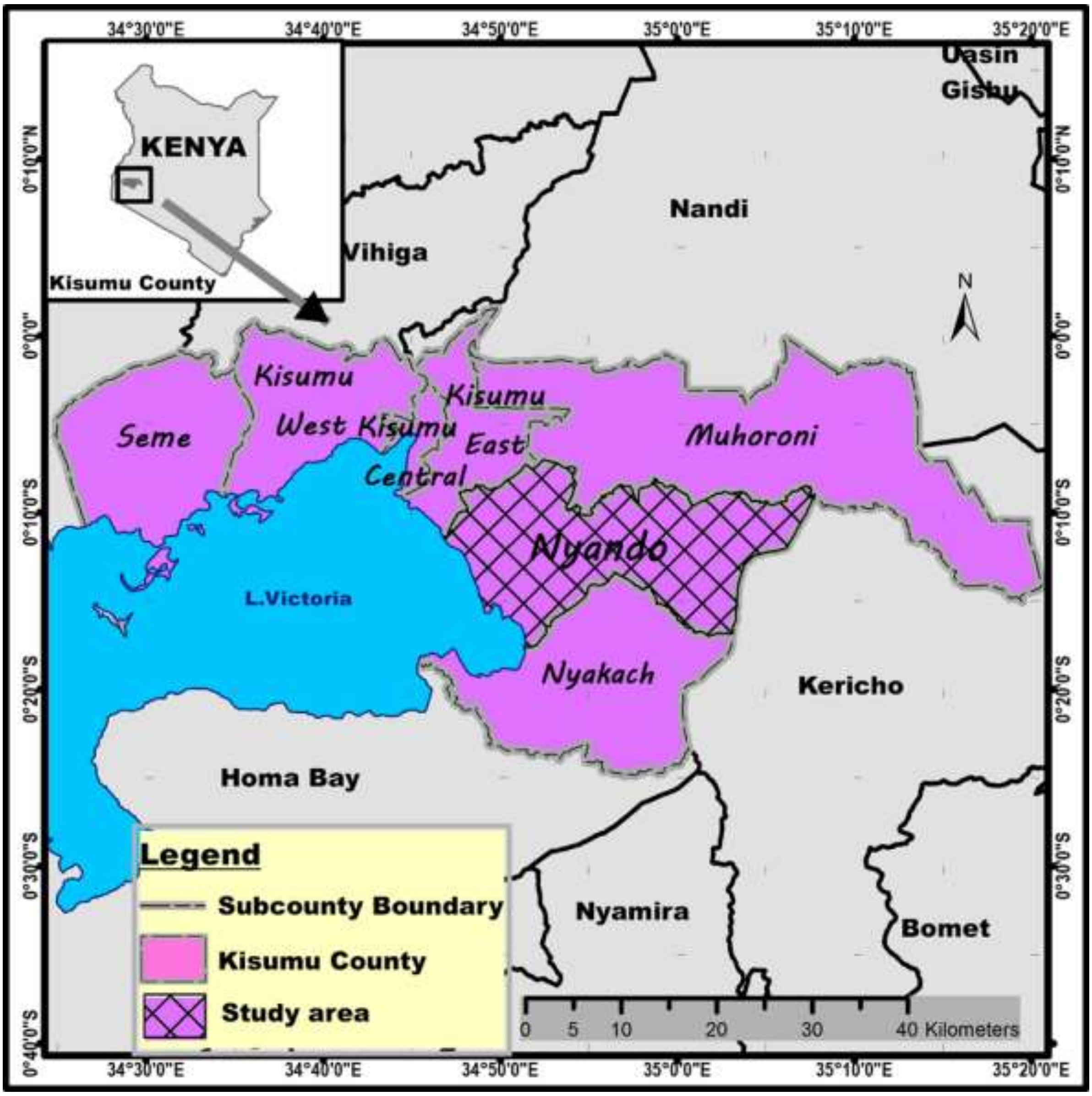

Figure 3.1: Map of the study area

Source: Murono *et al.* (2018)

3.2 Research Design

The research design was descriptive survey integrated with Participatory Action Research (PAR) design. The descriptive survey involved both quantitative and qualitative approaches to analyse farmer participation in cassava production and marketing in Nyando CSV. This was preferred to collect information on farmers' perceptions, knowledge, practices and behaviour and define their characteristics (Frankel & Wallen, 2000; Hammersley, 2004; Orodho, 2003).

PAR was implemented to catalyse change in cassava production and marketing through participatory learning process (Mapfumo *et al.,* 2013). Through PAR, cassava producing farmers and multi-stakeholders participated in experiential learning involving planning, action, reflection and re-planning actions, and documentation (Buenavista *et al.,* 2001; Kemmis & McTaggart, 1998). This participatory cyclical process was to empower and build capacity of the primary beneficiaries to transform from being information providers to collegial partners. The participating primary beneficiary group were made of cassava growing farmers in Nyando CSV with the desired change being enhanced capacity to solve cassava production and marketing challenges.

3.3 Target Population

The target population consisted of the 10,000 families in the 11 villages that make up the administrative sub-location of Nyando Sub-County known as Jimo (KNBS, 2019). These settlements make up the Nyando Climate Smart Villages in the broader Kisumu County's Nyando Sub-County. The target audience was specifically chosen because it lived in an area where cassava was one of the technologies for climate-smart agriculture that was promoted and catered to the needs of the local community (Recha *et al*., 2017). In this designated hotspot of changing and variable climate, which is having a negative impact on food security, the Climate Change and Food Security (CCAFS) in 2011–2012 established the Nyando Climate Smart Village, where cassava was used as a priority climate smart innovation among a variety of other climate smart agriculture interventions which is impacting negatively on rural livelihoods.

3.4 Instrumentation

The views, adaptation plans, and climate change determinants of smallholder farmers will be the subject of integrated approaches using both qualitative and quantitative methods. Qualitative data for this study will be collected through focused group discussion (FGD) and key informant's interviews. Additional qualitative information will be collected through extended case studies using ethnographic interviewing. Quantitative data will be collected by use of structured questionnaires.

3.4.1 Questionnaires

The majority of the items on the structured questionnaire will be open-ended and closed-ended. Closed-ended questions will be used to gauge involvement and non-participation in cassava production and commercialization as a climate smart technology, while open-ended questions will be used to address bias-prone concerns in how farmers view climate change. While adaptation techniques will be tied to changes in on-farm activities during the past ten years, perceptions of climate change will be related to changes in the climate over the previous ten to twenty years. The questionnaire will be used to interview sampled households within Jimo East Climate smart village. The household questionnaire will be designed to cover all stated objectives, and it will include diverse issues that will provide an understanding of the socio economic attributes of the study farm households and their perception of climate change, adoption strategies to climate change, factors that make them adopt specific strategy and challenges experienced.

3.4.2 Focused Group Discussions (FGDs)

According to Onwuegbuzie *et al*. (2009) focused group discussions are used to gather in-depth qualitative data regarding groups' perspectives, attitudes, and experience on a specific topic. This will be achieved by the use of PRA tools and a checklist. Respondents for focused group discussions will be farmers (about 10-15 in number) and will include those who are participating in climate smart activities.

3.4.3 Key informants Interviews

This will involve interviewing of knowledgeable people within the society who are likely to provide the required information, ideas and insights on a particular subject (Kumar, 1989), in this context cassava production and marketing as climate smart technology. Key informant interviews will target Ministry of agriculture officials working at the county, Non-

Government Organization officials working in the agriculture sector within the Nyando Climate Smart villages, officials from the research institutions and opinion leaders in the community. The topics of discussion will be based on the research questions formulated. Participants will include opinion leaders in the communities where the research will take place, researchers, extension workers (from government and NGOs), and community-based organisation representatives.

3.4.4 Case Studies using Ethnographic Interviews

Since the study will conduct case studies on individual farmers (herein referred to us positive deviants) that will have in their own ways excelled in cassava production and marketing, ethnographic interviews will be used. Case studies will be the basic methodology to be used in exploring the central analytical problem on positive deviance. Positive deviants will be selected along the cassava value chain. At least five positive deviants along the cassava value chain will be selected as cases using snowball sampling technique. Respondents for this interview will include purposively selected farmers, traders, and processors.

Data was collected using three tools: questionnaire, Focus Group Discussion (FGD) checklist guide and Key Informant Interview (KII) checklist guide. While FGD and KII were used in collecting qualitative data and validation processes, the questionnaire was used in farm survey to collect both quantitative and qualitative data (Appendix I). The questionnaire used in baseline survey had sections to capture data needed to answer the specific research questions, except for initiating improvements in cassava production and marketing, which was through a collaborative learning forum. The sections were divided into: trends in use of climate smart cassava innovations; benefits realised from use of cassava innovations; innovative climate smart “best bet” practices; and relative importance of the seven functions of innovation systems. The next sections describe data collection as implemented for each of the research questions. The instrument was implemented in face to face sessions during home visits. The questionnaire had consent statement for ethical purposes to give committal assurance to the respondents on upholding confidentiality of the shared information.

Following Onwuegbuzie *et al.* (2009) recommendations, FGD was used to collect in-depth qualitative information about cassava production, marketing and innovation process. Each FGD session comprised 8 to 12 members representing farmers, extension and farmer group leadership and service providers in the Nyando CSV. The topics of discussion were guided by a checklist (Appendix II). The researcher facilitated the discussions. The key informants were drawn along the cassava value chain and were engaged for being considered more knowledgeable to share experiences and perspectives and insights on specific issues on cassava production and marketing as a promoted climate smart innovation in the Nyando CSV. As such, the key informants for the study were, two of the identified outstanding farmers by other farmers in the region, two value chain actors, two researchers, two cassava traders, extension staff and one staff from an NGO operating in the study area. A check list (Appendix III) guided specific issues discussed with the key informants.

Three instruments were used to collect data for this study. The instruments used to collect data were: questionnaire (structured, unstructured, and face to face) as shown in Appendix I, Focus Group Discussion (FGD) guide, as shown in Appendix II and Key Informants Interview Schedule (Appendix III). Focus Group Discussions with a minimum of 10 respondents was used and helped in clarification and confirmation of data gathered using a questionnaire. Appreciative 4-D cycle tool was used during FGDs to collect data from the study respondents on marketing of cassava produce by smallholder farmers. Four steps of the 4-D iterative cycle namely, the Discovery, the Dream, the Design and the Destiny steps, were used to guide the discussion. The discovery phase assisted participants in finding high-point experiences and smallholder farmers' marketing talents and capabilities. In this phase, participants considered and discussed the most beneficial information pertaining to the inquiry object. Participants in the "Discover" phase conducted pair interviews with one another to gather anecdotes about the group at its finest, suggestions for the group's most valuable resources, and details about the group's ideal future based on the marketing of its agricultural products.

Farmers were encouraged to imagine what further might be feasible in terms of the marketing of their products as part of the second step, which is the dream. Participants were instructed to envision their group, organization, or community at its best and try to pinpoint the shared aspirations of its members to represent this in some way during this stage. The third step, known as the design step, then followed. Participants were requested to create specific recommendations for the new organizational state after establishing a shared vision. The final step, dubbed destiny, required deciding to commit to an iterative exploration of learning, innovation, and producing results that matter to all stakeholders.

Judy and Hammond (2006) noted that organizations can bring about and sustain positive change by using Appreciative Inquiry (AI) to understand their capabilities and resources. AI encourages groups to inquire about, learn from, and build on what is working when they are at their best, rather than focusing on what's gone wrong and solving problems. Instead of focusing on the causes of their issues and failures, they contend that the group advances by recognizing the elements that contribute to their success. They also mentioned that Appreciative Inquiry cannot ensure a future route devoid of impediments. It can help people of groups, families, organizations, communities, and businesses unite and maintain their passion and drive so they can face the future with strength, assurance, self-awareness, and respect for themselves.

Stakeholder identification, face-to-face meetings, technical consultations, documentation of agreed-upon roles and responsibilities, work plan development, strategic planning, and training workshops were all used as part of the innovation Learning Platform methodology to ensure effective stakeholder engagement.

Key informant interviews was used to capture information from the study area leaders and opinion leaders who were conversant with the households farming and issues regarding agricultural produce marketing.

This research had four phases. Phase 1 focused on baseline survey research which helped in identifying smallholder marketing capacity building needs. Phase 2 dwelt on identification of the relevant stakeholders to engage in capacity building the farmer groups on market development and creation of the Learning Platforms which was used for learning. Three farmers' groups in the Climate Smart Villages were selected for capacity building and transfer of knowledge necessary for improving their marketing capacities. There was one Learning Innovation Platform created in the climate smart village. Phase 3 majored on consultation among stakeholders and building marketing capacity needs of the farmer groups. Phase 4 centered on organizing a stakeholder workshop which was a forum used to discuss the results from Phases 1-3 (Reflection). This means that there was data collection before and after capacity enhancement of smallholder farmers in the innovation platform on marketing development by actors, purposely to determine if learning ever took place, making the study to involve the concept of praxis, hence reflection. Reflection is the process of taking stock of what has been accomplished, thinking about it, and drawing conclusions about what has worked and what has not (Conway, 1994). One can learn at a deeper level through reflection. The learning that occurs without reflection is referred to as surface learning. According to Schon (1983), reflection is important for building models from a body of prior knowledge that are then used to reframe a problem or issue. After interventions are carried out, the results are then further assessed. Retrospective reflection takes place after the fact and is referred to as reflection-on-action (Schon, 1991). The process of planning for new action is crucial. Reflection-in-action allows the practitioner to assess changes that take place in the midst of intense professional action, making it contemporaneous reflection. Thinking about something while doing it is another aspect of reflection (Schon, 1983).

According to Sankar (2005), critical reflection is a type of analysis that examines both the underlying beliefs and how and why things transpired. At the end of the action cycle, it is especially important to conduct a critical reflection on what occurred, using initial observations and notes made in diaries, to determine how effective the changes made during learning in the innovation platforms were, what was learned, what were the barriers to change, and how the study can improve on the changes the study is attempting to make in the future. Even while critical reflection can be conducted in solitude, it will be more successful if it is done in small groups where thoughts and impressions can be shared in the hopes of bringing about changes in practice and attitude among individuals who are involved with the innovation. The training's results in terms of learning outcomes will be assessed. This aligns this research with the action research methodology, which was developed by Kurt Lewin in 1958 and is based on the cycle of problem identification, baseline data collection, introduction and implementation of change, and finally re-measuring the change.

3.4.5 Validity of research instruments

Anastasi and Urbina (1997) define validity as the degree to which a measuring tool achieves its objective by examining whether it accurately captures the behaviour or quality that it is meant to assess. Whiston (2012) defined validity as obtaining data that is appropriate for the intended use of the measuring equipment. The use of a recognized measurement tool ensures the validity of the studies' findings. To establish the validity of the measuring instrument, various validity categories have been proposed in the literature (Oluwatayo, 2012). The literature typically acknowledges that content validity and construct validity are particularly important. Bollen (1989) defined content validity as a qualitative sort of validity that examines whether the phrases used to describe the thing being measured are accurate. This definition designates a content validity analysis of a measuring instrument as a validity investigation that evaluates the extent to which each component of a measuring instrument serves the intended purpose. Construct validity is consequently the degree to which an instrument evaluates a concept, behaviour, idea, or quality, i.e., a theoretical construct that it is meant to measure. It is the ability to distinguish between participants who display the desired behaviour or quality and those who do not. The validity of the instruments was examined to see how well they would facilitate the collection of information relevant to the problem and study goals. Experts in rural innovation research and agricultural extension evaluated the questionnaire and its composite components. The construct validity of the items based on their flow and ability to elicit the desired data and responses, as well as the content validity of the items based on their coverage of the objectives and variables, were the main criteria for expert assessment. Based on the suggestions/recommendations given by review experts, the necessary changes to the content item structure and item order were made before the instruments for the pilot study were administered.

3.4.6 Reliability of research instruments

The stability and consistency of the used measuring device over time are referred to as reliability. In other words, reliability is the capacity of a measurement system to yield consistent results when used at various points in time. Ten smallholder cassava farmers in the village of Agoro East Ward of Nyando Sub-County participated in a pilot study of the questionnaire to ascertain its clarity, efficacy, and degree of consistency in results. This village had similar characteristics as those found in the Nyando Climate Smart Villages. The village where the questionnaire was pilot tested was chosen because it was far from the study villages and also, it contains same characteristics as the actual study area hence this was envisaged to give a pre-visualization of how the study data would appear. The sample of 10 households was settled for on the recommendation of Kathuri and Pals (1993), that a sample size of 10 in pre-testing can yield meaningful results on data analysis in survey research.

In pre-testing, split-half analysis technique was applied to eliminate the chance error due to differing test conditions and to test whether the desired reliability coefficient was attained (Mugenda & Mugenda, 2013). The Cronbach's alpha test was employed to assess the reliability of the study instruments, and coefficients above 0.7 were regarded as reliable. These coefficients range from $-1<r<+1$ and 1.00, with the lower value indicating no dependability and the higher value indicating complete reliability. With this sample size, split-half analysis achieved a reliability value of 0.83, which is higher than the threshold of 0.7 advised for questionnaire pilot studies (Santo & Reynaldo, 1999). According to Mugenda and Mugenda (1999), the advantage of the split-half technique is that it eliminates the chance error due to differing test conditions.

3.5 Sample Size Determination and Sampling

The minimum desired sample size was determined with the Fisher's exact formula (Charan & Biswas, 2013):

$$n = \frac{(Z_{1-\alpha/2})^2 P(1-P)}{(d)^2}$$

Where;

n = sample size; $\boldsymbol{Z_{1-\alpha/2}}$ = Z statistics for a 95% level of confidence (1.96), P = predicted prevalence of cassava cultivation is expected to be 25% based on reported priori estimates, and d = acceptable margin of error is set at 8%.

The sample size that resulted was increased by 10%, giving a minimum sample size of 124 farmers. A simple random selection procedure was used to choose this sample from the list of farmers taking part in the Nyando CSV activities. The list utilized to create the study sample was provided by Kenya Agricultural and Livestock Research Organization, a leading research institution stakeholder in the Nyando CSV Agriculture Innovation System. Interviews were conducted after visiting the chosen farmers. 150 farmers made up the final sample that was examined since each visited farmer was asked to name three other farmers who they believed to be excelling in cassava CSA techniques.

This study used a snowballing and validation method to identify such PDs with the help of peer farmers and key informants. Each farmer visited was asked to name three other farmers who cultivate improved cassava varieties in the village when the questionnaire was given out during the survey. A respondent was then asked to name the one of the three farmers producing improved cassava varieties that they thought performed very well in terms of CSA cassava techniques, production, and productivity. Each of them was asked to provide an explanation for why they had chosen that specific peer farmer as an outstanding performance in an open-ended question to the respondent. Then, without revealing the opinions of their fellow farmers, each of the selected top performers was tracked down for an on-farm visit and interview using the same questionnaire. Each of these exceptional performers then went on to name one more outstanding performer and explain their selection criteria after identifying three farmers in the village who were cultivating enhanced cassava varieties. An open-ended query contained these and captured them.

Following the completion of the survey, a list of individuals who stood out as great performers was created, and those who were mentioned the most were isolated. With this list, the people who were mentioned at least three times totalled 30, of whom two were invited to a subsequent stakeholder FGD. The actors in the value chain, extension personnel, and researchers from the public and private sectors who work in the Nyando Climate Smart Villages were present at this FGD session. Through the use of ethnographic interviews during the FGD sessions, participants came to the conclusion that farmers matched the definition of a positive deviant (PD). Six farmers emerged as "positive deviants," those who had displayed exemplary performance in embracing climate-smart innovations for growing and marketing the crop and were outperforming their peers and comparable farmers in the village in terms of production and productivity. The 124 farmers determined using the Fisher's exact formula (Charan & Biswas, 2013):) were purposefully chosen for the study, and they were added to the 26 farmers from the 30 farmers who were recognized by their fellow farmers as outstanding in cassava production and marketing to get the 150 farmers used for the study.

3.6 Inclusion and Exclusion of Respondents Criteria

3.6.1 Inclusion Criteria

a. The client must be households within the selected climate smart villages. These households can be adopters or non-adopters of climate smart technologies.
b. The client must have consented.

3.6.2 Exclusion Criteria

Those who will not be eligible to be part of the study include:

a. Households that are outside the Climate smart villages.
b. Clients who are mentally disturbed
c. Clients who will not consent to be involved in the study

3.7 Data Collection

3.7.1 Data collection authorization

The National Commission for Science, Technology, and Innovation (NACOSTI) granted research permit to this research, informed by approval from the Graduate School of Egerton University and the Ethical Clearance.

3.7.2 Data collection process

Data collection was done from January 2021 to July 2022. Data collection process was in four phases using mixed methods with questionnaire in baseline survey; FGD in learning forums and in identifying outstanding farmers in climate smart cassava innovation;

KII, secondary sources of information and case studies. Phase one was baseline survey using the questionnaire (Appendix 1) to map cassava production and marketing and innovation process. Identification of positive deviant farmers was integrated in household surveys and completed in a follow up FGD with stakeholders.

Each farmer visited during the survey was asked to name three other farmers who cultivate better cassava varieties in the community when completing the questionnaire. A respondent was then asked to name the one of the three farmers producing improved cassava varieties that they thought performed very well in terms of CSA cassava techniques, production, and productivity.

Some farmers in smallholder agriculture outperform their comparable peers who only achieve average performance when the production environment and circumstances are the same. Positive deviants (PDs) are used to describe the top performers, while typical farmers (TPs) are used to describe the average performers. This CSA practice phenomenon can be attributed to the more successful and effective use of CSA techniques that result in better performance indicators, in this case, achieving higher CSA triple wins, cassava production, marketing, and innovations. In order to find such PDs, this study involved key informants and peer farmers in a snowballing and validation process in FGD with stakeholders.

Each respondent was asked in an open-ended question during the questionnaire's administration why they had chosen that particular peer farmer as an exemplary performance. Then, without revealing the opinions of their fellow farmers, each of the selected top performers was tracked down for an on-farm visit and interview using the same questionnaire. Each of these exceptional performers went on to name one more outstanding performer and explain their selection criteria after identifying three farmers in the village who were cultivating enhanced cassava varieties. These were recorded in a free-form query..

A list of respondents who were singled out as great performers after the survey was completed was then created, and those who were cited the most frequently were isolated. A follow-up FGD of stakeholders was requested from the 30 people on this list who were mentioned at least three times. The actors in the value chain, extension personnel, and researchers from the public and private sectors who work in the Nyando Climate Smart Villages were present at this FGD session. The FGD sessions deployed ethnographic interviews through which stakeholders reached a consensus on farmers fitting a description of positive deviant (PD). Six farmers emerged and were described as the positive deviants, being those who had demonstrated an outstanding performance in uptake of cassava climate smart innovations in growing and marketing the crop, and were also realising outstanding production and productivity above their peers and comparable farmers in the village.

Phase two involved identifying the pertinent parties with whom to engage in addressing the farmer groups' capacity-building requirements for cassava production and marketing. The development of the learning forum, which served as the Agricultural Innovation System's platform for learning and co-creation, was informed by both the FGD and the KII throughout this phase. Phase three involved discussions about the farmers' capacity needs for innovation in cassava production and marketing. Participants in the cassava value chain were consulted.

Phase four involved reflection in a stakeholder workshop to talk about the results of the first three phases' experiences, qualitatively analyze the degree to which learning had taken place, and start improvements in cassava marketing and production. The implementation of reflection in the learning forum was guided by earlier suggestions (Conway, 1994; Schon, 1983; Schon, 1991). The cycle of recognizing a problem, gathering baseline data, introducing and executing change, and finally re-measuring the change, as described by Kurt (1958), was also followed in this reflection process.

3.7.3 Trends on use of climate smart cassava innovations by typical and positive deviant farmers

The data on trends in use of climate smart cassava innovation was for the period 2011 through 2020. This is in line with objective one, on the differences in use of climate smart cassava innovations since 2011 between typical and positive deviant farmers in the Nyando Climate Smart Villages In the household survey, each visited household indicated land allocation to improved cassava varieties, whether they had been sourcing certified planting materials, whether they had been practicing improved postharvest handling to reduce losses and whether they had been processing cassava products to increase market value.

Data on innovative climate smart "best bet" determined the differences between typical farmers and positive farmers in terms of, the size of land allocated to improved cassava varieties, increased cassava productivity, minimizing post-harvest losses and wastes, and increasing marketing of cassava. For size of land allocated to improved cassava varieties, the respondent indicated the size of their land under improved cassava varieties; while on increased productivity, the respondents were presented with a list of farming practices for which they were to indicate whether they had practiced (yes, no), when they started practicing (year) and whether had ever discontinued the practice (yes, no). To determine whether the respondents used certified cassava varieties, they indicated source of the varieties used and the particular variety. For increasing cassava post-harvest handling, respondents indicated whether they were practicing value addition (sorting, grading, packaging, polishing and milling). For increasing cassava marketing, respondents indicated the extent to which they agreed or disagreed with the statements presented to them about the potential of collective action to improve performance of both input and output markets. The degree of agreement or disagreement was captured in Likert scale (1=strongly disagree, 2=disagree, 3=indifferent, 4=agree, 5=strongly agree) and was used to distinguish the differences between the typical and positive deviant farmers.

3.7.4 The Abandoned Cassava Production and Marketing Practices by Typical and Positive Deviant Farmers in the Nyando Climate Smart Villages

This is in line with objective 2, of determining the differences in the abandoned cassava production and marketing practices by typical and positive deviant farmers. In the household survey, each visited household indicated the cassava production, postharvest handling, processing and marketing practices abandoned.

Data on innovative climate smart "best bet" determined the differences between typical farmers and positive farmers in terms of abandoned "Best Bet" cassava production practices, post-harvest handling, processing and marketing practices. For abandoned best bet cassava production practices, the respondent indicated the practices they no longer used; while on cassava post handling practices, the respondents were presented with a list of post-harvest handling practices for which they were to indicate whether they had practiced (yes, no), and cassava processing practices discontinued (yes, no). To determine whether the respondents used collective marketing practices for their cassava, they indicated whether they marketing cassava as a group or not. For increasing cassava marketing, respondents indicated the extent to which they agreed or disagreed with the statements presented to them about the potential of collective action to improve performance of both input and output markets. The degree of agreement or disagreement was captured in Likert scale (1=strongly disagree, 2=disagree, 3=indifferent, 4=agree, 5=strongly agree) and was used to distinguish the differences between the typical and positive deviant farmers.

3.7.5 Cassava Production Gains Realised by Positive Deviant Farmers and Typical Farmers

Data on the gains realized from adopting cassava innovations by normal and positive deviant farmers were gathered during the survey. Gains included increased productivity, food security, adaptation, and climate mitigation. A farmer was given a list of 13 farm products and 14 cassava products to indicate which ones they had been producing in their own or rented farms during the previous 12 months in order to diversify their produce.

Data on adaptation differences relate to farming practices that have changed since 2011. Data on food security was collected for a normal food year, and households indicated that they frequently found themselves lacking enough food for their family to consume each month. Since 2011, when CSV was first used, data on cassava intensification has been based on seven (7) potential adjustments in input to the cassava crop. Cassava yield (Kg/acre) and the percentage of this produce that was consumed at home and sold were the metrics used to measure productivity.

3.7.6 Relative Importance of the Seven Functions of Innovation Systems

During a study of farm households, information was gathered to determine the relative value of the seven roles of innovation systems in supporting cassava innovation. The seven roles of the innovation system were covered in a section of the questionnaire (Iizuka & Gebreeyesus, 2016; Kao *et al*., 2019). These seven roles knowledge development, knowledge diffusion, entrepreneurship, market formation, direction of the search, resource mobilization, and support from advocacy coalitions are described in Table 3.1. Projects, programs, and policies put in place to support and facilitate the growth of the cassava innovation system as a technological innovation are referred to in this study as innovation system functions.

The Best-Worst scaling (BWS) method involved giving respondents various options and asking them to select the best (most important) and worst (least important) solutions in order to gather data on the relative relevance of each of the seven functions of innovation systems. As opposed to the profile and multiple cases BWS, the object case BWS was chosen for this study since the analysis aimed to determine the relative significance of each of the seven functions of innovation systems. When given a choice set with three possibilities for each of the individual functions of the innovation systems, it was simpler for respondents to select the extremes they associate with the best (most important) and worst (least important) among the functions. Evaluating the extremes allows the respondents better judgement of the presented objects (Marley & Louviere, 2005), reduces scale-use bias compared to Likert scales (Erdem *et al.*, 2012) and allows for better discrimination of scale items and better interpretation of the computed relative importance.

Table 3.1: Definitions of the seven functions of innovation systems

No.	Function	Definition
1	Knowledge development	Farm demonstrations of technologies for cassava production and processing
2	Knowledge diffusion	Strengthening extension services in disseminating knowledge on cassava production and processing.
3	Entrepreneurship	Promoting entrepreneurship orientation in cassava production and processing and trading
4	Market formation	Policies that are directed to developing cassava value chain
5	Guidance of the search	access to markets where cassava goods are in great demand
6	Resource mobilization	For the purpose of supporting the production, processing, and trading of cassava, there is access to credit that is inexpensive.
7	Support from advocacy coalition	strengthening farmer organizations and service providers in the cultivation, processing, and trade of cassava

The choice set was a combination of choices created in a balanced incomplete block design (BIBD), in which each choice set and combination of each choice set appeared the same number of times in all choice sets. The respondent was asked to choose one best (most significant) function and one worst (least essential) function from each choice set, which contained three of the seven functions of innovation systems. A combination of each innovation system's functions also featured once, for a total of three appearances for all options. Table 3.2 illustrates a choice set presented to the respondents. The design follows v innovation functions denoted by (c, r, z, λ), where c is the number of blocks, in this case the choice sets, r is the number of repetitions per level, z is the block size, in this context the number of objects in every choice set, and λ is the pair frequency.

Following Louviere *et al.*, (2015), the design of the survey questions should satisfy equation:

$$c \times z = v \times r$$

The length of the questionnaire and number of questions was determined by the seven functions in a design structure of 7, 3, 1, which denotes that for the seven choice sets, one attributes appeared only once in a choice set for a maximum of three times in all the choice sets.

Prior to being presented each choice set, the choices were explained to the respondents to make them understand the most important and least important innovation functions before providing their responses. Thereafter, each survey respondent was asked to choose the most important innovation function and the least important innovation function from each choice set. The process was repeated for all choice sets.

Table 3.2: Sample Best-Worst choice set presented to respondents

Most important (**B**)	Innovation Function	Least important (**W**)
[ ]	Knowledge Development: Farm demonstrations of technologies for cassava production and processing	[ ]
[ ]	Access to markets where cassava products are in high demand is a search strategy.	[ ]
[ ]	Advocacy coalition support: strengthening farmer organizations and service providers in the cultivation, processing, and trade of cassava	[ ]

3.7.7 Formation of the Collaborative Learning Forum to Improve Cassava Production, Postharvest Handling and Marketing

A collaborative learning forum was established to improve cassava production and marketing practices in Jimo East village and to strengthen participatory learning specifically to improve on portfolio of promising innovations earlier introduced in the Nyando CSV. The strengthening in participatory learning was a response to differential uptake and benefits evident among cassava producers, as observed in the reports of Kinyangi *et al.* (2015), Njogu (2020) and in Recha *et al.* (2017). This was expected to result into improved cassava production, post-harvest handling and marketing practices among the households

Formation of a collaborative learning forum was initiated in a joint workshop organised with key stakeholders along the cassava value chain (farmers, research institution, input service provider, government service providers, traders and CCAFS) in Nyando sub-county. In the learning forum were 28 farmers (two from each of the 11 villages of Jimo East and six outstanding cassava farmers in the village). These were purposely identified and selected for capacity building and transfer of knowledge and skills on improved cassava production and marketing and CSA technologies and innovations. Participating stakeholders in the learning forum were mostly those who had entered CSV at the introduction stage and included research, extension, CCAFS, Ministry of Agriculture (Cooperative), farmer, trader and MAGO (Input service provider).

By establishing a learning forum, the researcher aimed to purposely catalyse action learning, provide technical backstopping, foster collaboration, facilitate connectivity among actors and create opportunities for peer-to-peer learning between members. The learning forum was the equivalent of Innovation Platform, which fosters interactions between stakeholders and contributes to jointly identifying and solving challenges as well as exploring opportunities (Cadilhon, 2013). Interactions in the learning forum was facilitated through communication, negotiation, information sharing in face to face meetings where participants developed action plans. As established, the learning forum thus aided the process of action learning tailored to addressing challenges flagged in the baseline survey. The challenges addressed in the collaborative forum were improvements in crop-smart, postharvest-handling-smart and market-smart innovations.

After a year of participatory learning engagement, a FGD was organised with stakeholders and beneficiary farmers to document improved learning in three areas of innovation selected for this study: crop-smart, postharvest-handling-smart and market-smart innovations. In a FGD, cassava producers self-scored the degree of improved knowledge, skills and competency in these three innovation areas on a Likert scale of 1 (very low) to 5 (very high) comparing their situation before and after the yearlong participatory learning engagement.

3.8 Data Processing and Analysis

Data processing and analyses performed were to answer five research questions defined in the study. Three of these five analyses were comparative to determine differences between positive deviant farmers and typical farmers. The differences were on trends in the use of climate smart cassava innovations in production, post-harvest handling and marketing; the differences in the abandoned best bet cassava production, post-harvest handling and marketing practices; differences in gains realised from the cassava production, post-harvest and marketing innovations such as production diversification, adaptability, food security, productivity and climate mitigation realised from use of cassava innovations; and innovative climate smart "best bet" practices for increasing productivity, minimizing post-harvest losses and waste, and increasing marketing of cassava. One analysis determined the relative importance of each of the seven functions of innovation systems in supporting fostering cassava innovation. The last analysis was descriptive documentation of improvements in cassava production and marketing initiated through a collaborative learning forum. Each of these are subsequently described in the next sections.

3.8.1 Characterising Trends in use of Climate Smart Cassava Innovations

The analysis was to answer whether there have been substantial trend differences between positive deviant farmers (PDs) and typical farmers (TPs) in land allocation to improved cassava varieties, and use of certified planting materials, improved postharvest handling to reduce losses and processing cassava products to increase market value.

The trend was illustrated by computing average acres of land allocated to cassava for PDs and TPs then plotted over the years. The use of certified planting materials, improved postharvest handling and processing cassava products were binary responses (yes or no). So, frequency counts were generated in cross tabulation then yearly trend plotted for PDs and TPs. Analysis by plotting of the trends over the years was used because there were small frequency counts of PDs versus TPs (6 vs. 144) for meaningful and informative inferential statistical test for differences between PDs and TPs.

3.8.2 Identifying the Abandoned Innovative Climate Smart "Best Bet" Practices

Analysis was to find whether positive deviant farmers and typical farmers were significantly different in climate smart practices in cassava production, in particular innovative climate smart "best bet" practices for increasing productivity, minimizing post-harvest losses and waste, and increasing marketing of cassava. The differences between typical farmers and positive deviant farmers in what is innovative climate smart "best bet" practices for increasing productivity were identified by computing dis adoption rates for input intensification, land and soil management, and cropping systems. Dis adoption rate is the proportion of farmers stopping the practice after practicing for some period of time. In this study, zero dis adoption rate indicated that the practice was innovative climate smart “best bet” for farmers; otherwise the practice was not innovative climate smart “best bet” for farmers.

The differences between typical farmers and positive deviant farmers in what is innovative climate smart “best bet” practices for minimizing post-harvest losses and waste of cassava was computed as percentage of farmers practicing value addition (sorting, grading, packaging, polishing and milling). The differences between typical farmers and positive deviant farmers in what is innovative climate smart “best bet” practices for increasing cassava marketing was compared by computing a weighted index from the frequency counts of the degree of agreement. The frequency of strongly disagree was multiplied by 1, frequency of disagree was multiplied by 2, frequency of indifferent was multiplied by 3, the frequency of agree was multiplied by 4, and the frequency of strongly agree was multiplied by 5. The summation of these products was divided by the total frequency counts of respondents for all the levels of agreements.

3.8.3 Determining the Gains realised in Cassava Production, Post-harvest Handling and Marketing due to Climate Smart Cassava Innovations

The analysis was to find out whether positive deviant farmers and typical farmers realize differential gains in production diversification, adaptability, food security, productivity and climate mitigation from use of climate smart cassava innovations. These gains are also referred to as triple wins of CSA. For clarity, the computational process for each index is explained in the subsequent paragraphs.

For production diversification, food security, adaptability and intensification, a weighted index score was computed adapting the scoring approach used in CCAFS’s baseline surveys (Mango *et al.,* 2011; Yen *et al.,* 2015). Depending on the index being computed, the scoring was either in three or in five classes and reflected an increasing magnitude. Because PDs were fewer (n=6) as compared to TPs (n=144), an index was preferred to fairly compare these two groups of farmers for the gains they realized from cassava innovation.

A production diversification index for the entire farm was calculated using the scoring method used in the CCAFS baseline surveys, and a cassava diversification index was calculated using the scoring method used in the 14 possible products that farmers reported producing in the previous 12 months. One to four (1 to 4) product production was rated as low production diversification and received a score of 1, five to eight (5 to 8) product production was rated as intermediate production diversification and received a score of 2, and nine or more (≥ 9) product production was rated as high production diversification and received a score of 3.

The frequency counts of the households were then used to calculate a weighted index of diversification. The frequency counts for households with scores of 1 were multiplied by 1, those with scores of 2 were multiplied by 2, and those with scores of 3 were multiplied by 3. The resulting product number was then divided by the total of the frequency counts for all the score classes. The index (I_i), which is a weighted average of all scores for a specific indicator linked with practicing CSA, was generated from the scores using the formula:

$$I_i = \frac{Score\ class\ (1\ to\ 5) * Frequency\ counts\ for\ each\ score\ class}{Sum\ of\ frequency\ counts\ for\ all\ the\ score\ classes}$$

The same formula was used to calculate the intensification, adaptability, and food security indices. The frequency counts of changes in farming practices implemented since 2011 were used to calculate the adaptability index for the farm and cassava crop. Changes in practices that were zero or only one (≤ 1) were classified as low adaptability and scored one; changes in practices that were two to ten (2 to 10) were classified as intermediate adaptability and scored two; and changes in practices that were eleven or more (≥ 11) were classified as high adaptability and scored three.

The number of months that a household typically lacked adequate food for the family to consume was used to calculate the food security index for a typical food year. These were graded in five categories: hunger lasting more than six months in a year received a one, hunger lasting between five and six months in a year received a two, hunger lasting between one and two months in a year received a three, and hunger lasting no time at all received a five. The increasing magnitude indicated that food security in the homes was improving. A household was defined as a group of individuals who formed a family and regularly ate in the same residence for the previous 12 months prior to the survey. Since 2011, when CSV was first implemented, seven (7) variations in input in cassava have been used to calculate the cassava intensification index. No intensification was assigned to a farmer who indicated no change in input use, low intensification was assigned to those who changed one to three inputs (1-3), high intensification was assigned to those who changed four to seven inputs (4-7) and was assigned a score of 3. Indices for productivity and mitigation were calculated differently. The productivity index was calculated using the difference in yield of cassava (Kg/acre) between PDs and TPs as well as the percentage of this production that was sold and consumed at home. Positive difference showed that PDs outperformed TPs in performance.

3.8.4 Assessing the Relative Importance of the Seven Functions of Innovation Systems

The goal of the analysis was to determine the relative significance of each of the seven innovation system functions that promote the spread, acceptance, and scaling of cassava innovations in the Nyando CSV. Using the Best-Worst scaling (BWS) decision approach, a relative importance was calculated. The BWS choice technique makes the assumption that the distance between the "Best" and "Worst" items on the scale of importance is related to the likelihood that a farmer will select a pair within a given option set. The calculation of the relative relevance of each of the seven functions of the innovation system was done sequentially, in accordance with Jin *et al.* (2020) methodology.

To get the total best (most important) and total worst (least essential), it was first necessary to tally the number of times each function was chosen as the most and the least important. The B-W scores were then calculated by deducting the total worst from the overall best. A positive value meant that the function was chosen as the most crucial one more often than it was the least crucial one. Thirdly, the BW scores were standardized by dividing the B-W difference by the aggregate frequency counts by three, where each choice appeared three times while a combination of each innovation system function only once. The square root of (B/W) was used to calculate the relative relevance for each of the seven functions of innovation systems. After that, the square root (B/W) was scaled so that the item with the highest square root (B/W) was set to 100% for importance. The relative square root (B/W) ratio of each item is then used to compare them to one another. The percentage indicating the relative importance of each of the seven innovation system functions can be understood as the probability of that function being selected as the most crucial.

The BWS analysis was expanded to include econometric analysis to calculate the likelihood that farmers would choose each of the seven functions. The presumption is that a respondent must choose among a continuum of pairs of innovation system functions, from best to worst. The difference between the "best" function of innovation and the "worst" function of innovation on the best-worst important scale directly relates to the likelihood that a pair of functions will be selected. The respondent first identify all possible pairs from a set of J innovation functions from $J(J-1)$ possible pairs of best-worst to evaluate the difference of importance for each pair of functions. The respondent is then expected to select from among the seven potential best-worst combinations the one that maximizes the difference between the best and worst function in importance. In this manner, the respondent selects the two functions that differ the most, resulting in an unobservable latent variable that may be deduced as:

$$D_{bw} = \delta_{bw} + \varepsilon_{bw}$$

Where D_{bw} is the difference between the best and worst functions on the underlying BWS, whereas ε_{bw} is the stochastic error term. Thus, the probability that a farmer chooses the best and worst pair repetitively for t number of times is given as:

$$\mathrm{P}(bw/t) = \mathrm{P}\left(\delta_{bw} + \varepsilon_{bw} > \delta_{ij} + \varepsilon_{ij}\right)$$

Where $ij \neq bw$ for possible choices. An assumption is made that bw is an independent and identically distributed random variable, making the probability that chooses the best and worst pair repetitively a multinomial logit function written as:

$$\mathrm{P}(bw/t) = \frac{\exp\left(\delta_{bw}\right)}{\sum_{ij}\exp\left(\delta_{ij}\right)}$$

Where also $ij \neq bw$ for all possible choices. Thus, a change in functional form results in difference between best and worst choices on the scale of importance of the seven functions of innovation systems to be denoted as:

$$\delta_{bw} = \beta_b - \beta_w$$

In this study, the multinomial logit was used to estimate the probabilities that a farmer chooses the best and worst pairs t number of times using the explained expressions now expressed as:

$$\mathrm{P}(bw/t) = \frac{\exp\left(\beta_b - \beta_w\right)}{\sum_{ij}\exp\left(\beta_i - \beta_j\right)}$$

The significance of the seven functions in promoting cassava innovations was assessed using shared importance because interpretation of multinomial logit model coefficients is not always simple. According to Lusk and Briggeman (2009), the likelihood that one item from a continuum would be chosen as the most significant is known as shared importance or preference. The share of importance is therefore defined as:

$$\text{Share of importance} = S_i = \frac{e^{\hat{\beta}}}{\sum_{m=1} e^{\hat{\beta}_m}}$$

Where $\hat{\beta}_i$ is the predicted probability that function i is selected as most important in fostering cassava innovation. The seven functions' combined relevance is one, demonstrating how significant a function is in stimulating cassava innovation relative to other functions.

3.8.5 Documenting Learning initiated through Collaborative Learning Forum to Improve Cassava Production, Post-Harvest Handling and Marketing

Analysis was to document the extent to which collaborative learning forum improved learning among farmers about cassava production, postharvest handling and marketing innovations. The extent of improved learning was obtained by comparing the degree of improved knowledge, skills and competency before and after a yearlong participatory learning engagement. An average index score was computed from the self-scored degree of improved knowledge, skills and competency in a Likert scale of 1 (very low) to 5 (very high) for before and after collaborative learning engagement. For clarity of comparison, the average index score of after collaborative learning was subtracted from the average index score of before collaborative learning. A positive value of the resulting difference after-before index score indicated that improved knowledge, skills and competency had occurred through collaborative learning engagement in the forum that was established in the climate smart villages.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results obtained from the analysis of survey data, Focus Group Discussion, Key informant interviews and collaborative learning initiatives. The chapter is presented in six sections, with first section (4.1) presenting a description of the sample characteristics. The five subsequent sections from two through six reports the findings for each of the five research questions of the study. Section two (4.2) reports the trends in the use of climate smart innovations while section three (4.3) abandoned cassava production, post-harvest handling and marketing, section 4.4 reports on gains realised due to climate smart cassava innovations such as the production diversification, adaptability, food security, productivity and climate mitigation realised from use of cassava innovations, which include the innovative climate smart "best bet" practices used to increase productivity, minimize post-harvest losses and waste, and increase marketing of cassava. Section 4.5 presents the relative importance of each of the seven functions of innovation systems in supporting fostering cassava innovation in the Nyando climate smart villages. The last section 4.6 documents improvements in cassava production and marketing initiated through a collaborative learning forum, which was established in Nyando Climate Smart Villages.

Farmers demonstrated awareness of recognising positive deviance behaviour amongst their peers. At least seven in ten could identify an outstanding farmer (positive deviant) using climate smart cassava innovations and interacting with them, more frequently on accessing improved cassava cuttings. As a result, better cassava varieties are currently grown by more than half of farmers (51%) and nine out of ten farmers (91%) are implementing climate wise cassava methods in their cassava farms. A response to the dangers brought on by climate change and variability is the growing of enhanced cassava cultivars. More unpredictable rainfall, infertile soil, and frequent droughts are of greatest worry to at least eight out of ten farmers, whereas high temperatures, a rise in disease incidence, and more frequent floods are of concern to at least five out of ten farmers.

Cassava plays important roles in rural households' livelihoods, as shown by farmers' desires to increase yields in order to sell surplus at higher prices and ensure their own food security. This farmers' aspiration reflects the roles that good deviant farmers are expected to play in the community to bring about the necessary improvements in cassava production and marketing. The positive deviant farmers' successes offer insights that teach development professionals how to encourage cassava innovation and deliver the advantages of climate savvy cassava inventions.

4.2 Descriptive Characteristics of Sampled Farmers

4.2.1 Socio-Demographic Characteristics

Table 4.1 lists the sample farmers' sociodemographic characteristics. The sample farmers that were acquired were older (>35 years), with women outnumbering men (57 to 43%). The majority (82%) had completed at least their first year of formal education, and farming accounted for 67% of primary sources of income. Eighty-seven percent (87%) of the time, the household head made the decision to cultivate cassava. About a quarter (26%) of the farmers grew both local and improved cassava varieties, whereas 50% of the farmers grew improved cassava types.

Table 4.1: Socioeconomic characteristics of respondents by type of farmer

Variable	Pooled (N=150)	TYP (n=144)	PD (n=6)	*P*
Sex of farmer (%)				
Female	56.67	56.25	66.67	0.698
Male	43.33	43.75	33.33	
Percent of male-headed households	69.33	69.44	66.67	0.885
Mean age of household head	55.01	54.70	62.5	0.156
	(13.17)	(13.13)	(12.86)	
Marital status (1=Married, 0 otherwise)	75.33	75.69	66.67	0.848
Educational attainment (%)				0.371
No formal education	18	18.75	0	
Primary	49.33	47.92	83.33	
Secondary	29.33	29.86	16.67	
Post-secondary	3.33	3.47	0	
Farming as main occupation (%)	66.67	65.97	83.33	0.377
Household size	6.40	6.37	7.17	0.522
	(2.98)	(3.01)	(2.23)	
Farm decision maker (%)				0.013
Head	92.67	93.75	66.67	
Spouse	7.33	6.25	33.33	
Total land size owned by household	3.11	3.06	4.33	0.110
	(1.91)	(1.88)	(2.28)	
Total cropped land	2.52	2.47	3.83	0.035
	(1.58)	(1.40)	(3.76)	
Area under improved cassava	0.50	0.49	0.63	
	(0.44)	(0.30)	(0.21)	
Member of climate smart village (%)	88	87.5	100	0.356
Number of years of group membership	7.48	7.49	7.33	0.905
	3.16	3.16	3.44	

Note: *Standard deviation provided in parentheses*

4.2.2 Membership to Climate Smart Village and Group Activities

Being a member of a group is a crucial step in the innovation process for the Nyando CSV's on-farm testing, co-development, adoption, and promotion of cassava innovation. Members of the Agricultural Innovation System (AIS), a group of interactively involved actors, start, import, modify, and disseminate information. The membership of Climate Smart Village groups and their involvement activities are summarized in Table 4.2.

The survey explored the respondents further to learn about the kind of group activities they participate in. In terms of those practising both local varieties, 42% were engaged in crop production group activity while 40% of those practising local varieties were actively involved in group livestock production activities. The majority (36%) of farmers who practiced local and improved varieties were engaged in vegetable production group activities. One potential explanation is that the group decided to try out different types of vegetables before deciding which to engage in totally as a group.

With group membership being critical and informative to its members through access to credit and finances, 40% of those practicing improved varieties were engaged in savings and credit activities in their groups. Lastly, 42% of the farmers who were practising both local and improved varieties were actively engaged in nursery/tree planting activities within their groups. Of all the respondents interviewed, those practising both local and improved varieties had been members of a group for close to 9 years, while those practising improved varieties and local varieties had subscribed to a climate smart group membership for at least seven years.

Table 4.2: Membership to Climate Smart Village Groups and activities of engagement

Membership	Indicators	Local varieties	Improved varieties	Local and improved varieties
Group membership (%)	No	22.2	72.2	5.6
	Yes	22.7	48.5	28.8
Group activities (%)	Crop production	41.6	31.8	26.6
	Livestock production	40.0	28.7	31.3
	Vegetable production	29.6	34.6	35.8
	Saving and credit	25.1	39.9	35.0
	Nursery/tree planting	24.7	33.1	42.2
Membership	Years	7.3	7.0	8.5

4.2.3 Positive Deviant Farmers in Cassava Production

Analysis of the farmers regarded by their peers as excellent cassava farmers using CSA methods was done in order to understand the function of positive deviance behaviour in encouraging development of climate-smart cassava innovations in the Nyando CSV (Table 4.3). The findings show that 68.7% of the farmers who responded to the survey had at least one farmer who they thought used climate smart cassava technologies to an exceptional level. At least eight out of ten (82%) of these farmers said they interacted with the exceptional farmers. Other agronomic approaches came up more frequently (51.2%) in conversations with the exceptional farmers.

4.2.4 Positive Deviance Behaviour

Positive deviants are individual farmers who outperform their average counterparts while working within the same limits and resources. Shija *et al.* (2022) in a study of smallholder dairy farming in Tanzania applied positive deviance concept but with a narrower definition of positive deviants. In their study, they defined true positive deviant as those who consistently outperform their peers above threshold points in standard deviation units on five performance indicators simultaneously. Though their approach varies from the present approach, positive deviants in that study and the present study are those outperforming their peers under same production circumstances. Through their outstanding performance in use of the innovations, positive deviant farmers are source of viable solutions present within the local farming community. This is relevant in smallholder farming systems where multiple challenges impede implementation of innovations packaged by researchers (Toorop *et al.,* 2020).

Due of their success with the innovations locally, positive deviants offer concrete evidence of the innovations' feasibility in the area. Because it encourages learning and scaling of the innovations, this has a local advantage in enhancing smallholder response to the continuously changing and unpredictable climate. Positive deviants outperform their counterparts in performance by utilizing cutting-edge techniques and technologies (Shija *et al.,* 2022). This innovativeness is a valuable source innovations that are scalable and tailored to local farming circumstance (Bradley *et al.,* 2009).

Bringing about change often proves difficult due to complexity of the process and vested interests among key stakeholders. However, this can be solved by positive deviant farmers who demonstrate that it is possible to come up with viable solutions towards implementation of new improved innovations. Results revealed that positive deviant farmers accrued several benefits from cassava innovations as opposed to typical farmers. The deviant farmers are believed to have some better viable solutions to fostering cassava innovations in Nyando CSVs. By being a central force to initiating innovational changes, positive deviance behaviour has empowered cassava farmers to be productive and be innovative catalysts. Therefore, cassava innovations require farmers who demonstrate positive deviance behaviours who are more creative, are entrepreneurial oriented and are innovative.

Among the positive outcomes posted by the positive deviant farmers were increase in both land allocated for planting to improved cassava varieties and productivity. Due to training received on improved cassava varieties and knowledge of its benefits, positive deviant farmers increased their allocation of land to cassava farming. Additionally, they used improved cassava planting materials during their planting which subsequently led to higher production yields. Shija *et al.* (2022) who found out that positive deviant farmers invested in more farm inputs documented these results. However, the same study, ibid, established that fewer positive deviant farmers had managed to attain higher productivity relative to other farmers. This in turn meant that most of the farmers did not enjoy the benefits of improved livelihoods. Nonetheless, positive deviance behaviour equips farmers with adequate knowledge on a new improved technology which further fosters its uptake. For cassava innovations to pick up at a fast rate therefore, there is need for farmers in Nyando CSV to embrace the behaviour in order to adopt the new cassava varieties.

Accordingly, this led to high consumption patterns among positive deviant farmers and increased food security. As production yield increase, the farmers harvest enough cassava to feed themselves and the local market around. This increases their consumption level of cassava successively leading to improved food security following a continuous flow of food supply. Early maturing improved cassava varieties provide a continuous food supply to farmers. This avails them with the cassava product to consume as well as market. Due to the positive deviance nature, these farmers have developed an entrepreneurial mindset of innovating end products such as chips, porridge flour and snacks from the cassava. As such, they are able to actively market their products and sell them to consumers which leads to increase in household income and improvement in livelihoods.

Steinke *et al.* (2019) established similar results that as through the positive deviance approach, there has been a spur in livelihood improvement following increased farmer income through sale of cassava products. Additionally, their study revealed that positive deviant farmers were using improved cassava variety cuttings which further improved their farm productivity. Padmaningrum *et al.* (2019) documented similar findings that indeed positive deviance behaviour among farmers leads to entrepreneurial mindsets which further improves their farm productivity.

Product quality improvement was predominant among positive deviant farmers relative to typical farmers. Arguably, positive deviant farmers are more than likely to appreciate cassava product innovations when given freedom to try out new product quality improvements as opposed to being forced into various program fits. By deviating from the norm, farmers exercising positive deviance use their own ideas and insights to come up with entrepreneurial products from the cassava food crop. Similar results were established by Kibirango *et al.* (2017); Mayanja *et al.* (2019) who postulated that positive deviance behaviour among employees enabled them to think out of the box, perform their duties way better from the organizational norm and brought out innovative mindsets as opposed to other employees. As such, positive deviant farmers are able to develop new product ideas aimed at product quality improvements which is not common among cassava farmers in Nyando CSVs.

As mentioned above, positive deviance behaviour has been a centrifugal force in fostering cassava innovations among Nyando CSV farmers. They have initiated innovative minds, entrepreneurial skills and established effective ways of embracing improved cassava varieties in the community. This has also seen them being a community resource making other farmers acknowledge them as outstanding and borrow ideas on cassava farming from them such as improved cassava cuttings for planting. Positive deviance approach has brought about cassava farming as a positive nuance making typical farmers learn from their counterparts/positive deviant farmers hence expectations are that they will be able to embrace cassava innovations.

Table 4.3: Outstanding farmers growing improved cassava varieties as identified by peer fellow farmers

Engagement with outstanding cassava farmers	Indicators	Frequency	Percentage (%)
Are there any great cassava farmers in your opinion? (n=150)			
	No	47	31.3
	Yes	103	68.7
Do you communicate with those exceptional farmers? (n=103)			
	No	19	18.4
	Yes	84	81.6
Interactions with exceptional farmers typically involve (n=84)			
	obtaining better cuts	23	27.4
	using only approved clippings	5	6.0
	combining other crops with your own	4	4.8
	Cover crops and mulching	4	4.8
	marketing for cassava	3	3.6
	fertilizer use	2	2.4
	additional agronomic factors	32	51.2

4.2.5 Reasons for practicing Climate Smart Cassava Production

The justifications for each farmer's adoption of climate smart cassava techniques are listed in Table 4.4. According to the findings, nine out of ten (91%) of the sample's responding farmers engaged in climate wise cassava farming practices. Eight out of ten of those using climate-smart cassava production methods reported more erratic rainfall, infertile soil, and frequent droughts, while five to six out of ten cited high temperatures, high disease incidences, or frequent floods as key factors. For market related reasons, better yields is the most important reason to practice climate smart agriculture in cassava production while at least six in ten indicate opportunities to sell and better price being important reasons for engaging in climate smart cassava production.

Table 4.4: Reasons for practicing climate smart agriculture in cassava growing

Reasons for practicing CSA	Indicators	Frequency	Percentage (%)
CSA practices in cassava production?	Yes	136	90.7
	No	4	9.3
Climate change related reasons (n=136)	More erratic rains	110	80.9
	Soil infertility	111	81.6
	Frequent droughts	109	80.2
	High temperature	80	58.8
	High disease incidence	67	49.3
	Frequent floods	61	44.8
Market related reasons (n=136)	Better yields	130	95.6
	Opportunities to sell	88	64.7
	Better price	84	61.8

The reasons for growing cassava as self-declared by individual farmers on a scale of 1 to 5 reflecting the degree of agreement (01=strongly disagree; 02=Disagree; 03=Not sure; 4=Agree; 05=Strongly agree) with different reasons is summarised in Figure 4.1. The weighted average score reveal that attaining food security and drought tolerance were more important reason for climate adaptation, while earning cash income was the most important reason for increasing productivity. For mitigation of climate change, controlling soil erosion and conserving soil fertility were both of equal importance to farmers in growing improved cassava varieties.

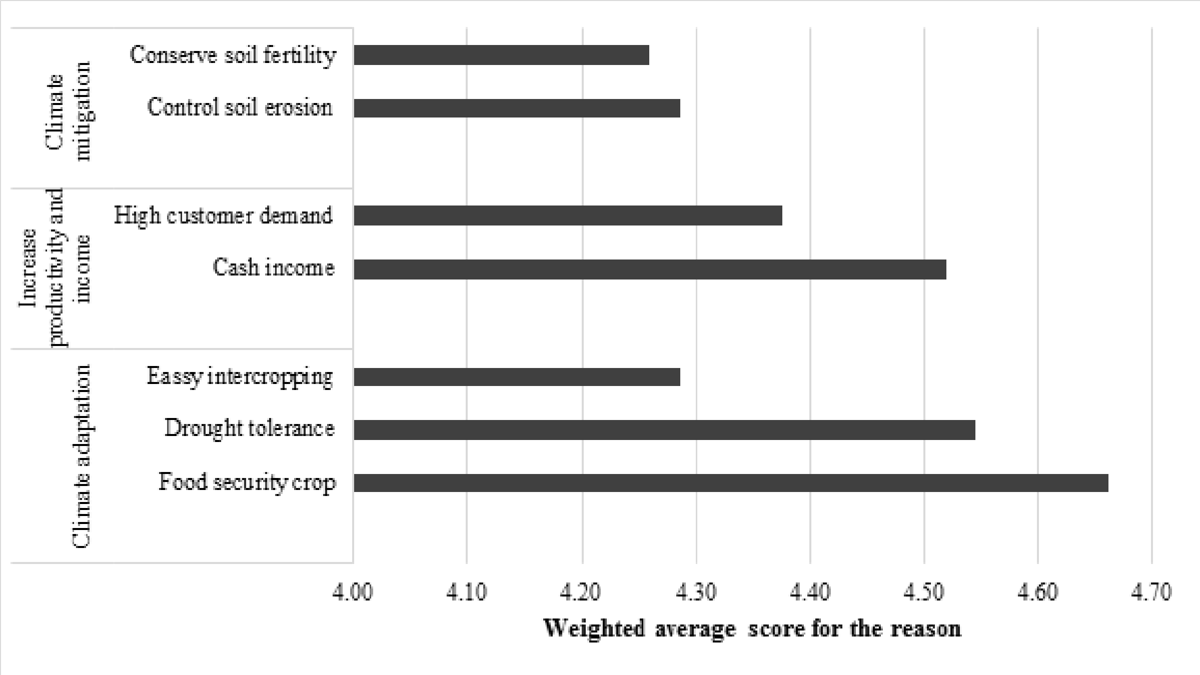

Figure 4.1: Weighted average score (1 to 5) for reasons for growing improved cassava varieties

4.3. Objective One: Trends in Use of Climate Smart Cassava Innovations by Typical and Positive Deviant Farmers in the Nyando Climate Smart Villages

4.3.1 Trends in Land Allocation to Growing Improved Cassava Varieties

The analysis was to answer whether there had been a marked trend differences between positive deviant farmers (PDs) and typical farmers (TPs) in land allocation to improved cassava varieties and use of certified planting materials, improved postharvest handling to reduce losses and processing cassava products for the purpose of increasing market value. Figure 4.2 illustrates the yearly trends in acres of land allocated to growing local and improved cassava varieties by positive deviant and typical farmers. The trend reveals a marked difference between positive deviant and typical farmers in the land allocated to improved cassava varieties.

Typical farmers have maintained same size of land allocation to local cassava varieties except for the year 2019 where there was a steady increase in land allocated to local cassava varieties. The typical farmers have also been steadily increasing land size allocated to improved cassava varieties annually. In contrast, positive deviant farmers reduced the land allocated to local cassava varieties, replacing it with increased land allocation to improved cassava varieties. Further, both typical and positive deviant farmers have increased the land allocated to production of improved cassava varieties. However, typical farmers increased land allocation from 0.26 acres in 2011 to 0.55 acres in 2020, while their counterpart positive deviant farmers, increased land in the same period from 0.25 acres to 0.58 acres in 2014 and have remained so through to 2020.

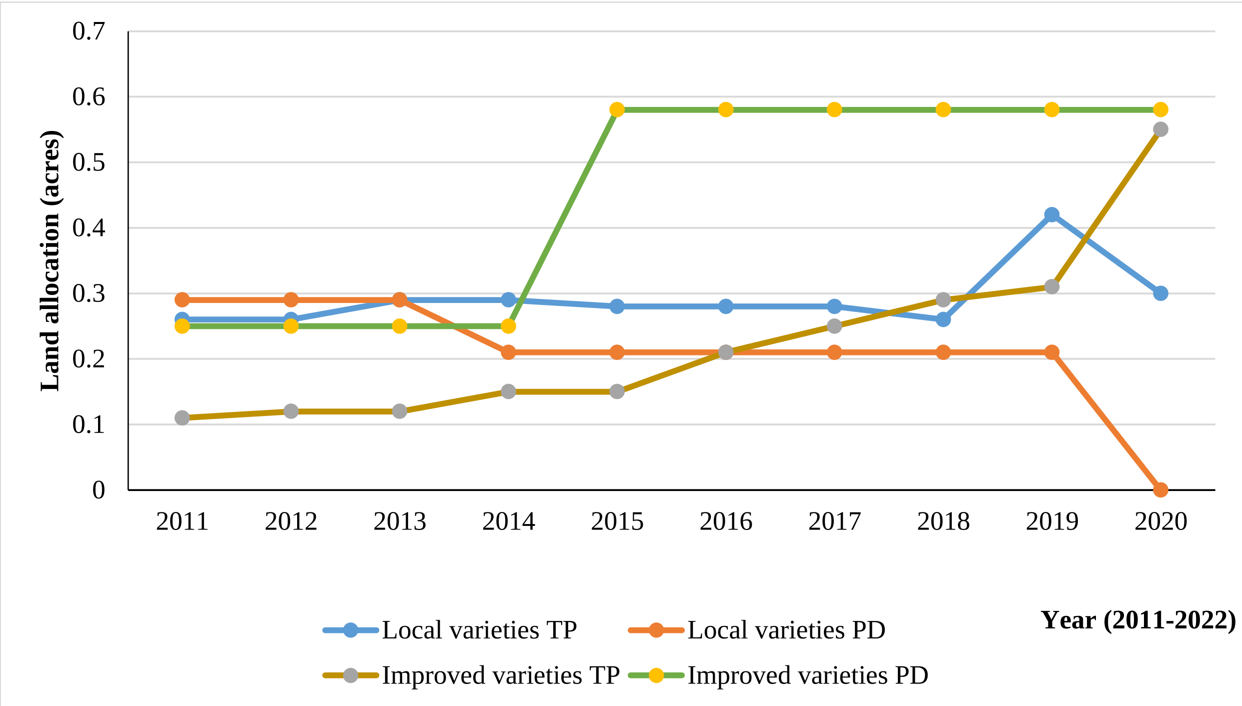

Figure 4.2: Yearly trends in acres of land allocated to growing local (Locvar) and improved (Impvar) cassava varieties by positive deviant (_PDs) and typical (_TPs) farmers

Plate 1 shows a well-prepared field by one of the study farmers which is ready for planting improved cassava variety, in the Nyando Climate Smart Village.

Plate 1: Well prepared field ready for planting cassava cuttings

Photo taken by Paul Tana on 18th February 2021

In the Learning Platform, farmers were capacity built on proper land preparation for planting cassava cuttings. Positive deviant farmers, whose cassava yields were appreciated and found by other farmers as good, were used during capacity building other farmers in the Learning Platform in training their peer farmers on proper land preparation. Since the identified positive deviants are farmers emanating from the study area, the study found it appropriate to use them during capacity building of the other farmers as they enjoy the same environmental conditions and resources with their peer farmers. They are also individuals or groups with uncommon behaviours who, while having access to similar resources, find better solutions to challenges than their fellow framers and this case, proper land preparation for planting cassava cuttings. In this study, the identified Positive deviants were using non-traditional or innovative methods to remedy obstacles that affect them and other members of their community. This concurs with what Gluecker *et al.* (2021) found in their project "Searching for Positive deviants among Cultivators of Rain-fed Crops in Niger". It emerged during the focus group discussion that majority of the farmers were ploughing against the contour, a practice that contributed heavily on soil erosion in the study area. Based on that, during the training of farmers in the Learning Platform, emphasis was more on ploughing along the contour to help in soil and water conservation, which is one of the problems the study area suffers from.

4.3.2 Trends in use of Certified Planting Materials, Improved Postharvest Handling and Processing Cassava Products

Figure 4.3 illustrates yearly trends for the typical farmers while Figure 4.4 illustrates for positive deviant farmers the number using certified cassava planting materials, improved postharvest handling and processing cassava products. Results reveal that number of typical farmers using certified cassava planting materials increased substantially in 2020. On the other hand, the use of practicing improved postharvest handling and processing of cassava products among the typical farmers has been varying across the years. The results indicate that for the years 2011, 2015, 2019 and 2020 there has been increased usage in the practicing of improved postharvest handling and processing of cassava products while for the rest of the years there was a decrease. The trends for positive deviant farmers show similar pattern to that of typical farmers, except that they started using certified cassava planting materials one year earlier in 2019 compared to typical farmers and all the two categories of farmers practice improved postharvest handling and processing of cassava products.

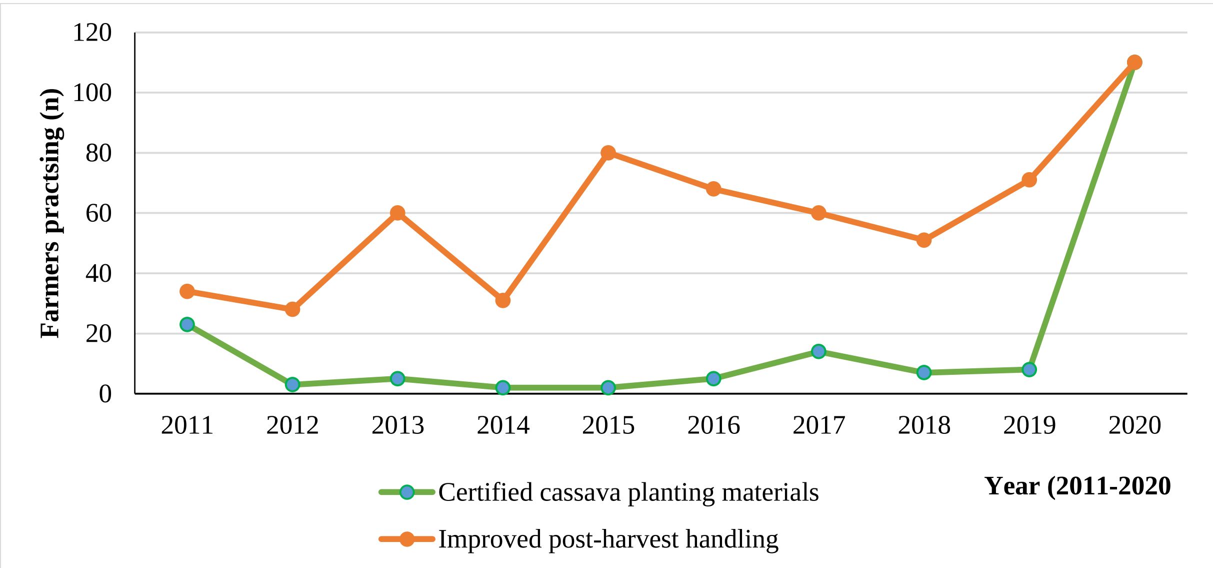

Figure 4.3: Yearly trends in the number of typical farmers using certified cassava planting materials and improved postharvest handling and processing cassava products

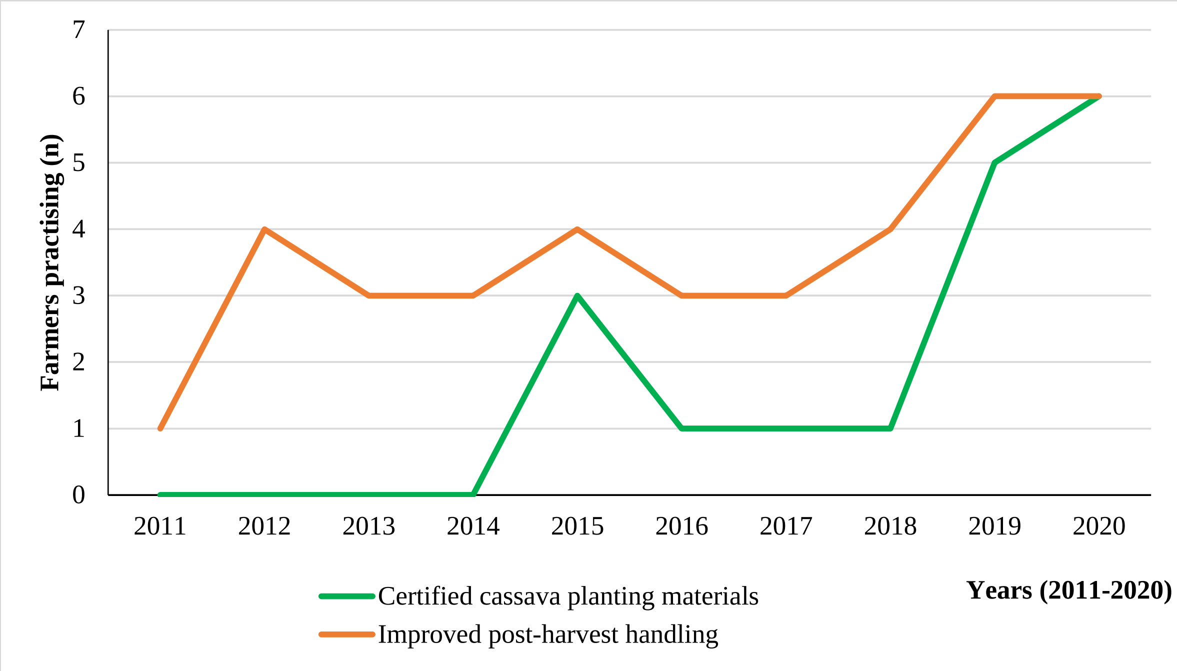

Figure 4.4: Yearly trends in the number of positive deviant farmers using certified cassava planting materials and improved postharvest handling and processing cassava products.

The trend reveals a noticeable difference between positive deviant and typical farmers in the land allocated to improved cassava varieties. While typical farmers maintained same size of land allocated to local cassava varieties and steadily increased land size allocated to improved cassava varieties, positive deviant farmers reduced the land allocated to local cassava varieties and increased land allocated to improved cassava varieties. In both cases, both farmers increased their land allocated to improved cassava varieties. There was also an observed increase in the number of typical farmers using certified cassava planting materials in the year 2020. In addition, among those processing cassava products and practising improved postharvest handling there was an average improvement. This could be attributed the influence of positive deviance farmers who are found outstanding in cassava production and marketing and also to the fact that the cassava sector is currently being prioritized in Kenya following numerous Research and Development initiatives.

Following this, more varieties have been released into the market and disseminated to households to increase the adoption rates. In the availability of information, typical members borrowing one or two ideas from positive deviant farmers and sharing of information amongst them has largely contributed to the increase in using certified cassava planting materials among typical farmers. Moreover, majority of them noted that there are cassava farmers that they consider outstanding in production hence they interact with them to share information on the same. Accessing samples of improved certified cassava cuttings has also been one way in which typical farmers have benefited from positive deviant farmers hence justifying the increase in use of improved certified cassava planting materials.

In contradiction however, Wossen *et al.* (2020) established that in as much as there were dissemination platforms for improved cassava varieties, there was a low adoption rate of the improved varieties yet cassava remains a key food security food crop. This was attributed to inadequate public investment in cassava stem multiplications and channels for distributions to rural smallholder farmers. Active cassava programs also offered only a one-off initiative to farmers leaving them out of the next initiative hence most farmers always felt neglected thus leaving the programs (Wossen *et al.,* 2018).

The point of discussion therefore should centre on the knowledge that farmers gain about the improved cassava variety. Findings further reveal that positive deviant farmers increased their land allocated to improved cassava planting materials relative to typical farmers in the Nyando climate smart villages. The lack of knowledge transfers on improved cassava variety and its attributes is one factor that makes typical farmers slow in adopting improved cassava varieties. Factors such as education and family income are also contributing factors to slow adoption in improved cassava varieties. Mudege and Demo (2016) allude to the fact that farmers are likely to purchase cheaper cassava seeds/ planting materials even when they know that it is of poor quality. In support of this, Tadesse *et al.* (2017) also indicated that in as much as farmers may be willing to purchase and adopt new improved cassava varieties, they are constrained due to lack of skills, finance and labour to support their adoption rates.

Either way, proper information dissemination platforms, adequate support from relevant stakeholders and continuous trainings on cassava production will enhance increase in adoption of improved cassava varieties and planting materials. Additionally, availability and linkages to markets may also enhance adoption of improved cassava varieties by farmers in the study area and in the entire Nyando Basin. Farmers should be put in the limelight of the importance of the cassava food crop in order for them to embrace its farming. Additionally, social character through networking between positive deviant and typical farmers plays a key role in helping farmers transition from local cassava varieties to improved cassava varieties and allocation of more land to improved cassava planting materials. Improved cassava crop varieties also reduce the risks associated with crop failures and yield losses thus ensuring stabilization of household incomes, food and nutrition security and improved livelihoods. Farmers who embrace cassava farming rarely suffer effects of food insecurity.

4.3.3 Differences in the Use of Climate Smart Cassava Innovations in Production and Marketing between Positive Deviant Farmers and Typical Farmers

The analysis was to answer whether there had been a marked trend differences between positive deviant farmers (PDs) and typical farmers (TPs) in land allocation to improved cassava varieties and use of certified planting materials, improved postharvest handling to reduce losses and processing cassava products to increase market value.

Concerning land allocation to cassava production, the study found that since 2011, both positive deviant (PD) farmers and regular farmers have increased acreages under cassava irrespective of variety. However, positive deviant farmers are found to have reduced acreage under local cassava varieties and increased acreage of land under improved cassava varieties, as opposed to their counterpart typical farmers, who have maintained the acreages under local cassava varieties while steadily increasing acreages under improved varieties, even though capacity building of farmers on climate smart practices, was uniformly done in the Nyando CSV by stakeholders in the Learning Platform.

The steady increase on acreage of improved cassava varieties by typical farmers, could be attributed to their high interaction with the positive deviant farmers (81.6% as shown in Table 5) who are outstanding as far as cassava production and use of improved cassava technology is concerned and therefore are emulating their innovative practices. This finding of PD farmers having more land under improved cassava varieties than typical farmers, concurs with studies done by Savikurki (2013) who noted differences regarding herd sizes and land holdings between regular farmers and positively deviating farmers. His study found that positively deviating farmers had larger herd size and land holdings than their counterpart regular farmers.

Steinke *et al.* (2019) in their study on prioritizing options for multi-objective agricultural development through the positive deviance approach, found positive deviant farmers performing averagely better than other households regarding caloric food security. The more acreage under improved Cassava varieties by positive deviants could be attributed to their innovative use of available inputs, assets and processes (i.e. positive deviant practices). The high performance and high acreage under improved Cassava varieties by positive deviant farmers came out during the focus group discussion conducted in the study area. Plate 2 is a picture showing a typical farmers plantation of improved cassava variety.

It emerged from focus group discussion that majority of the farmers from the study area sourced their cassava seed cuttings from positive deviants farmers, which is an indication that performance of positive deviant farmers regarding improved cassava technology, is comparatively better than that of typical farmers. Apart from sourcing seed cuttings, focus group discussion also revealed that farmers from the study area, also source information regarding production of improved cassava technology from positive deviant farmers. The findings provoke a rethink in the design of agricultural development interventions and framing of strategies that can be utilized to scale the use of promoted climate-smart technologies.

The interventions should overcome what may mischaracterize the process of technology change and overcome the complex configuration of social and technological components by targeting a small number of farmers with sociotechnical influence in areas of interventions. Second, the findings highlight positive deviance approach as an effective concept that can support technology change in innovation platforms. Positive deviance is highlighted by the study as a proposition that evokes motivation and capabilities of certain groups of farmers to take up new methods, technology and techniques and engage, establish or modify the behaviour of other farmers, a task that project organizations, agricultural extension officers, and other actors in innovation platforms may not adequately accomplish.

Furthermore, the finding indicate that positive deviance farmers are positively disposed and respond swiftly to adopt and scale innovations, creating pathways through which regular farmers unpack and assimilate new practices. Experimentation by positive deviant farmers possibly allowed typical farmers to assess the practical, economic, and social aspects of the innovation before absorbing into their farms. Therefore, positive deviance approach to dissemination and adoption is occasioned by the ability of exemplary farmers to raise awareness, stimulate interest, and encourage positive responses towards innovation by non-starter farmers.

Plate 2 is a clean disease free field of improved cassava variety belonging to a positive deviant farmer. Majority of the study area farmers source their cassava seed cuttings from positive deviant farmers, a phenomenon that has helped in increased acreages under cassava and enhanced cassava yields in the study area.

Plate 2: Field of improved cassava variety

Photo by Paul Tana on 30th November 2021

Concerning improved postharvest handling to reduce losses and processing cassava products, the study results indicated that farmers in Nyando CSV had put in measures to improve their postharvest handling with the aim of reducing postharvest losses. Value addition through sorting, grading, packaging, polishing and milling cassava products were one of the ways that the farmers were using. Out of these, farmers managed to get flour and porridge relative to cake, snack or chips as end products from cassava farming. The role of postharvest handling of freshly harvested improved cassava is necessary owing to its rapid deterioration. This rapid deterioration, between three to four days, confers a short shelf life for cassavas (Luna *et al.,* 2021) hence if not careful, farmers are likely to underutilize cassava crop.

Processing of cassava into other foods such as cassava flour ensures a longer shelf life for cassava, high quality products and enhances its stability and storages. While postharvest handling is important, it is needful to identify the various cassava spoilage mechanisms in order to avoid them in the near future. In their study, Abong' *et al.* (2016) stated that a number of post-harvest issues prevent the cassava crop from being effectively commercialized and that freshly picked cassava roots have a relatively short shelf life of less than 72 hours after harvest, with post-harvest losses of more than 23%. In order to minimize these losses, cassava roots must be treated. Uchechukwu-Agua *et al.* (2015) opines that cassava is a valuable food crop hence it is vital to understand the role of postharvest handling through processing and storage procedures in order to reduce food insecurity concerns. Parmar *et al.* (2018) observed that, most of the farmers processed cassava into chips and milled cassava into flour, which corresponds with the findings of this study. It was further observed that, critical postharvest losses occurred during sun-drying and stock piling. This was found happening at both the farm and market level. In a bid to avoid postharvest losses, most of the cassava roots are marketed and sold without much postharvest value addition. This ensures it reaches the consumer early enough before it begins to deteriorate. As such, not much postharvest is carried out neither are innovations in cassava, viable at such setups. Since majority of the farmers from the study are selling their cassava produce without post-harvest value addition, they lose a lot in terms of revenue generated from production of the cassava crop. The need to equip farmers with training skills on how to manage postharvest losses and even introduce cassava innovations is therefore important. Other than milling the cassava into flour for making porridge, there are many other ways that farmers can be capacity built on to enable enhancing their capacity and skills on value addition of their cassava produce. Through this, farmers will come up with value added cassava products leading to enhanced utilization, demand for the products, income, hence, improved livelihood. The value added cassava products may include cassava crisps, chips, flour, animal feed, starch production and many other products that may be made from cassava. Plate 3 is a picture of cassava chips made by one of the study farmers from the Nyando Climate Smart Village.

Plate 3: Picture of cassava chips

Photo by taken by Paul Tana on 10th April 2022

4.4 Objective Two: Climate Smart Cassava Production and Marketing Practices that Typical and Positive Deviant Farmers are Abandoning in the Nyando Climate Smart Villages

The differences between positive deviant farmers and typical farmers on abandoned innovative climate smart "best bet" practices relating to increasing productivity, minimizing post-harvest losses, and improving marketing of cassava products.

4.4.1 Innovative Climate Smart "Best Bet" Practices for Increasing Cassava Productivity

Dis-adoption rate for input intensification, land and soil management, and cropping systems indicates the proportion of farmers discontinuing the practice after applying for some period of time. A practice with zero dis adoption rate in this study is considered innovative climate smart "best bet" for farmers otherwise, it would have been abandoned. Figures 4.5, 4.6 and 4.7 illustrates the difference in dis adoption rates between typical farmers and positive deviant farmers in cassava production.

Figure 4.5 illustrates the difference in dis adoption rates between typical farmers and positive deviant farmers for input intensification in cassava production. Intensification refers to improved productivity or output using proper agricultural inputs in optimum amount and time. Results reveal that irrigation, inorganic fertilizer, organic fertilizer and improved cassava varieties were innovative climate smart “best bet” to positive deviant farmers but not to typical farmers. Dis adoption rates of these input intensification practices by typical farmers was between 6 and 24%, with irrigation as the most abandoned practice. Rogers' (1995) Diffusion of Innovation Theory, which describes how new ideas or inventions are adopted, can be used to explain the findings of adoption and dis-adoption. According to Rogers (1995), an innovation's adoption is determined by five qualities: relative advantage, compatibility, complexity, trialability, and observability. Relative advantage is the degree to which an innovation is deemed to be superior to the concept it replaces.

Positive deviant farmers, as shown in Figure 4.5, found use of irrigation, inorganic fertilizer, organic fertilizer and use of improved cassava varieties having advantages in cassava production. According to Rogers' idea, innovations that clearly outperform the current strategy will be more readily accepted and implemented. An innovation won't be adopted if a potential user perceives no comparative benefit in employing it. The degree to which an invention aligns with the values, experiences, and requirements of potential adopters is known as compatibility, according to Rodgers' thesis. The possibility of an idea being adopted increases with how compatible it is. The complexity of an innovation is the degree to which it is thought to be difficult to understand and apply. In addition, Rogers suggested that new innovations may be categorized along a complexity-simplicity continuum, with the proviso that potential adopters could not completely comprehend the significance (and hence the relevance) of the idea.

Key stakeholders will accept innovations more quickly if they believe they are easy to utilize. Trialability is the capacity for small-scale experimentation with a unique idea. As they require investing time, effort, and resources, innovations that may be tested before being completely implemented are more likely to be embraced. Last but not least, observability describes the ease with which adopters can perceive an innovation's effects. If an idea produces measurable advantages, it is more likely to be implemented. This means that adoption of improved cassava technologies that were disseminated by actors to the Climate Smart Village of Nyando were keenly observed by the positive deviant farmers and were found to be beneficial to them attributing to their adoption by them.

The difference in dis adoption rates between typical farmers and positive deviant farmers for land and soil management practices in cassava production is illustrated in Figure 4.6. Mulching and using legumes in crop rotation were innovative climate smart “best bet” practices to positive deviant farmers but not to typical farmers. Terracing was innovative climate smart “best bet” to both positive deviant farmers and typical farmers while contour ploughing and agroforestry were not innovative climate smart “best bet” to both positive deviant farmers and typical farmers. Terracing was an innovative climate smart “best bet” practice to both positive deviant and typical farmers due to the fact that, the high soil erosion witnessed in the study area, is a major problem which affects almost every household and is a major contribution to the high food insecurity in most households. It emerged from the focus group discussion that the study area experience long periods of drought and that many households have tried planting tree seedlings which end up drying due to prolonged dry spells and free grazing of livestock experienced in the study area. The long dry spells and free grazing livestock which graze the seedlings whenever they are planted, has killed the morale of many households making them not to practice agroforestry.

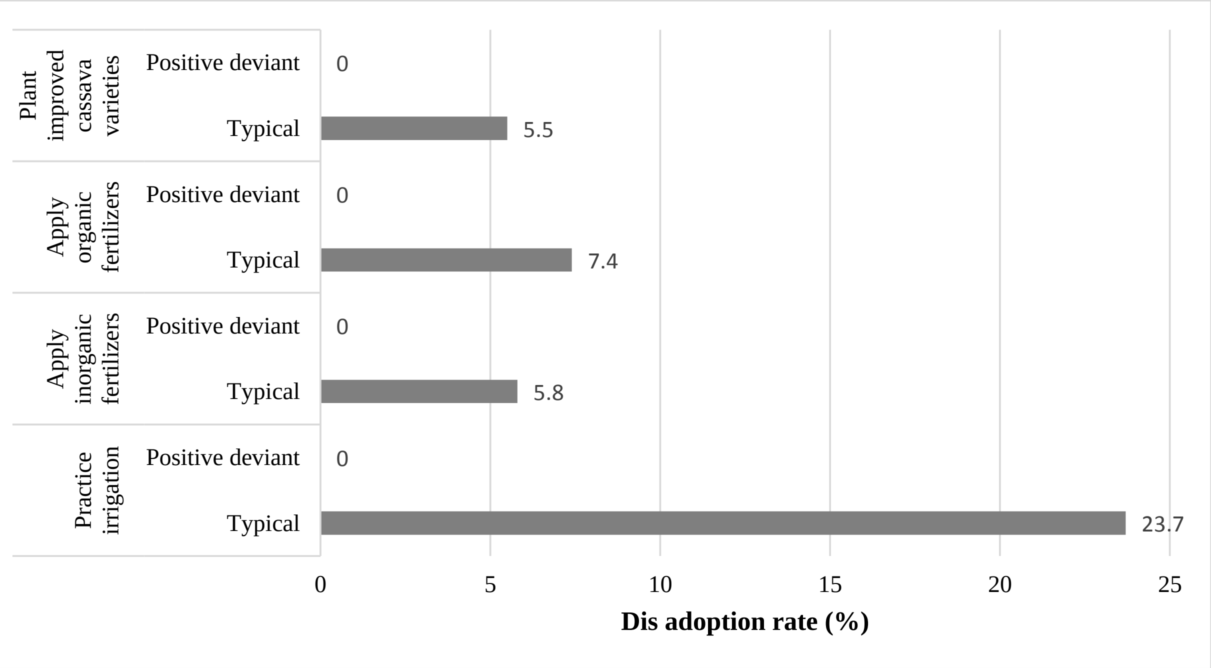

Figure 4.5: Dis-adoption rates by typical farmers and positive deviant farmers for input intensification in cassava production

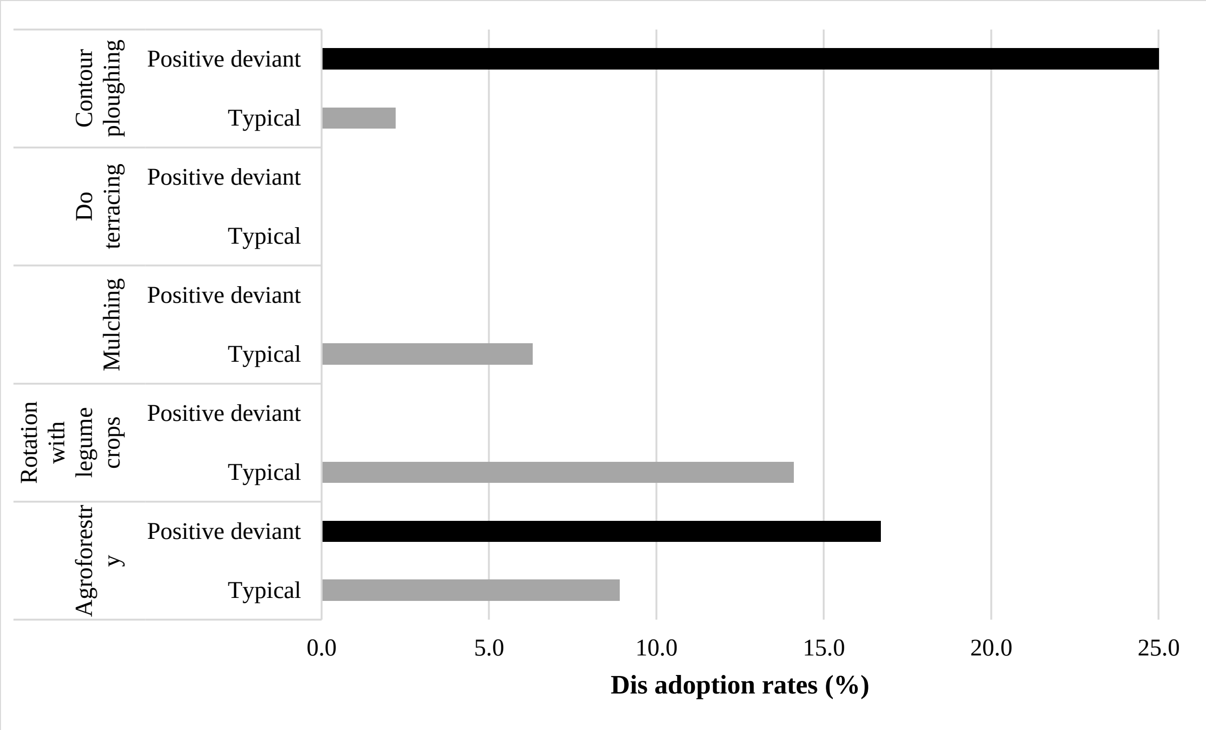

Figure 4.6: Dis-adoption rates by typical farmers and positive deviant farmers for land and soil management practices in cassava production

The difference in dis adoption rates between typical farmers and positive deviant farmers for cropping systems in Figure 4.7 reveal that diversifying crops, timely planting and changing planting dates were innovative climate smart "best bet" practices to positive deviant farmers but not to typical farmers. However, line planting and planting along the contours were not innovative climate smart "best bet" practices to both positive deviant and typical farmers.

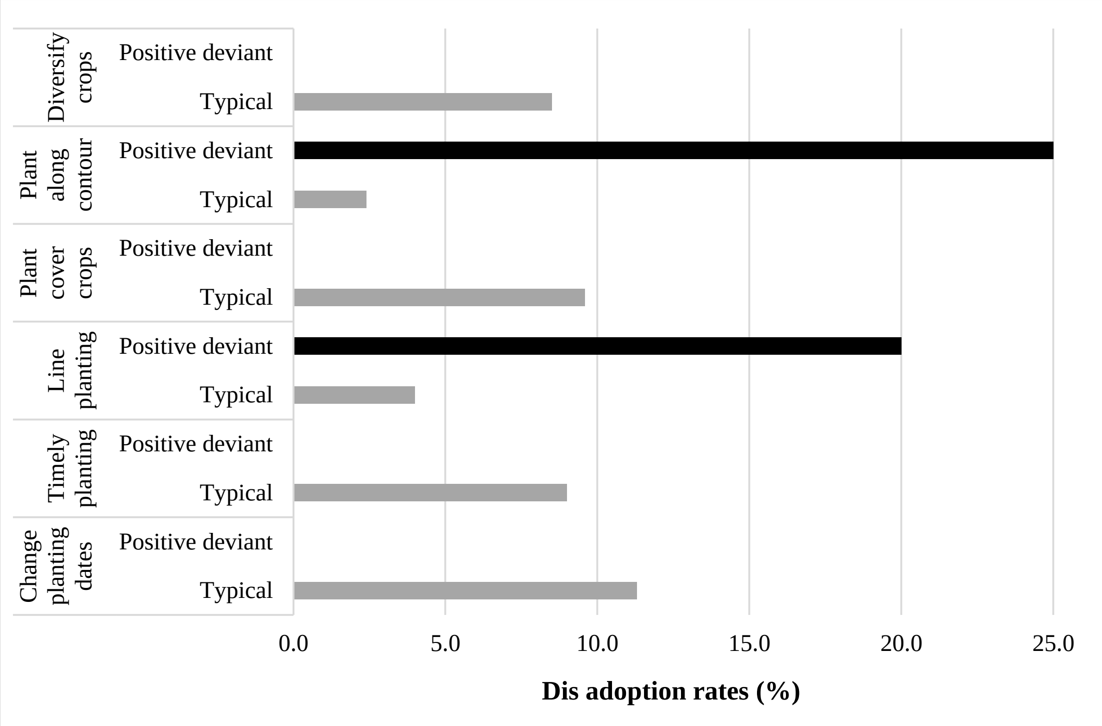

Figure 4.7: Dis-adoption rates by typical farmers and positive deviant farmers for cropping practices in cassava production.

4.4.2 Innovative Climate Smart "Best Bet" Practices for Improving Cassava Post-Harvest Handling

Figure 4.8 illustrates the differences between positive deviant farmers and typical farmers expressed as percent of positive deviants minus percent of typical farmers that were value adding cassava through sorting, grading, packaging, polishing or milling cassava products. The common products were flour and porridge relative to cake, snack, or chips. The positive value indicates that more positive deviant farmers than typical farmers were practicing value addition to cassava products. Results reveal that more positive deviant farmers than typical farmers were sorting, polishing or milling cassava products, with sorting the most form of value addition. Fewer positive deviant farmers than typical farmers were using grading or packaging to add value to cassava products.

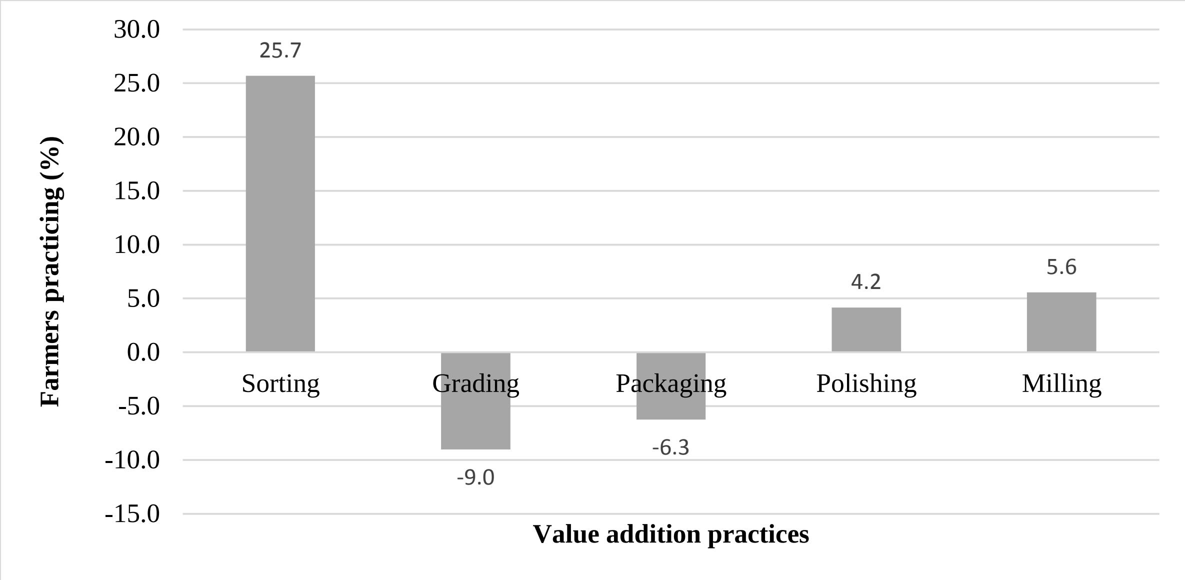

Figure 4.8: The percentage differences between positive deviant farmers and typical farmers expressed as percent of positive deviants minus percent of typical farmers who add value to cassava products by sorting, grading, packaging, polishing or milling

4.4.3 Market Arrangements Best Bet Practices

Figure 4.9 illustrates the difference in index score between positive deviant farmers and typical farmers for what they consider as best bet collective action arrangements to increase marketing of cassava products. A weighted index was first derived from the frequency counts of the degree of agreement then the index score of positive deviant farmers subtracted from that of typical farmers. A positive value of difference in index score indicates a higher score for the positive deviant farmers than typical farmers. Results show that improving product quality was a higher value for positive deviant farmers than typical farmers as best bet practice to increase marketing of cassava products through collective action arrangements. Product aggregation, accelerating sales, bypassing middlemen, or cementing long-term relationships were of lower value to positive deviant farmers than typical farmers as best bet practices to increase marketing of cassava products through collective action arrangements.

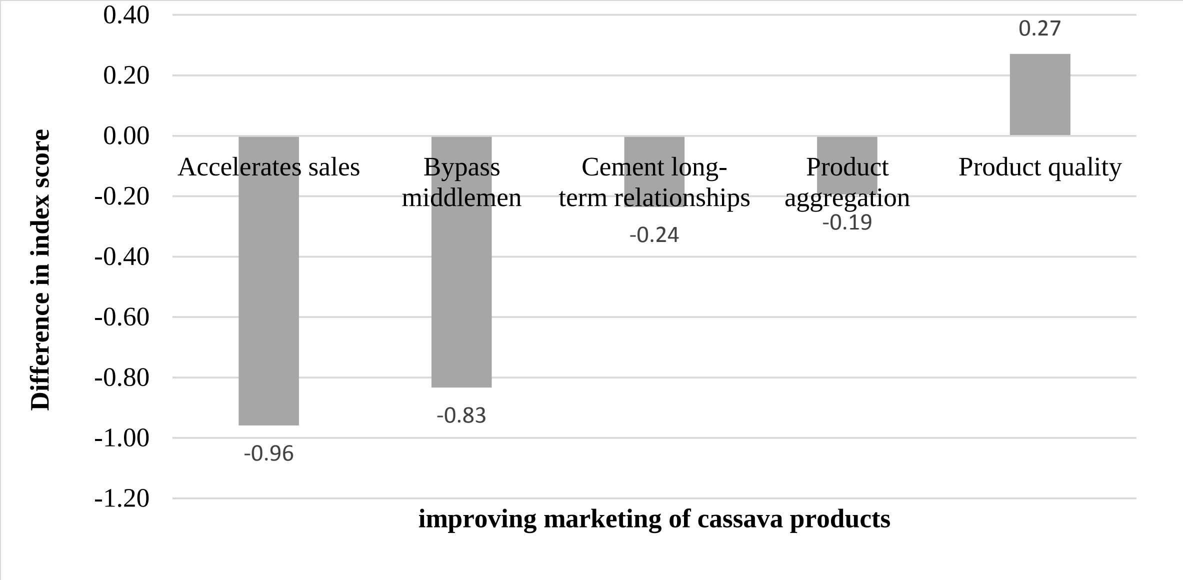

Figure 4.9: Difference in index score between positive deviant farmers and typical farmers for collective action arrangements as best bet practices to increase marketing of cassava practices.

4.4.4 Innovative Climate Smart "Best Bet" Practices for Cassava Productivity, Post-Harvest Losses and Marketing Discussions

Results indicated that positive deviant farmers practised irrigation, inorganic fertilizer, organic fertilizer and improved cassava varieties as practices they considered innovative climate smart "best bet" that favoured positive deviant farmers. Nonetheless, typical farmers did not embrace the dis adoption rate of climate smart innovative best practices. The irrigation best bet practice was the main practice abandoned by typical farmers. The difference in dis adoption rates between typical farmers and positive deviant farmers for land and soil management practices in cassava production revealed that use of legumes and mulching were the best bet practices for positive deviant farmers with terracing being embraced by both typical and positive deviant farmers. The results concurred with those of Githunguri and Njiru (2020) on cassava farmers embracing the art of irrigation.

Among the best practices for marketing as revealed from the study are product quality improvement among the positive deviant farmers while product aggregation, accelerating sales, by passing middlemen, or cementing long-term relationships were of lower value to positive deviant farmers than typical farmers. Since cassava is viewed as a product of the future due to its immense values, its marketing is important. Given that product quality is key among the deviant farmers, then measures geared to improving such is needful. Due to the rise of the knowledgeable customer, product quality dimensions are key in marketing of cassava foods. Product quality enables a farmer to earn sustainable customer loyalty, manage their costs and establish their own product brand in the market. While customers particularly buy products from organizations/ companies that they trust, cassava farmers need to understand how well they can build their customers trust. In support of these findings, Adejumo *et al.* (2020) found out that postharvest technology changes brought about improved quality changes in the product and thus led to clearing of sales stock faster than when the products were sold unprocessed in markets.

Githunguri and Njiru (2020) note that production of high quality cassava products such as flour is a key requirement and thus, there is need to improve on processing technologies to ensure not only product quality but also safety. However, in as much as cassava is of great value, competition from other crops such as sweet potatoes should be kept in mind given that they produce the same starch value. Hence, as cassava farmers need to exempt high product quality by ensuring their cassava is free from defects, excellently packaged and meets the price product value. This will enable them reach out to more customers encouraging them to buy their products and subsequently increase their revenues. Additionally, given that cassava is consumed in different forms, through flour, leaves, roots and various flavour varieties, there is need to ensure that these adjust with changing customer demands. While some are sold as fresh leaves and roots, post-harvest handling is important since the crop requires some preparation before being consumed. As mentioned above, market opportunities for cassava are great but more needs to be done as these opportunities tend to fade with time. Knowing the current cassava market trend is therefore important.

4.5. Objective 3: Cassava Production Gains realized by Positive Deviant Farmers and Typical Farmers in the Nyando Climate Smart Villages

The results presented answer to the research question of whether positive deviant farmers and typical farmers have realized differential gains in production diversification, adaptability, food security, productivity and climate mitigation from use of climate smart cassava innovations. The results for each of these indicators are presented in subsequent sections.

4.5.1 Production Diversification

A weighted production diversification index for the overall farm as well as cassava products produced on typical and beneficial deviant farms can be found in Figure 4.10.

Results show that positive deviant farms had relatively higher levels of production variety than normal farms, both for the total farm and for cassava products. These findings demonstrate that using cassava innovations, positive deviant farmers were able to diversify their produce to a greater extent than usual farmers.

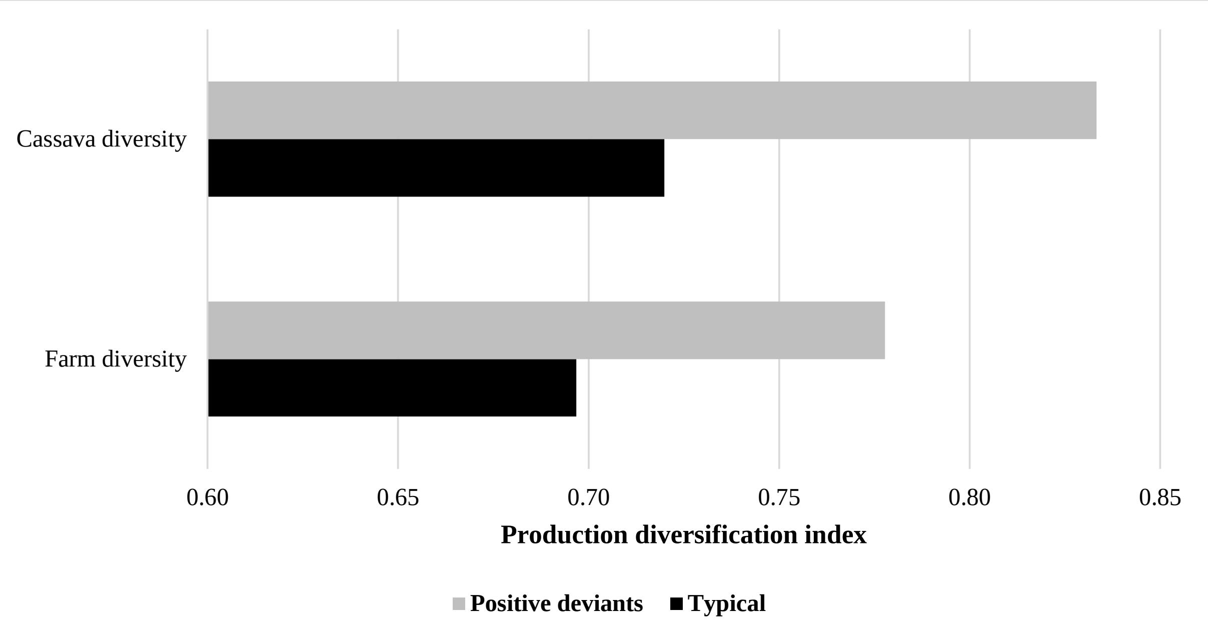

Figure 4.10: Production diversification index for the entire farm and cassava products produced on typical and positive deviant farms

Cassava is currently the second most consumed staple food crop in Africa after maize. Following this, there have been several cassava innovations that have had various outcomes on production diversification, adaptability, food security and productivity. Traditionally, cassava was mostly consumed in its traditional form as a snack, cassava flour and its leaves. However, with the upcoming cassava innovation trends worldwide, there has been a great impact on its innovation capacity leading to production of variety of products from cassava. It is nevertheless, disheartening to note that there is limited knowledge on the various production diversification that stem up from cassava innovations. A key question to ponder is whether or not these innovations are reaching their target population or not.

A higher production diversification of the entire farm and of cassava products was observed among positive deviant farmers relative to typical farmers as shown in Figure 4.5, an indication that positive deviant farmers were attaining relatively higher production diversification than typical farmers. Due to high production yields, positive deviant farmers have high yield in stock to consume and sell as well. Due to high crop yields, positive deviant farmers have to design ways of diversifying their crop production in order to meet the needs of their families and communities around. Similar findings were also documented by Toorop *et al.* (2020), who established that improved innovations led to farm diversification which subsequently led to high production yields.

Farm diversification is key especially to resource scarce farmers who have an interest in increasing their production yields. Through a model aided farm restructure, farmers can improve on farm performances. Dogliotti *et al.* (2014) note that in cases where farmers have limited scarce in terms of land, they can as well redesign their farms through various forms of diversification by optimizing resource allocation. The positive deviance approach is a technique that be efficiently used to explore the multiple farm diversities and cassava production diversification. By being innovative on the use of available resources, they achieve greater returns compared to typical farmers. Following this, there is need for a whole farm redesign modelling to inform better alternatives for farm diversification as reinforced by Jones *et al.* (2017).

4.5.2 Adaptability

Weighted adaptability index for the entire farm and cassava crop on typical and positive deviant farms is presented in Figure 4.6. The results show that relative to typical farms, positive deviant farms had attained higher adaptability in both farm and cassava crop. Ideally, compared to typical farmers, positive deviants have achieved exceptional results in their farming activities such as better adaptability to changing environmental conditions. One important feature that leads to the success of positive deviant farmers is their openness to try new approaches and procedures. For example, positive deviants have experimented with novel cassava varieties or planting techniques to increase yields. They also frequently combine local knowledge and techniques passed down through generations with modern farming methods to obtain greater outcomes.

Their ability to adapt to changing environmental conditions is another important factor. Positive deviant farmers are typically able to detect early warning indications of weather changes, such as drought or flooding, and take proper protective steps for their crops. Mulching or intercropping, for example, may be used to save soil moisture, or drought-resistant cassava cultivars may be planted which has often been exhibited by the positive deviants. The increase in cassava and farm adaptability among positive deviant farmers is a favourable trend that can assist food security and economic development in many locations. Lyon *et al.* (2020) documented that crop cultivars that are resistant to environmental variability are required for successful farming. It is critical to produce such varieties by assessing variety performance across the spectrum of environments represented on operating farms. Other farmers can enhance their yields and become more robust to environmental issues by learning from these farmers and adopting their best practices (Tittonell, 2020). This, in turn, can assist in assuring a consistent supply of food for local communities while also providing economic opportunities for farmers and their families.

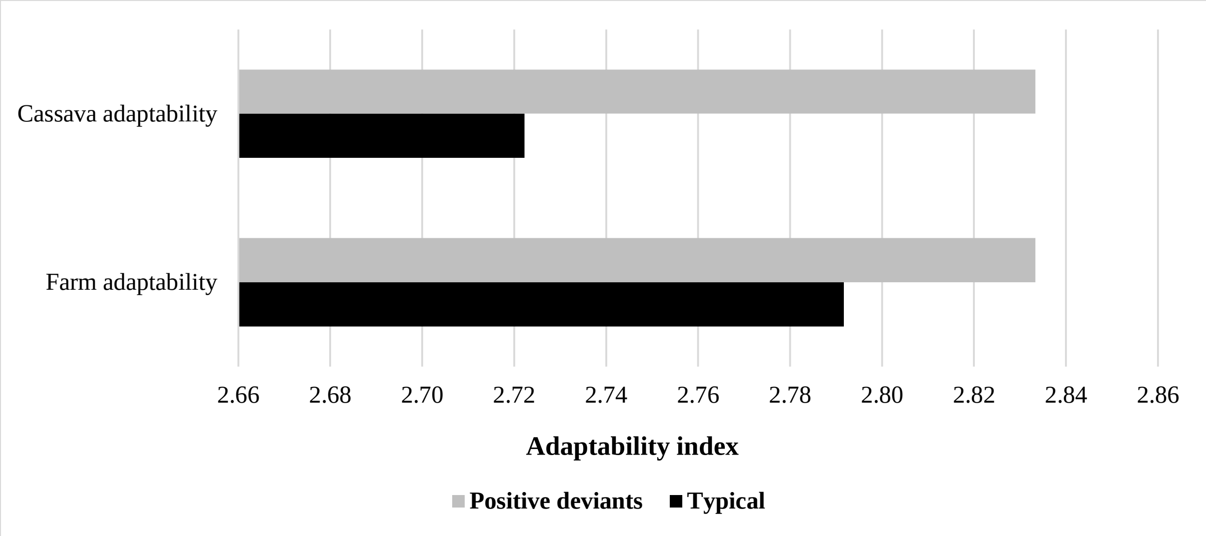

Figure 4.11: Adaptability index for the entire farm and cassava crop on typical and positive deviant farms

4.5.3 Food Security

Figure 4.12 presents the computed food security index for the typical and positive deviant households in reference to food availability in the households for the last 12 months before the survey date. The results reveal a better food security situation attained in positive deviant households compared to that attained in the typical households.

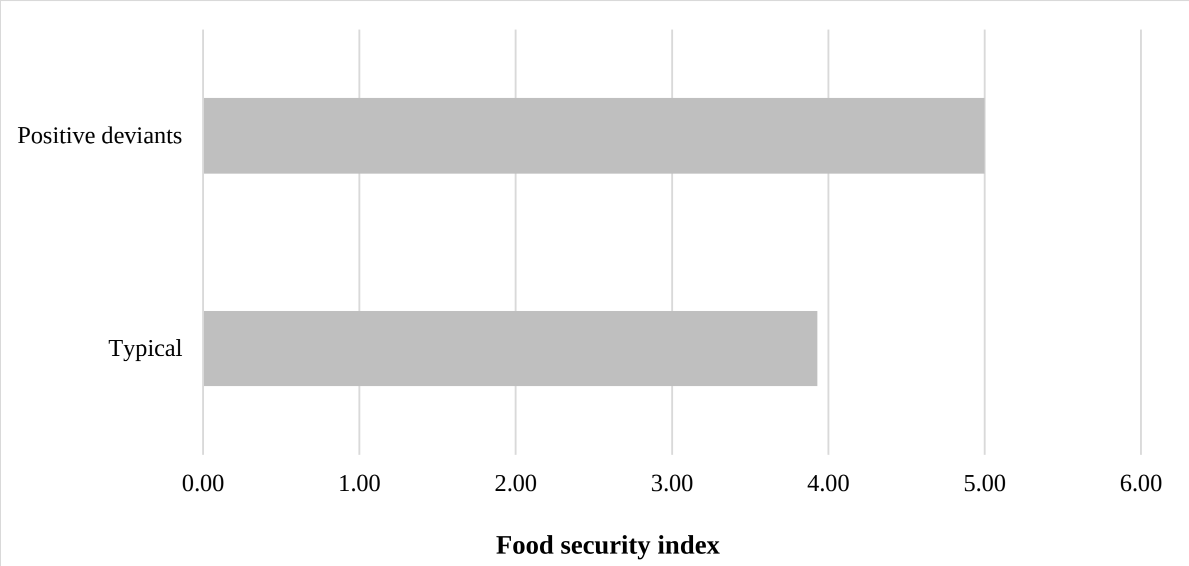

Figure 4.12: Food security index for the typical and positive deviant farm households

Cassava innovations worldwide have also led to increase in food security (Brüssow *et al.,* 2017). While it has been highlighted as one of the drought tolerant crops, there has been various discussions on how to make cassava beneficial and sustainable for enhancing food security in future. Additionally, Parmar *et al.* (2017) notes that following the ability of cassava to grow in a wide range of ago-ecological zones, its rich food calorie value and its affordability, it has been presented as one of the most readily accessible foods that can be used to overcome food insecurity. Results in Figure 4.7 indicated that better food security situation was attained in positive deviant households compared to that attained in the typical households. This means that households that majorly practised cassava farming in Nyando Sub-County had the ability to have sufficient food supply through their domestic production.

4.5.4 Productivity and Intensification

Table 4.5 presents productivity index on positive deviant farms and typical farms. Indicators of productivity in this thesis are cassava yield attained in kilograms per acre and the proportion of the yield that is consumed at home and the proportion that is marketed. Cassava yields attained was about 46% higher on positive deviant farms compared to yields attained on typical farms. With higher yields attained on positive deviant farms, the households consumed more (1.4%) and sold more (15%) to market, relative to typical farmer households.

Table 4.5: Productivity index on positive deviant farms and typical farms

Farmer	Yield (Kg/acre)	Proportion home consumed (%)	Proportion marketed (%)
Typical	1345	20.3	17.9
Positive deviant	1960	21.7	32.5
Percentage difference (%)	45.7	1.4	14.6

Input intensification index computed for the typical and positive deviant farms is presented in Figure 4.13. Relative to typical farms, positive deviant farms attained higher input intensification index.

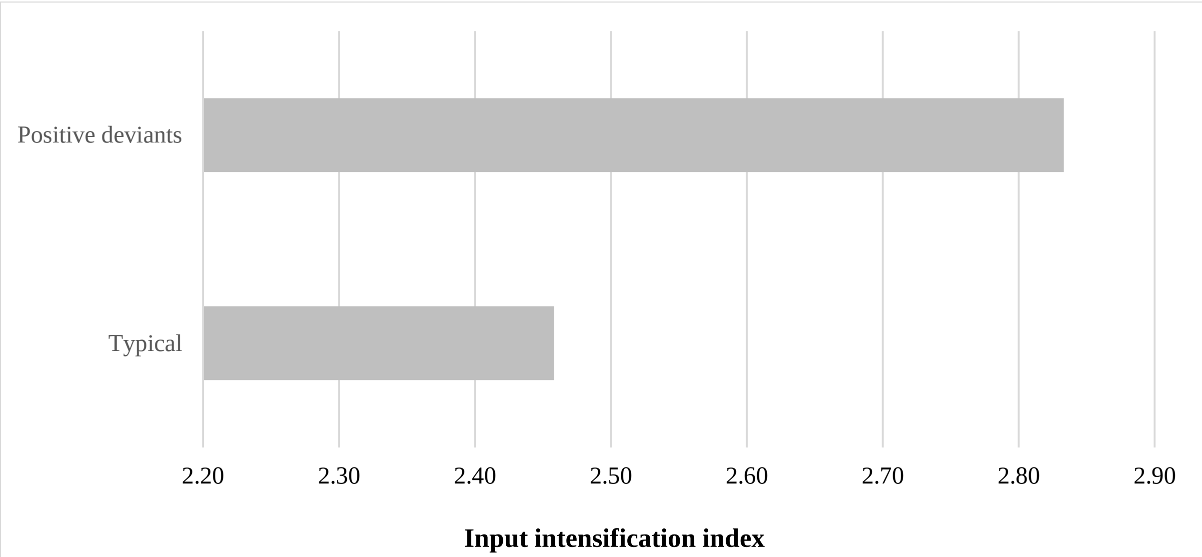

Figure 4.13: Input intensification index for the typical and positive deviant farms

Increased cassava cultivation has a great potential of improving food security based on the interviews, which concurs with findings by Reincke *et al.* (2018). In their study, Reincke *et al.* (2018) concluded that cassava farming is one of the best strategies of improving food security in Tanzania and more specifically in the semi-arid region. The findings further alluded to the fact that cassava being one of the drought tolerant crops faces various challenges, ranging from infertile soils to misconception by the communities around. However, most of the farmers in Kenya only have the knowledge of cassava being a drought tolerant crop hence rarely practise its farming. Positive deviant farms had attained higher cassava yield productivity, consumed and marketed more cassava compared to typical farms.

A plausible justification for this is that farmers who embrace innovative cassava farming have undergone numerous trainings and are highly aware of the kinds of inputs to use in their farm production. This translates to them realising high crop yields per acre. Additionally, through such, these households enjoy the benefits of being able to not only consume more cassava but also to market it. This enables them to have a sustainable food source from their farms hence food security within their households. By marketing their products, they are also able to generate income for their households and subsequently improve on their livelihoods. By growing the crops, they not only source for their own meals but contribute to food security in the entire region.

Access to information on new improved cassava varieties is currently available to farmers online hence this brings about a positive impact on the rate of adoption by the farmers. Olusayo *et al*. (2019), who found out that adoption of improved cassava varieties was positive and significantly correlated with cassava yield and improved, reported similar findings. Farmers who had adopted improved cassava variety indicated a high crop productivity yield. On average, they established that an increase in cassava yield was due to adoption of an improved variety.

Higher cassava yields lead to a significantly higher income as opposed to low cassava yields (Ogunniyi *et al.*, 2016). Due to its nutritious value, cassava crop sells more in the local markets hence being a source of income to majority of the households. By being a source of income therefore, cassava production further leads to a reduction in poverty levels of majority of the households. Hence, it is paramount to note the key role that cassava plays in production, source of income and poverty alleviation. The impact of improved cassava varieties among farmers as an innovation outcome is significant in cassava production.

4.5.5 Mitigation Actions

Table 4.6 summarises the tree planting and land management as the mitigation actions that were practiced on positive deviant farms and typical farms. The average land planted with trees was more than twice higher on positive deviant farms than it was on typical farms (0.54 vs 0.23 acres), but the proportion of land that was degraded was not different between the two farm groups. On average, whether typical or positive deviant farmers, five in ten produced or purchased tree seedlings. Relatively, positive deviant farmers were more likely to seek extension advice on tree management, to practice agroforestry and to introduce cover crops than the typical farmers were. With these tree planting and land management practices, eight in ten farmers indicated that they were realising improved land productivity.

Table 4.6: Mitigation actions practiced on positive deviant farms and typical farms

Mitigation action	statistics	Typical farmers	Positive deviant farmers
Sample (n)	number	144	6
Tree planting last 12 months			
Average land under trees	acres	0.23	0.54
Purchased tree seedlings	%	56.3	50.0
Produced tree seedlings	%	41.0	50.0
Extension advises on tree management	%	31.3	50.0
Land Management			
Land owned that is degraded or unproductive	acres	0.17	0.19
Land productivity improved with CSA practices	%	76.4	83.3
Agroforestry practice	%	54.9	100.0
Introduced cover crops	%	53.5	66.7

Positive deviant farmers in a bid to mitigate climate change planted more trees in relation to typical farmers. However, land degradation between the two groups of farms was not different as they both averagely planted and purchased tree seedlings. Similar results were established by Githunguri and Njiru (2020) that majority of the farmers who practised improved cassava varieties had designed ways of mitigating climate change through mulching, tree planting and to some extent irrigation to avoid soil degradation and erosion either through erratic rains or through drought seasons. Seeking of extension service advice on proper tree management and agroforestry and introduction of cover crop was a key attribute exercised by positive deviant farmers. This further enhanced improvement in their land productivity and nutrient consistency.

Jewel and Saifullah (2021) in their study noted that indeed agroforestry is key in fostering innovations especially among rural households. Due to the immense rise in technologies and practices in line with various innovations, there is need for an integrated modern and traditional land use where crops, trees and livestock can be managed together under one production system in order to ensure continuous supply of foods, soil nutrient improvement and climate mitigations. More training is however needed to equip farmers with knowledge of good agricultural practices in combination with climate mitigation measures, postharvest cassava handling and marketing of both agroforestry and cassava products.

4.6 Objective Four: Relative Importance of Functions of Innovation Systems in Fostering Cassava Production and Marketing in the Nyando Climate Smart Villages

4.6.1 Relative Importance Estimates

Figure 4.14 illustrates the best-worst scores associated with each of the seven functions of innovation systems supporting fostering cassava innovation in the Nyando climate smart villages. A positive value indicates that the function was selected as the most important, more times than it was selected as the least important. From the illustration, three out of the seven functions were selected as the most important more times than were selected as the least important. These functions were knowledge development, knowledge diffusion and resource mobilisation. Four out of the seven functions were selected as the least important more times than were selected as the most important. These functions were market formation, support from advocacy coalitions, entrepreneurship, and guidance of the search.

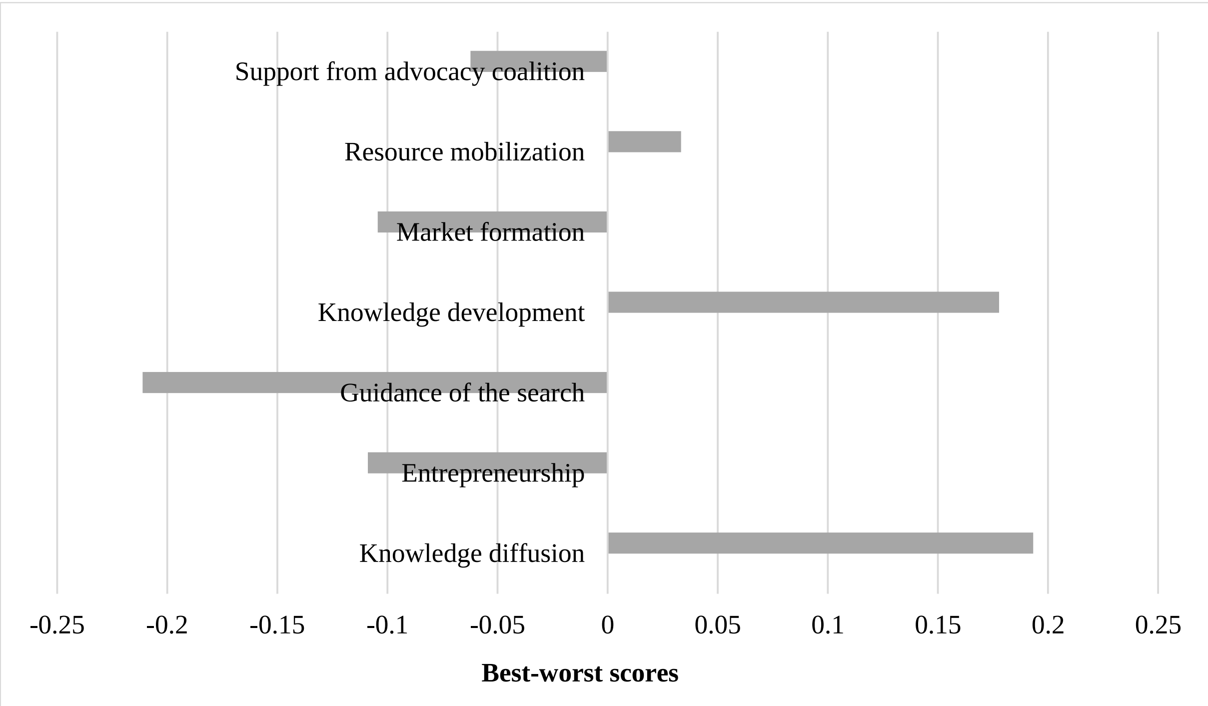

Figure 4.14: Best-worst scores associated with each of the seven functions of innovation systems supporting fostering cassava innovation in the Nyando climate smart villages

In Table 4.7 is summary of the relative importance of each of the seven functions of innovation systems supporting fostering cassava innovation in the Nyando climate smart villages. Results reveal that the functions ranked in order of relative importance from the most important function were knowledge development (19.17%), knowledge diffusion (18.86%) then resource mobilisation (14.88%). The other four functions (market formation, support from advocacy coalitions, entrepreneurship, and guidance of the search) had between 11% and 13% relative importance. However, the estimates showed a narrow relative importance, spanning between 11% and 19%.

Table 4.7: The relative importance of each of the seven functions of innovation systems supporting fostering cassava innovation in the Nyando climate smart villages

Functions of innovation systems	B	W	B-W scores	Sqrt (B/W)	Standardized ratio scale	Relative importance (%)	Ranking
Knowledge diffusion	201	114	0.19	1.33	98.36	18.86	2
Entrepreneurship	107	156	-0.11	0.83	61.35	11.76	6
Guidance of the search	109	204	-0.21	0.73	54.15	10.38	7
Knowledge development	178	98	0.18	1.35	100.00	19.17	1
Market formation	126	173	-0.10	0.85	63.22	12.12	5
Resource mobilization	169	154	0.03	1.05	77.60	14.88	3
Support from advocacy coalition	123	151	-0.06	0.90	66.85	12.82	4

4.6.2 Probabilities of Farmers Selecting the Seven Functions

Table 4.8 shows multinomial logit model estimates of the probabilities of farmers selecting the seven functions as important for fostering cassava innovation. Support from advocacy coalition was set the reference category. Only knowledge development coefficient was statistically significant, demonstrating important role of research in innovations in the climate smart villages. Results further reveal that knowledge development, knowledge diffusion, and resource mobilization were associated with positive coefficients while entrepreneurship, guidance for the search, and market formation were associated with positive coefficients. In order of relative importance, the knowledge development, knowledge diffusion, and resource mobilization were the most important functions of innovation systems in fostering cassava innovation in the Nyando CSV. In contrast, entrepreneurship, guidance for the search, and market formation ranked low in comparison to the support from advocacy coalition in importance to fostering cassava innovation. For importance to fostering cassava innovations, about a third (28%) of the farmers ranked knowledge development, about one fifth (17%) ranked knowledge diffusion while 13% ranked resource mobilisation as important functions of innovation systems.

Table 4.8: Multinomial logit estimates of the best innovation functions for fostering cassava innovation and shared importance

Function	Mean	SE	Shared importance	
			Mean	SD
Knowledge Diffusion	0.140	0.306	0.174	0.129
Entrepreneurship	-0.288	0.342	0.101	0.080
Guidance of the Search	-0.288	0.342	0.119	0.109
Knowledge Development	0.642*	0.276	0.275	0.131
Market Formation	-0.163	0.330	0.092	0.077
Resource Mobilization	0.095	0.309	0.128	0.063
Support from Advocacy Coalitions	Ref.		0.128	0.063

** $p < 0.05$*

4.6.3 Relative Importance of the Seven Functions of Innovation Systems In Fostering Cassava Innovation Discussions

The seven innovation system functions are dependent on each other through their interactions. How one function is performed clearly determines how the other functions will be performed. Research findings reveal that entrepreneurial experimentation was among the four least most important selected innovation system functions. A plausible justification for this is the fact that majority of the farmers have not yet known the benefits of cassava and how these products can easily be transformed to a variety of products to enable them generate income. Information accessibility and adequate training on new cassava innovation is lacking to enable them take up such opportunities in transforming the ideas to viable business opportunities.

Entrepreneurs are viewed as the core of cassava technological innovations. They act as initiators of various innovations by carrying out market research aimed at establishing a radical change in a given product. They further transform such ideas and insights into viable business opportunities. It is through them that customers are made aware of the available end products of cassava through creating a user awareness to stimulate and transition changes among customers. According to Planko *et al.* (2017), entrepreneurial experimentations play a key role in fostering easy and quick adaptability among users of an innovation as without any form of entrepreneurship there is no technological innovation in place. In cassava innovations therefore, entrepreneurs are key as they foster the uptake of innovation through championing for new technologies, new ideas, transforming them into products and services and testing new products before releasing them to the market.

Knowledge development and knowledge diffusion was among the most important innovation system functions that were selected by farmers in Nyando climate smart villages. These explains the importance of sharing out information and availing platforms where farmers can easily access the information. Knowledge development and diffusion of cassava innovation can effectively be developed through various desktop researches, feasibility studies and assessments, reports and R&D projects. Planko *et al.* (2017) stresses that knowledge development is the foundation for any innovation process. At the heart of all innovations are the knowledge and diffusion ideologies, which help to inform sound decisions and policies. Through interaction with various networks, knowledge is diffused across networks allowing for exchange of information. With Cassava as a product geared toward sustaining food security globally, different stakeholders need to come together and share ideas on how to improve on its innovation processes. While key policy makers are free to interact, share out information through learning by interacting, the end customer should also be kept in picture.

The gains from using cassava products from the subsequent use by the targeted customers justifies development of knowledge. Customers are key in provision of such information like the product attributes, packaging of the products, the value addition processes. It is through such interactions that those directly linked to cassava farming can be able to improve on their production capacities. Moreover, conducting of seminars, conferences and product training workshops helps to stimulate the sharing of information and its diffusion to various stakeholders. This also helps to reach quite a large number of interested parties in cassava farming hence improving on the innovation processes. The lack of information in cassava farming has made the uptake of cassava farming very low. Therefore, it is key that both technological and non-technological research and development are a prerequisite for the cassava innovation system to take place. Following the research, more needs to be done to ensure that knowledge attained from the development process is diffused to various stakeholders through an emergent system to help facilitate the information transfer and exchange.

While market formation is a key function in innovation systems, it was among the least many important functions selected by farmers in Nyando climate smart villages. Markets always have rules and regulations concerning what to sell and what not to sell and where to get their products. Due to the relatively low consumption of cassava and low sales volumes, farmers find it hard to market their produce and majorly produce for consumption purposes. Market regulations may also come in as a challenge to most of these farmers as they occupy a small percentage of the entire supply chain. Additionally, most of the consumers do not make their purchases from the market but rather from supermarkets, resulting in farmers making losses as they sell at low prices to large producers who enjoy the benefits of direct purchases from consumers.

In most cases, new innovative technologies may fail to outperform the already established innovations due to competition and rigidity to change. As such, market formation is important to help in transitioning from the old innovative technologies in cassava farming to new innovative technologies. To help foster cassava innovation therefore, it is necessary to develop strategies for entering a new market. Such strategies can include the identification and capturing a niche market where cassava products will be marketed, for easier acceptance into the market. The market formation function gearing towards cassava innovation is expected to strengthen the promotion of cassava products into the niche markets identified. Some of the ways in which this can be done is by being low-cost producers, lessening market regulations on cassava marketing, and ensuring they look into environmental standards (Underhill *et al.*, 2019). Additionally, these functions can aid in cassava market formation through establishment of associations that can aid them in marketing the products to local community members. Markard (2020) alludes to the fact that other than concentrating on new emerging markets segments, market formation can still concentrate on high degree saturated and established markets and counter attack their competitors by being low-cost producers.

Findings from the study placed guidance for search as one of the least important innovation system functions to farmers in Nyando climate smart villages. Majority of the farmers noted that the lack of guidance in advising them and supporting their requirements was lacking hence did not see the importance of the function in cassava innovation. They also felt that in as much as they are the first point in the cassava production, much of their needs had not been taken care of and most noted that they have been literally left out of important policy discussions surrounding cassava production. If then, there needs to be any increase in production of the food crop, then these farmers need to be part of such policy decisions to aid in supporting their requirements, inputs and ideas. In contrast, findings of Hekkert and Negro (2009) indicated that strong guidance for search was a motivating factor for entrepreneurs to accept new technology innovations and it directly influenced the amount of resources dedicated to knowledge development and diffusion. Besides, a lack of guidance made majority of the entrepreneurs reluctant to invest in the new technology.

Guidance for search is an important function as it represents policies and roadmaps that sets a clear path, vision and target for the cassava innovation opportunities. The activities that are bound to positively affect the perceptibility of the needs of cassava innovation users are under the guidance of search function. Stakeholders in the cassava innovation system have varied wants which shape their needs, expectations and requirements hence the search for solutions to the aforementioned wants required adequate guidance from them. This function is almost always supported by institutions through policy targets, government regulations and directives and market standards. Moreover, consumer expectations of the innovation, informal interfaces and change agents often contribute to shaping this function. Therefore, when designing cassava innovations, taking into account the current actors and stakeholders as well as the future stakeholders matters a lot in shaping the goals for long term cassava innovations. Anticipations should also be included as more than often such anticipations can come together, raise a specific topic and generate a change action. Accepting the farmers' guidance will foster cassava innovations through aiding policy makers to gain and use expertise from farmers which will be useful in making policies and decisions. Additionally, offering guidance is also a way of appreciating and preserving the autonomy of others which fosters better informed decisions not only for them but for other cassava users.

Nyando climate smart villages indicated that resource mobilization is one of the most important innovation functions that aids them in fostering cassava innovation. This is in corroboration with findings of Hermans *et al.* (2019) who established that various investments are necessary to support innovations such as capital funding for research and development, placement of subsidies to support development of projects and market concepts and training of experts in a specific innovation opportunity who can also train others to take up the new opportunity.

Pigford *et al.* (2018) note that human factors, financial and material factors are essential inputs for all innovation system developments globally. For cassava innovation to be sustainable, resource mobilization is important. Training of individuals to be experts in cassava production, processing and marketing, is needed to stimulate knowledge transfer to communities. These qualified specialists are seen as the face behind positive performance of cassava innovations. While human factors are needed, stakeholders in cassava production also need carry out resource mobilization in financial matters. These can be achieved by placing subsidies through various cassava innovation to help generate finances to run the innovations (Herman *et al.,* 2019). Similarly, government of Kenya can support them by having in place government programmes aimed at supporting cassava farming such as making provisions for input subsidies and lowering taxes for them.

Encouraging entrepreneurship in cassava farming and processing will further foster cassava innovation. Training of individuals in cassava farming enables them to get detailed insights about the product and come up with various by products from cassava crop such as crisps, flour and proper packaging of raw cassava. In the end, all this promote and support cassava innovations. Material resource mobilization is also important when it comes to cassava innovations. The availability of natural resources such as land for farming is one way of fostering cassava innovation. All said, without land for cassava farming, there would be no end products from cassava. Mobilization of farmers and encouraging them to increase their acreage of cassava farming ensures that much more cassava is produced, hence making input supply for the various cassava products be readily available and in supply.

The relative importance of legitimation and development of positive externalities was among the least important innovation system functions among farmers in Nyando climate smart villages. The support from advocacy is key in counteracting any form of resistance to change from externalities. However, in this case, this was not important among the farmers. New technologies come with all kinds of resistance to change and needs thorough support from the current stakeholders for it not to be overthrown. A strong association/ regime is key in standing foot in supporting new cassava innovations, otherwise, they will be forcefully ejected from the market even before the innovation is tried out. Keen to note is that all innovations come with various interests from different parties, cassava being one of the innovations. Hence, parties that have vested interests are likely to oppose its adaptability into the market. Therefore, strong advocacy associations and coalitions should be fronted to act as catalysts to create positive externalities in support of new cassava innovations in the market to counteract any form of resistance inclined towards it.

4.7. Objective 5: Climate Smart Cassava Production and Marketing Innovations Improved through a Collaborative Learning Forum in Nyando Climate Smart Villages

Improved learning (knowledge, skills and competency) among farmers about cassava production; postharvest handling and marketing innovations is presented as a difference after-before index score. A positive index score indicates that improved learning occurred through collaborative learning engagement. The difference of after-before index score for improved learning that occurred among farmers about cassava production innovations is well illustrated in Figure 4.15. The greatest improved learning occurred in counting the number of nodes in cassava seed cutting, using inputs in cassava growing, knowledge of right size of cassava seed cutting, and intercropping cassava with other crops. The least improved learning was recorded in weeding cassava crop.

Figure 4.16 is an illustration of the difference of after-before index score for improved learning that occurred among farmers about cassava postharvest handling and marketing innovations. In postharvest handling innovations, learning was greatest in value addition while in marketing, learning was greatest in linkage to processors.

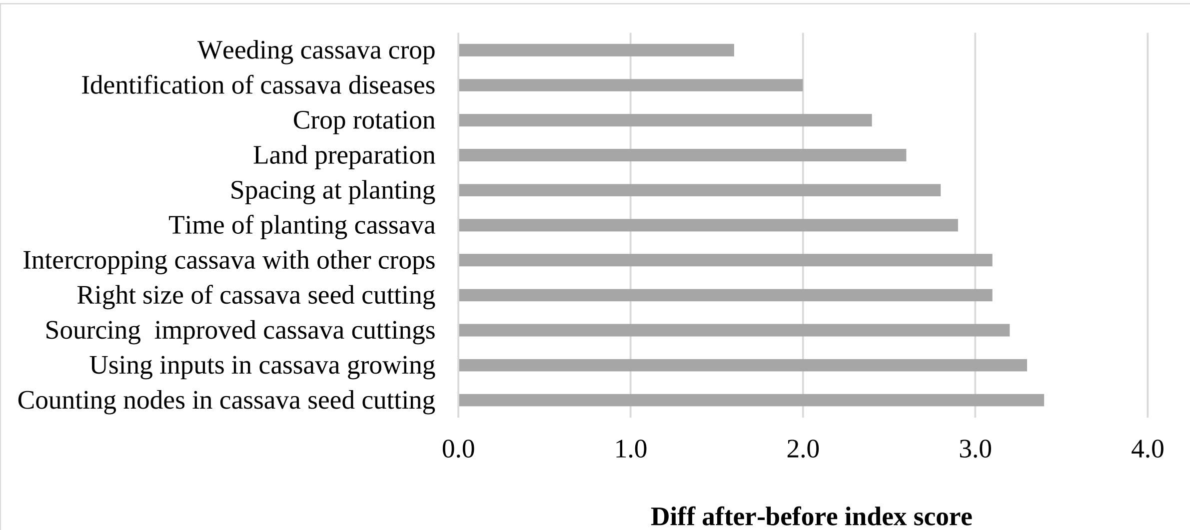

Figure 4.15: Difference of after-before index score for improved learning that occurred among farmers about cassava production innovations

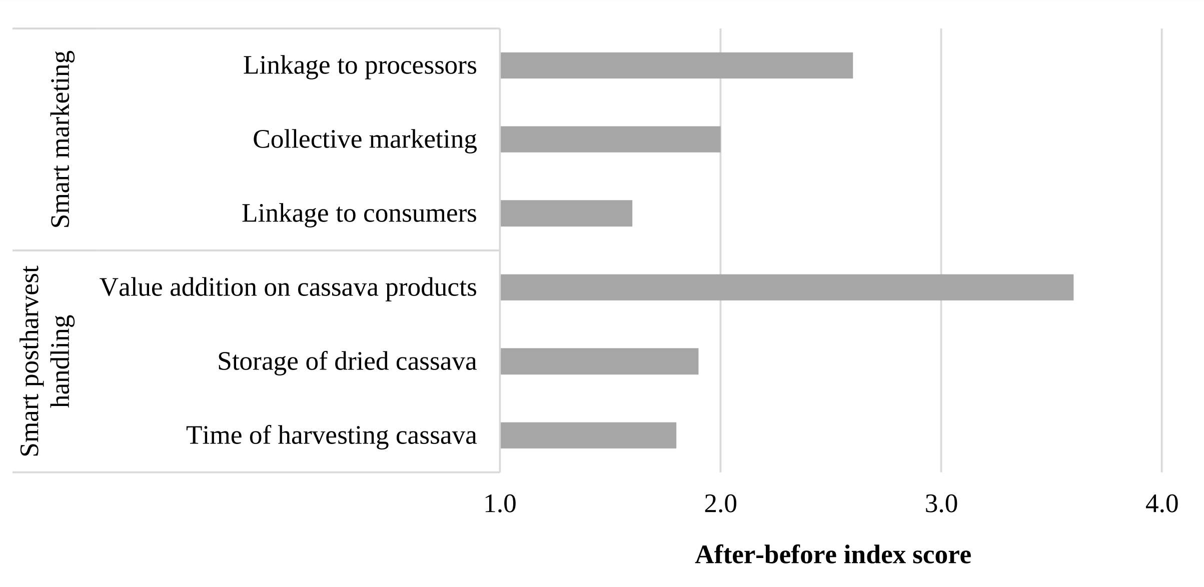

Figure 4.16: Difference of after-before index score for improved learning that occurred among farmers about cassava postharvest handling and marketing innovations.

The need for collaborative learning is essential in improving learning about cassava production, post-harvest handling and marketing innovations. Collaborative learning entails sharing of information, networking, understanding relationships, trainings and mobilization of resources. This means therefore that, by bringing relevant stakeholders together, ideas are shared out thereby improving cassava innovations. Through collaborative learning, results showed that the greatest learning among farmers was attained in counting number of nodes in cassava seed cutting, using inputs during growing of cassava, knowing the right size of cassava seed cutting and the crops intercropped in cassava. However, least learning was attained in weeding of the crop.

Collaborative learning comes in different forms such as organizing regular meetings with the aim of improving communication among key stakeholders. This can be done through village meetings, agricultural shows, seminars and conferences. Also, through collaborative learning, farmers are able to receive training for them to be able to gain technical understanding on a given cassava innovation techniques and strategies for improving them. Needless to note is the fact that, collaborative learning equips the farmer with adequate knowledge on various cassava innovation attributes. From sharing information with experts in the cassava field to engaging with cassava processors and policy makers, collaborative learning is a great way of fostering cassava innovations.

Moreover, through such interactions, it is easier to carry out a needs assessment among the recipients of the cassava innovation project and be able to conduct monitoring and evaluation with ease. This translates to enabling stakeholders know whether or not the uptake of cassava innovations is appreciated or faces reluctance of adoption. Therefore, establishing an effective communication channel with various cassava innovation stakeholders is important to enable sharing out of information and learning among them. While on the same, more needs to be brought forth and training conducted to equip these farmers with technical skills in cassava farming. Results indicated that the farmers had not learnt much on cassava weeding yet this is important in ensuring that cassava production flourishes. As such, more trainings through collaboration are needed to train farmers on climate smart climate smart cassava innovations, post-harvest management to avoid post-harvest losses, processing, packaging and marketing through promotion of cassava products. Figure 4.17 shows the various stakeholders linking with Nyando climate smart village cassava farmers and the roles played by each in the study area.

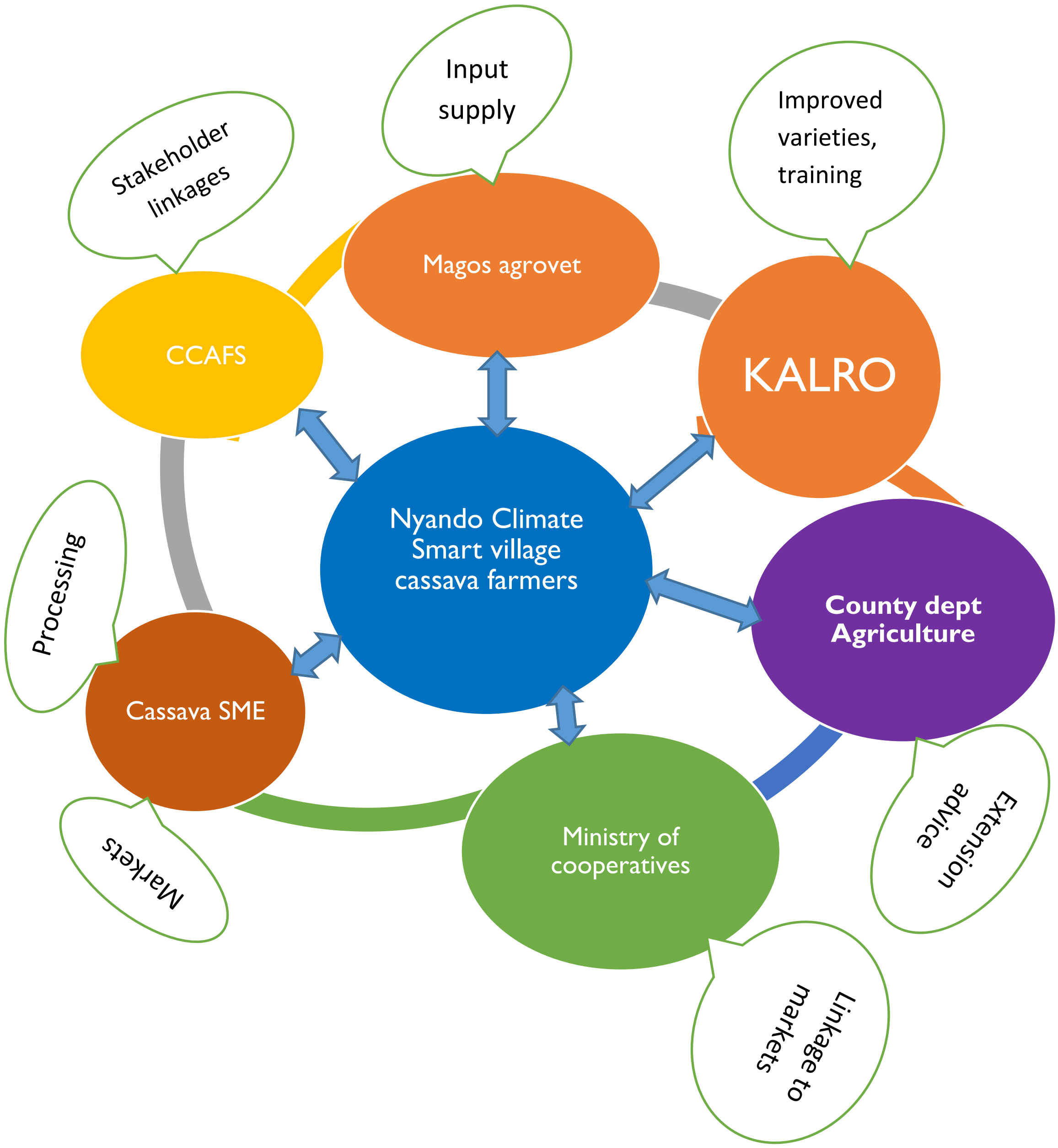

Figure 4.17. Stakeholders linking with Nyando climate smart village cassava farmers

This action research was implemented through the contribution of various stakeholders (Figure 4.18). The Kenya Agriculture and Livestock Research Organization (KALRO) developed improved varieties of cassava, trained farmers on value addition of cassava and distributed the cassava planting materials to the farmers. The county department of agriculture offered extension advice to the cassava farmers. Cassava growing inputs were sourced from MAGO Agrovet, CCAFS provided stakeholder linkages while the ministry of cooperatives capacity-built farmers on collective marketing and market linkage. One of the cassava markets was Kobondo Kamicha Cassava SME, which apart from providing a market for cassava farmers from the study area, also processes cassava produce which it sells to local and distant buyers. Plate 4 is a picture taken during collaborative learning and shows an actor demonstrating on how to plant cassava.

Plate 4: Picture taken during collaborative learning

Photo taken by Paul Tana on 15th January 2021

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary, conclusions and recommendations drawn from the study. It gives the summary the key findings on the hypothesis followed by the conclusions from each of the research questions. Thereafter, recommendations drawn from the study are discussed. Finally, the areas for further research are discussed at the end of this chapter.

5.2 Summary

Positive deviance is an approach that is used to realise the benefits accrued from using climate smart cassava innovations. The study established that positive deviant farmers had significantly gained from climate smart cassava innovations. Some of the benefits the farmers got were higher yields, increase in food security through availability of food for consumption, improvement in their livelihoods following sale of cassava products to local markets and increasing their land portions allocated to improved cassava varieties hence high production as opposed to typical farmers. Additionally, positive deviance among the farmers led to them being able to create linkages with different market players, be able to train other farmers and mitigate climate changes leading to rejection of the null hypothesis that there was no significant influence of positive deviance on the benefits gained from climate smart cassava innovations.

Through collaborative learning, farmers are able to gain knowledge on postharvest handling and marketing innovations. Improved learning entailing (skills, knowledge and competency) among farmers indicated that greatest learning was attained in counting the number of nodes in cassava seed cutting, using inputs in cassava growing, knowledge of the right size of cassava seed cutting and intercropping with other crops leading to high production yields. However, the least learning was attained in weeding of cassava crops. Value addition was also learnt during postharvest handling innovation collaborative learning while in marketing farmers were trained on effective ways of creating linkages to processors. This therefore leads to rejection of the null hypothesis since collaborative learning was effective in improving learning of cassava production, postharvest handling and marketing innovations.

5.3 Conclusions

i. The results from the study revealed a marked trend difference in the use of climate smart cassava innovations in production and marketing between positive deviant farmers and typical farmers. For typical farmers, land allocated under local cassava varieties was maintained as they steadily increased land under improved cassava varieties. On contrast, positive deviant farmers significantly reduced their land allocated to local cassava varieties while they increased land allocated to improved cassava varieties. A trend difference was also noticed where there was an increase in the number of typical farmers using certified cassava planting materials in the year 2020.

ii. Conclusively, production diversification among the positive deviant farms was relatively higher compared to typical farms. Also, results indicated that positive deviant framers attained a relatively high production diversification as opposed to typical farmers in using cassava innovations. On adaptability, there was a significant difference between the positive deviant farmers and the typical farms. While positive deviant farms attained a higher cassava innovation adaptability both on farm and cassava crops, the case was different with typical farms who attained lower farm and cassava crop adaptability. Findings related to food security revealed that among positive deviant farmers, there was a better food security situation following high production which enabled them to consume more and sell more subsequently improving their livelihoods.

Positive deviant farms attained a higher cassava yields as opposed to typical farms. Moreover, there was a difference between positive deviant farms and typical farms where households from positive deviant farms consumed more and sold more cassava to the markets than typical farm households. More input intensification was higher in positive deviant farms. The study looked into tree planting and land management as mitigation measures that were practised on both farms. Compared to typical farms, positive deviant farms planted twice as many trees on their farms. Half of the farmers from both typical and deviant farms purchased or produced tree seedlings. However, only the positive deviant farmers were more than likely to seek advice on proper tree management, agroforestry and introduction of cover crops in their farms which was unlikely of the typical farms. Finally, following these mitigation measures, eight in ten farmers indicated that their farms were improving in productivity compared to when they did not practise it.

iii. Findings for the innovative climate smart “best bet” practices for increasing cassava productivity indicated that irrigation, inorganic fertilizer, organic fertilizer and improved cassava varieties were innovative climate smart “best bet” that favoured positive deviant farmers. On the other hand, typical farmers did not embrace the dis adoption rate, with them abandoning the irrigation practice the most. The difference in dis adoption rates between typical farmers and positive deviant farmers for land and soil management practices in cassava production revealed that use of legumes and mulching were best bet practices for positive deviant farmers. However, terracing was an innovative best bet practice for both positive deviant and typical farmers.

The study also looked into innovative climate smart “best bet” practices for improving cassava post-harvest handling through sorting, grading, packaging, polishing or milling cassava products. Among the common products used were flour and porridge with few references for cakes, snacks and chips. Additionally, more positive deviant farmers were into cassava value addition and embraced it through sorting, polishing, and milling of cassava products relative to their counterparts, typical farmers. Sorting was the most common form of value addition among Nyando CSV farmers. The study further revealed that less positive deviant farmers than typical farmers were using grading/ packaging for cassava value addition.

Among the market arrangements best bet practices between positive deviant farmers and typical farmers, there was a significant difference. A higher weighted difference index score was established among positive deviant farmers than typical farmers. Improving of product quality was a best bet marketing arrangement practice among positive deviant farmers as opposed to typical farmers. On the other hand, compared to typical farmers, product aggregation, accelerating sales, bypassing middlemen, or cementing long-term relationships were of lower value to positive deviant farmers to increase marketing of cassava products.

iv. Among all the seven functions of innovation systems in supporting cassava innovations, only knowledge development had a statistically significant coefficient. Knowledge development, knowledge diffusion and resource mobilization were listed as the most important functions of innovation systems geared towards fostering cassava innovations. However, entrepreneurship, guidance for search, support from advocacy coalitions and market formation ranked low as innovation system functions geared towards fostering cassava innovations in Nyando CSV. Among the most important functions, knowledge development ranked highly followed by knowledge diffusion and resource mobilization came third. On the other hand, among the least important functions, in order of relative importance, market formation, support from advocacy coalitions, entrepreneurship and guidance for search were ranked between 11% and 13%.

v. Collaborative learning has been beneficial to cassava farmers and has fostered cassava innovations in Nyando climate smart villages. There has been improved learning among cassava farmers, which has been positive, basing on their difference after-before index. Through collaborative learning, cassava farmers have been able to improve more in counting the number of nodes in cassava seed cutting, using inputs in cassava growing, knowledge of right size of cassava seed cutting, and intercropping cassava with other crops. Little improvement has however been made in weeding of the cassava crop. The findings further reveal that the greatest learning was recorded in value addition during post-harvest handling and linkage to cassava processors in marketing.

Since the positive-deviance approach offers indigenous solutions, use of positive deviants during collaborative learning had two important advantages over conventional approaches that try to impose solutions from outside. First, progress among the smallholder farmers from the CSV was made quickly, with minimal requirements of outside intervention, analysis or resources. Secondly, the solution to the smallholder farmer's problems were found within the community (from positive deviants who live with them) and the resulting benefits were sustainable.

5.4 Recommendations

From the findings of the study, the following are the recommendations that can be derived;

i. To improve on the trend in the usage of climate smart cassava innovations in Nyando CSV, the study recommends that an alternate quality assurance system be formed to act as a primary mechanism of disseminating information on improved cassava varieties and innovations to farmers rather than relying on intermediaries.

ii. In order to foster cassava innovations using the seven functions systems, there is need to encourage entrepreneurial attitudes (innovativeness, proactiveness and risk taking) among farmers towards adoption of cassava innovations. This has an important policy implication, especially in cases where a new improved cassava variety is to be introduced. Given that entrepreneurial orientations have a diver influence on cassava innovations adoption rates, programs that are tailored towards entrepreneurial training to address the three key aspects; proactiveness, innovativeness and risk taking among cassava farmers need to be implemented.

iii. In order to improve learning among farmers on cassava production, postharvest handling and marketing innovations through collaborative learning, policies should be directed towards creation of networks based on social capitals by establishment of innovation platforms where farmers can interact, network and get trained on cassava innovations. This will enable them boost their cassava production, avoid losses and improve on their marketing through social capital networks hence a better livelihood and food security enhancement.

iv. Innovation systems have a significant role in predicting technological development. More understanding of the dynamics of innovation systems is therefore required. It has been shown that conventional techniques for innovation system analysis, which primarily concentrate on the structure of innovation systems, are insufficient. Therefore, it is essential to establish a framework that focuses on a number of activities (referred to as functions of innovation systems) that are crucial for innovation systems to function well. Functions interact with one another. The accomplishment of one function almost certainly has an impact on the accomplishment of other functions. Therefore, further development of the functions of the innovation systems approach is required to increase the rigor and utility of this approach. This development should be based on theoretical and empirical research into the dynamics of innovation systems-processes at the macro and micro level, as well as policy research into the implications for policy makers, policy concepts, and policy instruments.

v. Collaborative learning is advised since it makes it possible for professionals and farmers to learn in an enjoyable and efficient manner. Additionally, it aids in the development of important abilities like problem-solving and communication. When utilized to develop farmers' abilities, collaborative learning has many advantages. Since a group must debate and evaluate many solutions, collaborative learning enhances problem-solving abilities. As participants in collaborative learning learn to share and listen while working toward a shared objective, it promotes social interaction. Collaboration encourages diversity since it frequently brings together people from different ages, backgrounds, and educational levels. It fosters creativity because one person's thought or suggestion may spark a fresh and original idea from their team members. Participants utilize their verbal communication abilities to communicate ideas, explain concepts, and provide clear and concise feedback, which enhances communication skills. Additionally, it fosters trust among students since they are more likely to work together to assist one another's academic growth, which may enhance productivity. Collaboration in learning boosts self-assurance. Individuals who are introverted can benefit from collaborative learning because it fosters engagement and helps introverts gain confidence. Collaborative assignments also urge passive people to become more involved in the project or debate because the team depends on their input. Because collaborative projects allow students and professionals to strengthen their critical-thinking abilities while also fostering relationships, collaborative learning fosters the development of critical thinking. Due to the fact that collaborative learning frequently brings people together who would not normally interact or work together, it can foster new friendships and enhance existing ones. Team members get to know one another better as they spend time working on a collaborative learning project together. Higher morale and fruitful personal and professional connections may result from this.

5.5 Areas for Further Research

From this study, the researcher identified the following areas that require further probing;

i. It was observed that spoilage in cassava is rapid and that spoilage varies from one cassava variety to the other which was not indicated in this study. This thus brings up the question on the different spoilage mechanism of cassava roots that need to be identified and documented.

ii. Despite the findings indicating benefits accrued by positive deviant farmers towards improved cassava innovations, there is slow uptake of cassava innovations among typical farmers. This raises the concern on why despite the numerous benefits, typical farmers are still steadily adopting improved cassava varieties. Therefore, a detailed study on the willingness to pay for improved cassava innovations among the typical farmers is needed.

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APPENDICES

Appendix 1: Climate Smart Cassava Production Survey Questionnaire

"CONSENT STATEMENT
• This survey questionnaire is for gathering information on how farmers in the Climate Smart Villages (11 villages of Jimo) use Climate Smart Agriculture (CSA) innovations, role of the innovation in farmers attaining CSA benefits, and understanding how farmers foster cassava innovation production, processing and marketing or trading. • Information obtained will be solely for academic research authorized by Egerton University, NACOSTI and Ethical Clearance • Information obtained will not be used for financial or material gain whatsoever. • I undertake to uphold high level confidentiality and ethical standards. • Your name will not appear in any data that is made public. • Your responses to the questions will not affect any benefits to you personally.
• Participation in the questionnaire is voluntary. • I therefore seek your consent to proceed with administering the questionnaire. • Kindly append your signature and date below to give the consent to proceed with the interview

SECTION A: HOUSEHOLDDEMOGRAPHY

A/1: Household identity

Enumerator name		**Date DDMMYY**	

Village name	GPS coordinates	Questionnaire #

Name of head of the household (farm owner)	Gender of household head/ farm owner (*01=male, 02=female)*	Age (years) of household head/ farm owner

Name of person responding *if not the head of the household*	Relationship of respondent to head the of household 01=Head 02=Spouse 03=Child 04=Brother 05=Sister 06=Farm labourer	Household type 01=male headed; 02=female headed' 03=child headed (under 18 years)

A/2: Household demography

For people normally living in this household and head of the household:

Number of all people	Numbe r < 14 years	Number 15- 64 yrs	Numbe r > 64 yrs	Highest educatio n level of HH head	Primary livelihoo d base	Who is makes farm decisions	Who is makes cassava farming decisions
Highest level of education: 01=No formal education; 02=primary; 03=secondary; 04=college certificate/diploma; 05=University **Primary livelihood base:** 01=Crop farming; 02=Livestock farming; 03=Salaried job; 04=Casual labour; 05=Business; 06=Remittance; 07=Pension; **Who makes farm decisions:** 01=Head 02=Spouse 03=Child 04=Brother 05=Sister 06=Farm labourer							

A/3:Climate Smart Agriculture Farming

Member of Climate Smart Village Group 01=No; 02=Yes	If a member (02) then: Name of the Climate Smart Village Group	Years of membership (years)

Activities of the group (01=No, 02=Yes)					
Crop production	Livestock production	Vegetable production	Tree nursery /tree planting	Marketing agricultural products	Savings and/or credit

Do you grow cassava (01=No; 02=Growing local varieties; 03=Growing improved varieties; 04=Growing both local and improved varieties)	

Reason for growing cassava (01=Strongly disagree; 02=Disagree; 03=Not sure; 4=Agree; 05=Strongly agree)			
Can withstand drought		Cuttings easily available	
Can be harvested piece mill		High demand by consumers	
Helps during food shortage		Controls soil erosion	
Can be sold for cash		Conserves soil fertility	
Not labour intensive		Can be intercropped	

Identify any three farmers who also grow improved cassava varieties in this village *(full names and where to find them)*	#1:
	#2:
	#3:

For farmers growing improved cassava varieties, identify one that you rate **as an outstanding performer in Climate Smart Agriculture Practices**, and why so?	*Name of cassava that is outstanding performer in Climate Smart Agriculture Practices:*
	Reason?

Farmer performance category (01=Typical; 02=Positive deviant) **Only fill after the Positive Deviant farmers have been identified**	
Did you interact with the farmer that you consider as outstanding performer in CSA and cassava production in the last two years (1=Yes, 0=No)	
If yes, provide information or technology you obtained/receive from the farmer.	

SECTION B: CROP DIVERSIFICATION WITH IMPROVED CASSAVA VARIETIES

B1: Use of cassava in crop diversification since 2011

B1/1: Since 2011 indicate land acres you have allocated to cassava production including rented farms and whether you were accessing several cassava varieties listed

Cassava	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Land allocation to growing cassava (acres)										
Local varieties										
Improved planting materials										
Growing (01=No; 02=Yes):										
Local varieties										
Improved planting materials										
Certified planting material from fellow farmers										
Certified planting material from Research										

stations										
Adopted some Climate Smart Agricultural Practices **(01=No; 02=Yes):**										
Improved post-harvest handling to reduce losses & wastes **(01=No; 02=Yes):**										
Processed cassava products to sale **(01=No; 02=Yes):**										

SECTION C: ROLES OF CASSAVA INNOVATIONS IN ATTAINING CSA TRIPLE-WINS INDICES

C1: Farm Diversity

Use index score (1, or 2 or 3) to score farm diversity and Cassava diversity based on the frequency counts of agricultural products produced on-farm

C1/1: Production diversification

Use this index score (1, or 2 or 3) to score farm and cassava production diversification based on the frequency counts of agricultural products produced on-farm

Count the # products produced on the farm to score Farm diversity index and cassava diversity		
Index score	**Meaning of Index score**	**# of practices**
01	Low production diversification	producing one to four (1 to 4) products
02	Intermediate production diversification	producing five to eight (5 to 8) products

03	High production diversification	Producing nine or more (≥ 9) products

Farm Diversity score		**Cassava Diversity score**	

Indicate whether in the last 12 months you were producing these agricultural products on the land you were owning or renting

Farm production diversification	(01=No; 02=Yes)	**Cassava production diversification**	(01=No; 02=Yes)
1. Food/cereal crops		1. Local cassava varieties	
2. Cash crops		2. Improved cassava varieties	
3. Fruits		3. Cassava tubers raw	
4. Vegetables		4. Cassava boiled/steamed	
5. Fodder		5. Cassava dried	
6. Large livestock		6. Cassava flour	
7. Small livestock		7. Cassava chips	
8. Livestock products		8. Cassava leaves	
9. Fish		9. Improved Cassava planting materials	
10. Honey		10. 10.Cassava ugali	
11. Timber		11. Cassava porridge	
12. Fuel wood		12. Cassava biscuits/bread	
13. Manure/compost		13. Cassava starch	
14. Agro-forestry tree			

C1/2: Adaptability

Indicate whether you have made these changes in your farming practices and cassava crop since 2011 when CSV was initiated

Farming Changes effected	**Entire farm** ***(01=yes; 02=No)***	**Cassava crop** ***(01=yes; 02=No)***
Introduced a new crop?		
Tested new crop?		
Stopped growing a crop totally?		

Stopped growing a crop in one or more seasons?		
Planted disease-resistant variety crop?		
Planted drought tolerant variety		
Planted higher yielding variety		
Planted shorter cycle variety		
Planted flood tolerant variety		
Expanded area under crop		
Reduced area under crop		
Started irrigating crop		
Introduced intercropping		
Mulch during dry spell		
Introduced crop cover		
Introduced contour ploughing		
Introduced rotations		
Introduced mechanized farming		
Practiced early land preparation		
Practiced late planting		
Started using or using more mineral/chemical fertilisers		
Started using manure/compost		
Weeding crops		
Started using integrated pest management		
Started using integrated crop management		

C1/3: Food security

CSI Scale

Use this Frequency: Number of days out of the past seven: (Use numbers 0 – 7 to answer number of days; Use NA for not applicable), to fill the table below. In the past 7days, if there have been times when you did not have enough food or money to buy food, how many days has your household had to:

	Behaviours	Frequency
a	Rely on less preferred and less expensive foods?	
b	Borrow food, or rely on help from a friend or relative?	
c	Purchase food on credit?	
d	Gather wild food, hunt, or harvest immature crops?	
e	Consume seed stock held for next season?	
f	Send household members to eat elsewhere?	
g	Send household members to beg?	
h	Limit portion size at mealtimes?	
i	Restrict consumption by adults in order for small children to eat?	
j	Feed working members of HH at the expense of non-working members?	
k	Reduce number of meals eaten in a day?	
l	Skip entire days without eating?	

HOUSEHOLD FOOD INSECURITY ACCESS SCALE (HFIAS)

Each of the questions in the following table is asked with are call period off our weeks (30 days). The respondent is first asked an occurrence question– that is, whether the condition in the question happened at all in the past four weeks (yes or no). If the respondent answers "yes" to an occurrence question, a frequency-of-occurrence question is asked to determine whether the condition happened rarely (once or twice), sometimes (three to ten times) or often(more than ten times) in the past four weeks.

No.	**Occurrence Questions**
1.	In the past four weeks, did you worry that your household would not have enough food?
2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?

4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?
5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?
6.	In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?
7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?
8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?

Months of Adequate Household Food Provisioning (MAHFP) for Measurement of Household Food Access

QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
1. Now I would like to ask you about your household's food supply during different months of the year. When responding to these questions, please think back over the last 12 months, from now to the same time last year. Were there months, in the past 12 months, in which you did not have enough food to meet your family's needs? PLACE A *1* IN THE BOX IF THE RESPONDENT ANSWERS YES. PLACE A *0* IN THE BOX IF THE RESPONSE IS NO.	|__|	IF NO, END HERE
2. If yes, which were the months in the past 12 months during which you did not have enough food to meet your family's needs? *This includes any kind of food from any source, such as own production, purchase or exchange, food aid, or borrowing.* *Do not read the list of months aloud. Place a 1 in the box if the respondent identifies that month as one in which the household did not have enough food to meet their needs. If the respondent does not identify that month, place a 0 in the box.* *Use a seasonal calendar if needed to help respondent remember the different months.* *Probe to make sure the respondent has thought about the entire past 12* **Months.** A January B February	A [ ] B [ ] C [ ] D [ ] E [ ] F [ ] G [ ] H [ ]	

C March D April E May F June G July H Aug I Se J Oct K Nov L Dec	I [ ] J [ ] K [ ] L [ ]	

Food category	How often?	Where does this food come from?
Cereals		
Roots and tubers		
Vegetables		
Fruits		
Meat, poultry, offal		
Eggs		
Fish(sea food)		
Pulses, legumes and nuts		
Milk and milk products		
Oils/fats		
Sugar/honey		
Other		

Frequency: 1= everyday (or almost every day), 2= a few times a week, 3= once a week, 4= once a month, 5= Rarely, 6= never

Where does the food come from: 1= self-produced; 2 = purchased; 3=both; 4= gathered, gifted or traded

C1/4: Farm productivity index

ID	Crop	Which proportion of farm land do you use for growing this crop'	Quantity harvested	Unit	Was the harvest good or bad in the last year?	Cropping system 0 = mono 1= intercrop	Which proportion of the harvest did you consume?	Which proportion of the harvest did you sell?	Value of sold crop	Unit of value 1=total value 2=value per unit weight
1										
2										
3										
4										
5										
Proportions 1= All or nearly all (87-100%); 2= More than half of it (63-87%) 3= About half of it (38-62%) 4= Less than half of it (13-37%) 5= A small amount (1-12%)				**Weight unit** 1= Kg, 2= Tonne, 3= Bunch	**Harvest** 1 = Good harvest 2 = Normal harvest 3 = Bad harvest 4=No harvest					

C1/4: FARM INTENSIFICATION

Indicate whether you have effected significant changes in use of the following inputs in cassava, food crops, cash crops since 2011 when CSV was initiated

Cassava intensification index will be computed from seven (7) changes in agricultural practices/behaviour since 2011.

i. Purchased fertilizer
ii. Started to irrigate
iii. Started using manure/compost
iv. Started using mineral/chemical fertilizers
v. Started using pesticides/herbicides
vi. Started using integrated pest management techniques
vii. Planted higher yielding varieties

C1/5: MITIGATION STRATEGY

C1/5A: Water use for Agriculture

Indicate whether you have adopted water use strategies in your farm since 2011 when CSV was initiated in the following areas:

Do you have and use the following in cassava? **01=Yes 02= No**	Irrigation	Water tanks	Dams, water ponds	Boreholes	Water pumps	Piped water
I have on the farm						
I use in cassava production						
I use in cassava processing						
I use for other crops						
I use for livestock						

C1/5B: LAND MANAGEMENT

Indicate whether you have adopted land management strategies in your farm since 2011 when CSV was initiated in the following areas:

Land you own (acres)	**Acreage**	**Land under grazing:** ***owned & rented*** **(acres)**	**Acres**
Land you rent		Land under trees (acres)	
Land under crops (owned*& rented*		What area of your land is degraded or unproductive?	
Land under cassava owned*& rented*		Land has become more productive with practice of Climate Smart Agriculture	(01=No; 2=Yes)

C1/5C: TREE MANAGEMENT

How many trees have you planted on your farm over the last 12 months? *(00=none, 01=less than 10, 02=11 to 50, 03=51 to 100, 04=more than 100)*		Do you sometimes hire farm labour? *(01=Yes, 02=No)*	
How many trees have you deliberately protected on your farm over the last 12 months? *(00=none, 01=less than 10, 02=11 to 50, 03=51 to 100, 04=more than 100)*		Do you sometimes hire a tractor or other farm machinery? *(01=Yes, 02=No)*	
In the last 12 months did you produce any tree seedlings? *(01=Yes, 02=No)*		Do you sometimes hire an animal-drawn plough? *(01=Yes, 02=No)*	
In the last 12 months did you purchase any tree seedlings? *(01=Yes, 02=No)*		Do you sometimes seek for extension advice for your tree management? *(01=Yes, 02=No)*	

D: CLIMATE AND WEATHER INFORMATION

D/1: Access to Weather Information

Please indicate whether you have received any weather information during the last 12 months and what form this takes.

Type of information	Did you receive any information? *01=Yes, 02=No)*	From whom or how did you receive the information?	Were you able to use the advice? *01=Yes, 02=No)*	Did you find the information, advice applicable to cassava production? *01=Yes, 00=No)*
Forecast of drought, flood				
Forecast of pest or disease outbreak				
Forecast of the start of the rains				
Forecast of the weather for the following 2-3 months				
Forecast of the weather for today, 24 hours and/or next 2-3 days				
Weather information sources: 01=Television; 02=Friends/relatives/neighbours; 03= Radio; 04=Govt. agricultural extension; 05= Newspaper; 06= Climate smart village sources				

D/2: Reasons for Starting Climate Smart Agriculture Practices

Reasons	**Cassava**			
		Food crops	**Vegetables**	**Fruits**
Market reasons				
Better price				
Better yield				
New opportunities to sell				
Climate-related reasons				
More overall rainfall				
More erratic rainfall *Early or late start*				
More frequent droughts				
More frequent floods				
Higher temperature				
High disease incidences				
Strong winds				
LAND-RELATED REASONS				
Land is less productive				
Land is more productive				
Land is small				
Others				
Project intervention				
Labour shortage				

SECTION E: FOSTERING CASSAVA INNOVATIONS

Set 1 of 7: Please select from this set of three statements that in your experience and observation has been the most important/effective/facilitative (01) and the least important/effective/facilitative (02) in FOSTERING CASSAVA INNOVATION IN THE NYANDO CLIMATE SMART VILLAGE		
Most important /effective /facilitative / relevant	Statement about the functions of innovations	**Least** important /effective /facilitative / relevant
	Knowledge Diffusion: Strengthening extension services in disseminating knowledge on cassava production and processing	
	Entrepreneurship: Promoting entrepreneurship orientation in cassava production and processing and trading	
	Guidance of the Search: Access to high demand for cassava products	

E1: The relative importance/ effectiveness/ facilitative of the Seven Functions of Innovation Systems (7-FIS) Framework

In this section you are presented with seven sets of three statement options you may choose from to indicate which one you consider has been most important /effective /facilitative / relevant for fostering cassava innovation and which one has been least important /effective /facilitative / relevant for fostering cassava innovation. ***(It is about what your experiences is in this village, there are no right or wrong answers, just objectively evaluate the statements.)***

System function	**Descriptive statement**
F1. Entrepreneurship	Promoting entrepreneurship orientation in cassava production and processing and trading
F2. Knowledge Development	Farm demonstrations of technologies for cassava production and processing

F3. Knowledge Diffusion	Strengthening extension services in disseminating knowledge on cassava production and processing
F4. Guidance of the Search	Access to high demand markets for cassava products
F5. Market Formation	Policies that are directed to developing cassava value chain
F6. Resource Mobilization	Access to affordable credits and funding support for cassava production, processing and trade
F7. Support from Advocacy Coalitions	Empowering farmer groups and service providers in cassava production, processing and trading

Set 2 of 7: Please select from this set of three statements that in your experience and observation has been the most important/effective/facilitative (01) and the least important/effective/facilitative (02) in fostering cassava innovation in the Nyando Climate Smart Village

Most important /effective /facilitative / relevant	Statement about the functions of innovations	**Least** important /effective /facilitative / relevant
	Entrepreneurship: Promoting entrepreneurship orientation in cassava production and processing and trading	
	Knowledge Development: Farm demonstrations of technologies for cassava production and processing	
	Market Formation: Policies that are directed to developing cassava value chain	

Set 3 of 7: Please select from this set of three statements that in your experience and observation has been the most important/effective/facilitative (01) and the least important/effective/facilitative (02) in fostering cassava innovation in the Nyando Climate

Smart Village		
Most important /effective /facilitative / relevant	Statement about the functions of innovations	**Least** important /effective /facilitative / relevant
	Knowledge Development: Farm demonstrations of technologies for cassava production and processing	
	Guidance of the Search: Access to high demand markets for cassava products	
	Support from Advocacy Coalitions: Empowering farmer groups and service providers in cassava production, processing and trading	

Set 4 of 7: Please select from this set of three statements that in your experience and observation has been the most important/effective/facilitative (01) and the least important/effective/facilitative (02) in fostering cassava innovation in the Nyando Climate Smart Village		
Most important /effective /facilitative / relevant	Statement about the functions of innovations	**Least** important /effective /facilitative / relevant
	Guidance of the Search: Access to high demand markets for cassava products	
	Market Formation: Policies that are directed to developing cassava value chain	
	Resource Mobilization: Access to affordable credits and funding support for cassava production, processing and trade	

Set 5 of 7: Please select from this set of three statements that in your experience and observation has been the most important/effective/facilitative (01) and the least important/effective/facilitative (02) in fostering cassava innovation in the Nyando Climate Smart Village		
Most important /effective /facilitative / relevant	Statement about the functions of innovations	**Least** important /effective /facilitative / relevant
	Market Formation: Policies that are directed to developing cassava value chain	
	Support from Advocacy Coalitions: Empowering farmer groups and service providers in cassava production, processing and trading	
	Knowledge Diffusion: Strengthening extension services in disseminating knowledge on cassava production and processing	

Set 6 of 7: Please select from this set of three statements that in your experience and observation has been the most important/effective/facilitative (01) and the least important/effective/facilitative (02) in fostering cassava innovation in the Nyando Climate Smart Village		
Most important /effective /facilitative / relevant	Statement about the functions of innovations	**Least** important /effective /facilitative / relevant
	Support from Advocacy Coalitions: Empowering farmer groups and service providers in cassava production, processing and trading	
	Resource Mobilization: Access to affordable credits and funding	

	support for cassava production, processing and trade	
	Entrepreneurship: Promoting entrepreneurship orientation in cassava production and processing and trading	

Set 7 of 7: Please select from this set of three statements that in your experience and observation has been the most important/effective/facilitative (01) and the least important/effective/facilitative (02) in fostering cassava innovation in the Nyando Climate Smart Village

Most important /effective /facilitative / relevant	Statement about the functions of innovations	**Least** important /effective /facilitative / relevant
	Resource Mobilization: Access to affordable credits and funding support for cassava production, processing and trade	
	Knowledge Diffusion: Strengthening extension services in disseminating knowledge on cassava production and processing	
	Knowledge Development: Farm demonstrations of technologies for cassava production and processing	

SECTION F: INNOVATIVE CLIMATE SMART 'BEST BET' PRACTICES FOR INCREASING CASSAVA PRODUCTIVITY, POST-HARVEST HANDLING AND MARKETING

SECTION F/1:Innovative Climate Smart 'Best Bet' Practices for Increasing Cassava Productivity

Have you changed any aspects of farming based on the climate information received and climate information changes in the last 10 years? _______1=Yes, 0=No

If Yes, which crop farming changes have you made? [MR]__________1= Land management, 2= Crop type, 3=Crop variety, 4= Change in commercial input use, 5=Use of manure/compost, 6= Land area, 7= Field location, 8= Change in timing farming activities, 9= Soil and water conservation, 10= Water management, 11= Tree planting, 12=Timing of harvesting, 13=Timing of crop sales, 14=Cropping system, 99= Other, specify

F1: 2. Please indicate if you are undertaking/have undertaken the listed farming practices on your farm.

Farming Practice	**1=Yes 2=No**	**Year started**	**Ever discontinued (1=Yes, 0=No)**
Use of improved cassava varieties			
Use of legumes in crop rotation			
Use of cover crops			
Diversified crop			
Contour ploughing			
Timely planting			
Line planting			
Planting along the contour			
Changing planting dates			
Efficient use of inorganic fertilizers			
Use of terraces			
Agroforestry			
Use of live barriers			

Irrigation			
Use of organic fertilizers			
Use of inorganic fertilizers			
Planting crops on tree land			
Mulching			
Soil conservation structure			

SECTION F/2:Innovative Climate Smart 'Best Bet' Practices for Increasing Cassava Post-Harvest Handling to Minimize Greenhouse Gas Emission

Type of value addition	If milled, value added product MR
1=Sorting, 2=Grading, 3=Packaging, 4=Polishing, 5=Milling, 6=Product diversification 7=Local brew	1=Flour 2=Cake 3=Snack 4=Porridge 5=Chips 6= Using peels as manure 7= Using flour for making local brew 99=Other, specify

SECTION F/3:Innovative Climate Smart 'Best Bet' Practices for Increasing Cassava Marketing

In this section you are presented with a set of statements about innovative market models you use when marketing, acquiring inputs and marketing cassava products or the ones you may consider as crucial to enabling cassava marketing in your locality. Please indicate to what extent you agree or disagree with the statements with respect to the potential of the market innovation to improving performance of both input and output markets.

1. Collective Action. 1=Strongly disagree, 2=Disagree, 3=Indifferent, 4=Agree, 5=Strongly Agree		
	Input market	Output market
Facilitates/enables access to climate smart farming technologies and innovations		
Enables labour sharing thereby lowering costs associated with cassava production		
Enables bulk purchasing thereby lowering input costs		
Facilitates collective marketing hence inhibits middlemen		
Facilitates access to extension and agricultural training services		
Facilitates access to climate information		
Facilitates mitigation of production risks through contract farming (production insurance and input provisioning)		
Fosters access to financial services		
Fosters product aggregation		
Enables access to buyers that offer product quality premiums/facilitates farmer investment in product quality differentiation		
Fosters scaling of market information delivery through a range of initiatives		
Increases farmers' bargaining power to keep off middlemen		
Encourages uptake and involvement in post-harvest values addition		

Provides access to storage activities		
Lower transport costs associated with marketing		
Creates long-term marketing relationships enabling members to reduce transaction costs		
Enables farmers to have market information and requirements (prices, product quality and standards, and consumer preferences)		
Facilitates mitigation of price risks through contract farming (minimum price guarantees)		
Enables ease of sale of cassava products		

2. Marketing Arrangements

Are you aware of cassava marketing requirements by formal buyers? **_____ 1**=Yes, **0**=N0,

If yes, which formal buyer requirements are you aware of: **________________**

1=Volumes/Quantity, **2**=Quality/Purity, **3**=Safety, **4**=Reliability, **5**=Price, **6**=Variety, 7=,

99=Other, specify **______**

How long does it take before you sell dried cassava after harvesting? 1= Immediately 2= Within 1-month 3= 2-3 months , 4 = More than 3 months

Appendix II: Guiding Question for Focused Group Discussion

Activity 1. Mapping Exercise

Objective: The main objective of this exercise is to develop area profile by mapping the natural resources, infrastructures, social services and land use system within the village.

Tools: Village resource map and focus group discussion, in plenary.

Expected duration: 1 hour

Activities: Ask group members to map out their village/region and its key natural resources, infrastructures, social services and land use system. The checklist below should guide the discussion with community members.

1. Where are the locations of the most important area landmarks surrounding your community (give example of landmarks – external boundaries)?
2. Which resources are available in the village, which are considered to have an impact on people's livelihoods (e. g., crop fields, rangelands, grazing reserves, rivers, degraded areas)?
3. Map the village infrastructure (e. g., settlement patterns, roads, power supply, network access, different types of water points/sources, community buildings, shops, commodity markets)
4. What social services (e. g., health clinics, schools, dwelling places of village authorities, community meeting place, or other important facilities) exist in the area?
5. What are the main land use and resource management systems in the area (e. g., allocation of cropping, communal rangelands, grazing reserves (browse and fodder plant species), seasonal herd movement, areas that herders associate with diseases)?

Interviewing the diagram (Questions to ask or observations to make during the Mapping process)

1. Which resources are plentiful? Which are scarce or lacking?
2. Does the community have land that is held in common? Who makes decisions about how common resources are used?
3. Where are the cassava fields located?
4. Which resources are used-particularly in terms of cassava farming? By whom? Which resources are unused? Which of the resources indicated are the most problematic in relation to cassava production and marketing?

5. Do women and men have different access rights to resources related to agricultural production? If yes, what are they and how do they affect women and men's capacity to undertake cassava production activities? Other agricultural activities?
6. In the household, who makes decisions on the use of land?
7. What are some of the challenges to cassava farming?
8. Where are the markets for cassava products? The input and outlet markets? What are the distances? How are they accessed? By whom?

Activity 2: Livelihoods analysis

Objectives: To identify important livelihood activities and income sources (on farm, off-farm, and non-farm) and trends. To capture differences in key livelihood sources by gender.

Tools: Livelihoods matrix supplemented by focused group discussion with a mixed group.

Activity: Ask group members to list and rank main sources of livelihoods and cash income both from within and outside the area. Emphasize the role of crop related activities compared to the other activities. Discuss if the importance of livelihood activities has changed in the past ten years. Discuss the situation faced by women headed households and households headed by older people and other particular groups identified in the wealth ranking.

1. What are the main sources of livelihoods and cash income in the area?
2. Rank the sources of livelihoods in order of importance. What is the importance of cassava farming compared to other activities?
3. What livelihood activities are important sources of cash income? Is Cassava an important component?
4. What activities are new and what other changes did farmers observe in the relative importance of the livelihoods?
5. What differences do you observe for women and men (e.g., access to land and livestock, control over production and sale)

Activity 3: Problem/Constraints and opportunities in Cassava farming

Objective: To identify major constraints and problems in Cassava farming and to broaden the discussion about their causes and effects. Highlight current coping or response strategies and to indicate whether efforts to address a particular problem have already been tried and failed or have incompletely addressed the problem.

Tool: Problem ranking and Problem Analysis Chart

Activity: Organize a mixed group of men and women and ask them to think about their problems. Ask them to list at least six problems that are most important to them in Cassava farming. The group should then rank the problems according to importance and use different amount of stones to represent the ranking - the greater number of stones, the greater emphasis they place on the problem. Ask the group to discuss the causes and effects of these problems. Draw a problem analysis chart that lists the priority problems, the causes and effects, the coping or response strategies, and the opportunities or proposed solutions for change.

Questions to ask during the process:

1. Which problems/constraints are related?
2. Which groups (social categories) share which problems
3. What are the current coping/response strategies for each problem? Do men and women cope differently? Why these solutions were not already implemented? What solutions can be implemented locally? Which ones require outside assistance?

Activity 4: Innovation systems and actor analysis

Tools: Focused group discussion, actor linkage map, actor analysis matrix.

Objectives:

This session is aimed at:

- Identifying and documenting the status of innovations in Cassava industry
- Identifying major actors in the Cassava innovation systems, the roles they play, and activities in which they are involved,
- Assess attitudes and practices of main actors (focusing on the way they work, particularly their history of collaborations, pattern of trust, culture of innovation, etc.)
- Understand patterns and effects of interactions (particularly risk taking behaviours, informal/formal networks, partnerships, actor coordination mechanisms, etc.)
- Assess the enabling environment (policies and infrastructure)

Activities:

1 Identify and document status of innovations in Cassava industry as these relate to the Climate Smart Cassava Project

(a) What are the major innovations in the Cassava industry? (Suggestion: first, ask group members to list prevailing conventional inputs, products and process or practices in the cassava.

Then ask them to identify (and for you to document) new and emerging innovations. Structure the discussion around:

- (new) varieties selected and adopted
- (new) cassava services received or bought
- (new) products being implemented; new processes applied (for example, do farmers convert cassava tubers/leaves into other products and how?)
- packaging and other innovations
- (new) organizational innovations at the household level and community levels (for example, cooperatives societies being established).
- Other relevant innovations

(b) Who are the innovative farmers? (Identify innovative farmers in the Cassava innovation system, and give some characteristics of these farmers – are they rich, poor farmers; are they women farmers, educated farmers, etc. Also give some indications of their numbers).

2 **Identify actors in the Cassava innovation systems, the roles they play, and activities in which they are involved**

a. Who are the important actors in Cassava production, processing, marketing and use?
b. What are the core activities that major actors perform? What did they basically achieve in your village?
c. Are the actors still active in the village?
d. What are their main constraints? Do they vary by season?
e. Do different actors in the community link with different people, or have different types of links, for example, richer households, migrants, minority ethnic groups?

3 **Understand patterns and strengths of interactions**

a. How important are these actors to you?
b. With whom are they interacting? How strong/effective are those links?

(Categorize actors according to their importance. As you do this think about the quality of interaction you make with them; the frequency and speed of interaction, physical distance between actors, etc. Also think about if interactions vary by season. Indicate with arrows on the actor linkage map (0 = have no link, dotted line = link exists but not functioning, dashed line =

link exists but weak, thin line = link exists but needs strengthening, thick line = strong and effective; arrows denote direction of information or service flows).

c. Where and how frequently do you interact with these actors (media used, location)? Arrange the actors on a manila/flip chart according to their distance from the community/village, clarify if they are inside or outside the community/village, and in relation to the final consumers
d. Are interactions two or one way flows?
e. What new actors and/or new links would you like to create, or strengthen to help you with your Cassava production? Identify missing actors and linkages, using different colours than previously.
f. What actors are missing for improved Cassava production and marketing in your area? What activities and achievements would you expect from the missing actors? How should they be linked to the existing actors?

4 Assess attitudes and practices of main actors (collaborations, trust, culture of innovation, etc.)

(a) If any which actors have histories of collaboration? In which innovation areas were these collaborations?
(b) Are there some formal/informal networks in the Cassava innovation systems?
(c) Are there mechanisms for coordinating actors in the Cassava innovation systems? Identify these mechanisms.
(d) Do actors trust each other in what they jointly do?
(e) Give more indicators of attitudes and practices

5 Assess the enabling environment (policies and infrastructure)

(a) What are the (current) enabling (or constraining) policies, regulations, guidelines relevant to the Cassava industry?
(b) If any, what resources (personnel, budgetary, etc.) are allocated to the industry?
(c) What are the relevant and available (or missing) infrastructures to the Cassava industry? (These may include ICTs and credit facilities).

Activity 4: Appreciative Inquiry 4-D Model

Appreciative 4-D cycle inquiry tool will be used during the FGDs to collect data on marketing of farm products.

Discovery Phase

Participants interview one another in pairs, collecting stories about the group at its best, collecting ideas about the group's most valuable resources, and collecting information about the group's desired future.

1. In line with marketing of your farm produce, tell me a time when you felt most happy, energized, and proud of yourself.
2. Without being humble, what do you value most about yourself? Farming?

   Marketing of your farm produce?
3. What factors do you consider that can improve marketing of your produce?
4. What wishes would you want to make for the government to help in improving marketing of farm produce in this village?

Dream Phase

Here participants imagine their desired future and give it shape. A dream will be in form of a written vision of the future.

1. As a farmer who is also involved in marketing of farm produce, what should be done to help farmers get rewarding prices for their produce in future?

Design Phase

Here participants will be made to work toward the direction implied in the Dream. The group is expected to define the values, ideals, and methods of change and growth that will achieve these dreams.

1. Comment on strategies, structures and processes that can lead to improved marketing of farm produce in the future.

Design Phase

This will involve committing to the iterative exploration of learning, innovation, and delivery of results.

Questions to aid in reflection

1. How did you feel during the task?
2. How did you feel after the task?
3. What things didn't go so well?
4. What could have been changed to make the outcome more favourable?

Appendix III: Key Informant Checklist

Target group to be interviewed:

Market chain: middlemen, buyers, processors, transporters.

Service/input suppliers: government, NGO, private sector

Check list of actors identified in village meeting.

Objectives

Widen understanding of the current cassava innovation system in the Climate Smart Village:

- Identify key actors, channels of communication and flows of information and goods.
- Key events and forums where actors in this innovation system interact.
- Current innovations and potential entry points for effective interventions.

Check list for market actors

1. Who do you buy your cassava products from?
2. Who do you sell your cassava products to?
3. Who do you get information from to help you with your business?
4. Who do you share information with?
5. What events/forums/ means of communication do you use to interact with these people?
6. What are the key changes (good and bad) you have observed in this business since you started working in it? What were the causes of these developments (people, policy, other factors)?
7. What are the opportunities you see to develop your business?
8. What are the constraints that prevent you doing so?
9. What new links would you like to form to develop your business?

If the interviewees seem interested in the program, collect their names and addresses as potential future partners.

Checklist for - Service/Input providers

1. Who do you get inputs/services/information concerning Cassava farming from?
2. Who do you provide inputs/services/information concerning Cassava farming to?
3. What events/forums/ means of communication do you use to interact with these people?
4. What are the key changes (good and bad) you have observed in Cassava farming since you started working in it? What were the causes of these developments (people, policy, and other factors)?
5. What are the opportunities you see to develop your Cassava farming business/service?
6. What are the constraints that prevent you doing so?
7. What new links would you like to form to develop your Cassava farming business/service?

Appendix IV: Learning Forum Evaluation

Introduction

The purpose of this survey is to evaluate the Learning Forum for improving cassava production and marketing in Jimo East Climate Smart Villages. Your honest answers are important to this study and will be kept confidential.

SECTION 1: EVALUATION OF THE LEARNING FORUM

1. Knowledge before joining the Learning Forum

Rate the following activities regarding the level of farmer's knowledge on cassava production and marketing before joining the Learning Forum

	Level of Knowledge				
Activity	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Siting of the cassava plot					
Land preparation					
Time of planting cassava					
Sourcing of improved cassava cuttings					
Selection of cassava seed					
Number of nodes of cassava seed					
Size of cassava seed cutting					

Spacing at planting					
Planting of cassava seed cuttings					
Weeding of Cassava crop					
Identification of cassava diseases					
Crop rotation					
Intercropping with other crops					
Use of inputs in cassava growing					
Linkage to consumers					
Linkage to processors					
Collective marketing					
Value addition on cassava products					
Time of harvesting cassava					
Storage of dried cassava					

2. Knowledge acquired in LF

Rate the level of farmer's knowledge acquired from the LF in the following training areas:

	Level of Knowledge				
Training Area	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Siting of the cassava plot					
Land preparation					
Time of planting cassava					
Sourcing of improved cassava cuttings					
Selection of cassava seed					
Number of nodes of cassava seed					
Size of cassava seed cutting					
Spacing at planting					
Planting of cassava seed cuttings					
Weeding of Cassava crop					
Identification of cassava diseases					
Crop rotation					
Intercropping with other crops					

Use of inputs in cassava growing

Linkage to consumers

Linkage to processors

Collective marketing

Value addition on cassava products

Time of harvesting cassava

Storage of dried cassava

Appendix V: Rearch Permit

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Appendix Vl: Publications and Presentations

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ASSESSING DIFFERENTIAL GAINS THAT OUTSTANDING AND AVERAGE PERFORMING FARMERS ATTAIN FROM CLIMATE-SMART CASSAVA INNOVATIONS IN NYANDO CLIMATE-SMART VILLAGES, KENYA

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ABSTRACT

In adoption of agricultural innovations, a few farmers attain outstanding outcomes above their peer majority. This reveals a positive deviance behavior in successful deployment of technologies and innovations. Assessing this behavior in climate- smart agriculture (CSA) can reveal the yield gap in triple wins of CSA (adaptation, farm productivity and mitigation). This study investigated differential gains in these CSA triple wins between outstanding (positive deviants) and average (typical) performing farmers who have adopted climate smart cassava innovations in Nyando Climate Smart Villages (CSV). In a household survey, a sample of 150 farmers were reached, which through snowballing approach, peers identified 30 to exhibit positive deviant behaviour. Presenting these in Focus Group Discussion (FGD) with stakeholders further isolated six farmers being those they consider positive deviants (PDs) in climate smart cassava innovations. Data were subjected to cross-tabulation to generate frequencies used to compute weighted index scores. This revealed increasing magnitude and was a preferred fair comparison of a sample of fewer positive deviants (n=6) with large number of typical (n=144) farmers. Results revealed substantial differences in the attained triple win gains from climate smart cassava innovations between typical and positive deviant farmers. The weighted index scores showed that positive deviant farmers had attained higher adaptability, production diversification, farm productivity and intensification, food security and were implementing more mitigation practices for climate change. This empirical evidence demonstrates potential gains from climate smart cassava innovations when deployed effectively. This is because innovative management practices distinguish positive deviant farmers from typical farmers. These typical farmers would benefit more by learning from positive deviant farmers about effective deployment of climate smart cassava innovations. The study recommends strengthening extension services linked to farmer platforms in order to grow capacity for more effective deployment of climate smart cassava innovations for realising the CSA triple wins.

Key words: Adaptability, food security, productivity, production diversification, positive deviants, cassava innovation

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Full Length Research Paper

Relative importance of functions of innovation system on cassava climate smart farming in Kenya

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Functions of innovation systems framework have established their value as tools for exploring socio-technological transitions and economic development. Although the "seven functions" model has demonstrated its academic value across a vast literature, there have been few attempts to explore the role of the model in climate smart farming. Therefore, the aim of this study is to determine relative importance of functions of innovation system on cassava climate smart farming in Kenya. The study focused on the following seven functions of innovations; entrepreneurial activities, knowledge development and diffusion, search for guidance, market development and stabilization, resource mobilization and legitimacy development. Data were collected from 150 cassva farmers in Nyando Sub-County, Kenya. Data analysis deployed the Best-Worst scaling (BWS) choice method and expanded to include the multinomial logistic regression modelling. Results revealed that knowledge development, diffusion and resource mobilization were the functions of innovation systems ranked highest in terms of shared importance among the seven innovation functions. In fostering cassava innovations, their relative importance was knowledge development (19.17%), knowledge diffusion (18.86%) and resource mobilization (14.88%). Evidence from the multinomial logistic regression revealed that farmers chose knowledge development as most important innovation function to foster cassava innovations in the Nyando CSV.

Key words: Entrepreneurial activity, knowledge development, market formation, resource mobilization.

INTRODUCTION

Understanding the emergence of innovation systems and their role has been central to monitoring and evaluating technological innovation change processes in most organizations (Markard et al., 2015). In essence, the key activities that contribute to the development of the innovation system, as well as the functions of the innovation systems, have received a lot of attention (Nevzorova and Karakaya, 2020). It is already evident

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