MONITORING THE IMPLEMENTATION, PERFORMANCE AND OUTCOMES OF CLIMATE SMART AGRICULTURE IN THE CLIMATE CHANGE AGRICULTURE AND FOOD SECURITY CLIMATE-SMART VILLAGES

REPORT

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ABSTRACT

Climate-smart agriculture (CSA) puts the challenges of agricultural development at the heart of transformational change in agriculture by concurrently pursuing increased productivity and resilience for food security. Land tenure insecurity for millions of smallholder farmers, including women, declining soil fertility, degraded ecosystems, poor market access, inadequate funding and inadequate infrastructure development continue to hinder agricultural development in Africa. These challenges are expected to be further exacerbated by climate change which has emerged as one of the major threats to agricultural and economic development in Africa.

The proposed research work seeks to assess the different Climate Smart Agriculture practices carried out by the smallholder farmers, assess the performance and implementation rate of the practices and to identify barriers and enabler for wide scale adoption of these practices in order to scale up climate smart agriculture among smallholder farmers in Uganda to improve food security and farming system resilience of mixed crop-livestock. A multi-stage random sampling method was employed to survey 85 households of 154 smallholder farmer respondents in the study area. Data was analyzed using multivariate analysis, tested for significance, percentiles, graphs and an inductive analytical method was used.

The findings are expected to reveal the implementation rate, performance and outcomes of the selected practices for scaling up CSA in Uganda. It will also proffer recommendations on how to maintain and further strengthen the practices in Uganda.

Keywords: Climate Smart Agriculture, Uganda

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LIST OF ACRONYMS AND ABBREVIATIONS

- AEZs- Agro-ecological Zones
- AgMIP- Agricultural Model Intercomparison and Improvement Project
- CBOs- Community Based Organizations
- CCAFS- Climate Change Agriculture and Food Security
- CGIAR- Consultative Group on International Agriculture Research
- CIAT- International Center for Tropical Agriculture
- CO_2- Carbon dioxide
- COMESA- Common Market for Eastern and Southern Africa
- CSA- Climate Smart Agriculture
- CSOs- Civil Society Organizations
- CSVs- Climate-Smart Villages
- DWRM- Directorate of Water Resources Management
- EAC- East African Community
- ESSP- Earth System Science Partnership
- FAO- Food and Agriculture Organization
- GDP- Gross Domestic Product
- GHG- Green House Gases
- IFAD- International Fund for Agricultural Development
- IFPRI- International Food Policy Research Institute
- IIASA- International Institute for Applied System Analysis
- IPCC- Intergovernmental Panel on Climate Change
- LGA- Local Government Area
- MAAIF- Ministry of Agriculture, Animal Industry and Fisheries
- ML&E- Monitoring, Learning and Evaluation
- NEPAD- New Partnership for Africa's Development
- NGOs- Non-Governmental Organizations
- RBM- Result- Based Management
- RCPs- Representative Concentration Pathways
- SIM- Subscriber Identification Module
- SRES- Special Report on Emissions Scenarios

- SRF- Strategy and Results Framework
- SSPs- Shared Socio-economic Pathways
- UBOS- Uganda Bureau of Statistics
- UNFCCC- United Nations Framework Convention on Climate Change
- WDR- World Development Repot
- WFP- World Food Programme

CHAPTER ONE

1.0 INTRODUCTION

1.1 PROBLEM STATEMENT

The agricultural sector is a key sector of both the global economy and many national economies. It provides livelihoods and basic subsistence needs for millions of people, and contributes to the achievement of food security in both developing and developed countries. Worldwide agricultural production is expected to decrease under climate change projections, posing a threat to global food security (IPCC, 2007). However, it is also important to note that agriculture contributes a significant amount of global emissions annually, which would increase with the intensification or expansion of production to meet higher demand.

There is growing acknowledgement that agriculture and food systems need to change, irrespective of climate change (IFAD/FAO/WFP). The last time the world faced such pressure to find a permanent solution to world food insecurity was in the 1960s and 1970s, when food production and distribution could not keep pace with the growing population(primarily in Asia). The response was the Green Revolution: high-yielding, pest/disease resistant varieties of mainly rice and wheat were introduced and their cultivation was supported through subsidies for inputs such as seed, fertilizer and irrigation (FAO data).

The need for climate-smart agriculture for the world's 500 million smallholder farms cannot be overlooked, they provide up to 80 per cent of food in developing countries; manage vast areas of land (farming some 80 per cent of farmland in sub-Saharan Africa and Asia) and make up the largest share of the developing worlds undernourished. As the most vulnerable and marginalized people in rural societies –many of them are women heads of household or indigenous peoples – are especially exposed to climate change. They inhabit some of the most vulnerable and marginal landscapes, such as hillsides, deserts and floodplains. They often lack secure tenure and resource rights. They rely directly on climate-affected natural resources for their livelihoods.

Climate-smart agriculture might have the potential to offer 'triple-win' benefits from increased adaptation, productivity, and mitigation (Lipper *et al*, 2010), providing a possible strategy to address both climate change and food security concerns. Climate-smart agriculture involves the use of different 'climate-smart' farming techniques to produce crops or livestock, which could help reduce pressure on forests for agricultural use as well as potentially maintain or enhance productivity, build resilience to climate change and mitigate the sector's high emissions (Maybeck and Gitz, 2013).

About 1.2 billion hectares (ha) (almost 11 per cent of the Earth's vegetated surface) has been degraded by human activity over the past 45 years. An estimated 5 million to 12 million ha are lost annually to severe degradation in developing countries (IFPRI, 1999). The causes include deforestation, biomass burning and agricultural practices such as repetitive tillage and inadequate application of nutrients. The worst affected is sub-Saharan Africa, where per capita food production continues to decline and hunger affects about a third of the region's population. Continued cultivation of marginal areas without adequate management is a major driver of widespread land degradation through deforestation, wind and water erosion, and overgrazing.

1.2 OBJECTIVES OF THE STUDY

The overall objective is to examine and monitor the nature and patterns of the Implementation, Performance and Outcomes of the practices of Climate Smart Agriculture in the CCAFS Climate-Smart Villages.

The specific objectives of the study:

1. To assess the different CSA practices carried out by the farmers based on their socio-demographic features.
2. To assess the implementation, performance and outcomes of CSA on smallholder farmers
3. To identify barriers and enablers for wide scale adoption of CSA practices

1.3 JUSTIFICATION OF THE STUDY

Climate change is adding pressure to the already stressed ecosystems in which smallholder farming takes place. Over the centuries, smallholders have developed the capacity to adapt to environmental change and climate variability, but the speed and intensity of climate change is outpacing their ability to respond. Many of IFAD's smallholder partners are already reporting climate change impacts on the key ecosystems and biodiversity that sustain agriculture. In the absence of a profound step change in local and global action on emissions, it is increasingly likely that poor rural people will need to contend with an average global war warming of 4° C above pre-industrial levels by 2100, if not sooner (Betts *et al,* 2011). Such substantial climate change will further increase uncertainty and exacerbate weather-related disasters, drought, biodiversity loss, and land and water scarcity. The major cereal crops (such as wheat, rice and maize) are already at their heat tolerance threshold and with an increase in temperature of between 1.5° C and 2° C could collapse (IPCC, 2010). Livestock productivity will be impacted by increased temperature with higher-yielding breeds more likely to be negatively affected than more-robust local breeds. The rise in temperature will, of course, have an impact not only on crops and livestock but also on the pests and diseases they are exposed to. Some farming systems will not remain viable because of climate change, requiring farming system shifts (IPCC, 2010)

Due to constraints, project evaluations are often undertaken after projects have finished making it too late to make improvements. Even when impact assessment is considered from the beginning, such activities usually do not take into account farmer/participant feedback systematically. This research intends to monitor and explore the implementation level of the CSA practices, evaluate the performance of the practices as well as outcomes which will serve as a feedback mechanism for the stakeholders in order to keep track of the project, learn lessons from it and also make adjustments where necessary.

1.4 SCOPE OF THE STUDY

This study focuses on monitoring performance, implementation and outcomes of climate smart agriculture in Nwoya District. This study is a mid-term review of the project implementation. It will determine progress being made towards the achievement of outcomes and will identify course correction if needed. This study will focus on identifying the types of CSA practices implemented by the smallholder farmers after the demonstration and examine the performances of the implemented practices. Findings of this study will be incorporated as recommendations for enhanced implementation during the final half of the program's term.

CHAPTER TWO

2.0 BACKGROUND TO THE STUDY

2.1 INTRODUCTION

According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), rising temperatures and increased frequency of extreme events will have direct and negative impacts on crops, livestock, forestry, fisheries and aquaculture productivity.

Climate change is a universal and critical challenge for global food security. Improving the way we manage agricultural systems and natural resources is fundamental for effectively achieving food security. We can no longer afford to separate the future of food security from that of natural resources, the environment and climate change – they are inextricably intertwined and our response must be as well. Efforts to reduce food insecurity must include building the resilience of rural communities to shocks and strengthening their adaptive capacity to cope with increased variability and slow onset changes. The agricultural sectors (crops, livestock, forestry, fisheries) must therefore transform themselves in order to feed a growing global population and provide the basis for economic growth and poverty reduction. This transformation must be accomplished without hindering the natural resource base.

Climate change is already having a significant effect on agriculture, fisheries and forestry in Africa. Some impacts are being felt over time including increase in mean temperatures, changes in precipitation patterns and water availability, sea level rise and salinisation and severe disruptions to important ecosystems (FAO, 2013). Other climate change impacts present more sudden and extreme weather events such as desperate periods of droughts, extreme heat and/or floods.

FAO has recognized that for agriculture to feed the world in a way that can ensure sustainable rural development, it must become 'climate smart'. Climate-smart agriculture (CSA), as defined and presented by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010 is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. (FAO, 2013). It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing the food security, ecosystems management and climate change challenges. It contributes to the achievement of national food security and development goals with three objectives:

1) Sustainably increasing agricultural productivity and incomes
2) Adapt and build resilience to climate change
3) Reduce and/or remove greenhouse gas emission where possible

Climate-smart agriculture includes proven practical techniques, such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agro-forestry, improved grazing and improved water management and innovative practices, for instance better weather forecasting, more resilient food crops and risk insurance (Boto *et al*., 2012). Adaptation to CSA can occur in many ways; from the individual field, where a crop is grown, varieties are selected and management decisions such as tillage, fertilization, and pesticide application are made, through the farm level, where managers choose among crops, livestock and other activities and capital investment decisions are made, to the landscape level, where decisions are made about management of water resources, biodiversity, forests and energy.

2.2 AGRICULTURE AND DEVELOPMENT IN UGANDA

Agriculture is vital for the development goals of promoting growth and reducing poverty in Uganda. Agriculture supports the livelihoods of 73 percent of the households, provides employment for about 33.8 % (UBOS, 2014) of the economically active population, and over 80 percent of the poorest of the population. The proportional contribution of the agricultural sector to the Gross Domestic Product (GDP) of Uganda currently stands at about 20.9 percent. The sector continues to maintain its historical reputation as the primary driver of economic growth and poverty alleviation. Thus, the sector is most important in terms of food security, employment, household income, raw materials for local industry and exports to regional and international markets (Agriculture Policy, 2013).

Agriculture has been and continues to be the most important sector in Uganda’s economy. It employs about 65.6% of the population aged 10 years and older (UBOS, 2010). In 2010/11, the sector accounted for 22.5 percent of total GDP (MAAIF 2011). Agricultural exports accounted for 46 percent of total exports in 2010 (MAAIF 2011). The sector is also the basis for much of the industrial activity in the country since most industries are agro-based. Even though its share in total GDP has been declining, agriculture remains important because it provides the basis for growth in other sectors such as manufacturing and services. It is also the sector that provides equal opportunities for employment for both men and women in Uganda.

Uganda has a diverse agricultural production system within 14 Agro-ecological Zones (AEZs). The zones are characterized by different farming systems determined by soil types, climate, and socio-economic and cultural factors. The AEZs experience varying levels of vulnerability to climate-related hazards which include drought, floods, storms, and pests and diseases (GoU, 2007). Total dependence on rain-fed agriculture increases vulnerability of farming systems and predisposes rural households to food insecurity and poverty. This is largely attributed to the consistently low yields of major staples (maize, millet, sorghum, beans) and cash crops due to climate change and increasing weather variability. High population growth estimated at 3.2% p.a has led to dwindling of the average household landholding to less than 0.5 ha, accelerated land fragmentation and soil nutrient-mining in areas with high production potential. The predominant smallholder production system is therefore characterized by low use of external inputs (such as improved seeds, agro-chemicals and fertilizer), poor land management practices and rudimentary production tools which contribute to low agricultural productivity and high post-harvest losses currently estimated at 30%. Furthermore, marketing infrastructure and road networks in rural areas are still underdeveloped.

Although Uganda has a well-developed agricultural research system, use of modern science and climate smart technologies in agricultural production is still limited. Inadequate research–extension–farmer linkages to facilitate demand-driven research and increased use of improved technologies continue to constrain efforts to increase agricultural productivity as farmers continue to use outdated and ineffective technologies. The role of research will be re-oriented to support innovations that facilitate the transition to climate-smart agriculture by smallholder farmers. New and emerging agricultural research partnerships will identify technological advances that respond to the impacts climate change and climate variability. A major thrust will be use of climate-smart agricultural practices, promoting improved land management and sustainable crop-livestock and fisheries intensification, in order to bolster farmers' adaptive capacity and support the national vision of achieving food security.

People and Livelihoods

Nwoya district has one livelihoods zone, the 'Agriculture livelihood zone' dominated by crop farming and less livestock farming. Its topography is relatively flat characterised with streams, swamps, rocks and game reserves. Its vegetation is savannah characterised by long grass, thickets and trees of albizia species with a bi-modal rainfall pattern. The main soil type in this district is the sandy loam with some areas having black cotton soils.

The area has two agricultural seasons from March to June and August to November, the first rains of March to April characterise the main production season in the year. The main crops grown for food include; cassava, sweet potato, beans, groundnuts, sesame, sorghum and millet while those grown for cash include groundnuts, rice, maize, beans, sesame and to lesser extent cassava and millet.

Economic Relevance of Farming

Agriculture plays a pivotal role in many economies in Africa; it is the main engine for economic growth. The main livestock products for home consumption in the livelihood zone are poultry and eggs, pork, meat, mutton and cow's milk. The livestock and livestock products mainly sold for household cash income include poultry, pigs, goats, cow's milk and beef. Local farmers within the livelihood zone mainly practice subsistence farming and majorly labour on rich people' farms to meet their non-food needs.

Poultry keeping is mainly associated with poorer households compared with piggery, goats, sheep and cattle which are a domain of the wealthier households. The Zone is sparsely populated except at trading centres, where it is densely settled.

Agricultural Activities

Nwoya District is endowed with rich soils and much rainfall. This enables farmers to grow various crops and harvest many of those crops twice a year. In Nwoya District, there are still vast tracts of land which have not been fully used for crop production and livestock rearing. After accommodating returnees in their home villages, the population density of Nwoya District as a whole will be moderate.

Although the land in Nwoya District is mostly communal land, there are some large-scale privately leased lands in certain parts of the districts. There is development potential for commercial agriculture using modern technology. Agriculture is the backbone of the district economy in Nwoya District. The major source of household incomes is sale of crops. In Nwoya Districts, about 85% of income is from sale of crops, about 7% is from wages for casual labour and 5% is from sale of forest products. (DWRM, 2013). The major crops by quantity of production are cassava, groundnuts, sorghum, simsim (sesame), maize, rice, and other crops, such as finger millets, peas, and sunflowers. Fruits like citrus, mangoes, pineapple and bananas are also produced. These are considered as both food and cash crops. Cotton and tobacco were the major cash crops before. However, they are scarcely produced these days.

Gender Issues in Agriculture

Women in northern Uganda constitute about 51% of the population and 80% of all food crop producers according to Trust for African Orphan's Project. These women smallholder farmers are constrained by poor access to markets, limited entrepreneurial skills for diversification and burdened with taking care of the entire household which sometimes include older relatives. Also, rights to land, ownership, and control are in favour of men, as well as other cultural and social limitations that hinder women smallholder farmers from reaching their full potentials.

Agriculture Sector Challenges

There are various challenges for enhancement of the agricultural sector. When farmers restart their farms, they sometimes face conflicts over the land. Even when there are no land conflicts, clearing bushes is a big challenge for them. After starting farming, agricultural implements such as hoes are lacking, which causes farmers to carry out inefficient farming. Also, climate is changing these days and the rain patterns are now erratic. Because of this, farmers apply the method of trial and error to their farming practices in response to the erratic weather patterns.

As regards livestock, tsetse flies, which cause human sleeping sickness and animal trypanosomiasis, are spread among cows and goats. Spraying animals is one solution to protect animals from tsetse flies. However, it is expensive. Clearing bushes is another solution. But, it is not recommended from an environmental point of view.

When farmers want to sell their products, transportation is a barrier. There is an inadequate road network in Nwoya District and there are a lot of bottle necks, lacking proper bridges and culverts. Some roads become impassable when it rains. These make it difficult to reach farms by vehicles. After harvesting, farmers need to use vehicles to transport their products. However, many farmers cannot even afford to hire motorbikes.

How Climate Change is Affecting Agriculture

An increase in temperature or changes in rainfall intensity, distribution, and patterns are likely to have a direct effect on ecosystem functions, services, and species distribution and survival throughout Uganda. Projected climate change is likely to adversely affect the hydrological cycle of forested water catchments by weakening their capacity to maintain water cycles and recharge groundwater. This impact is likely to lead to a significant shift in flora and fauna distribution, disturb the ecological balance between species, cause habitat degradation due to increased prevalence of invasive species, and increase the occurrence of wild fires. As a result, the overall availability of ecosystem-specific goods and services that support human livelihoods is expected to be adversely affected.

Extreme dry or wet conditions may trigger wildlife migration outside home ranges or entry of people and livestock into protected areas. An increased temperature renders natural ecosystems vulnerable to disasters such as forest fires and more susceptible to pest and disease outbreaks. The prevalence of pests, diseases, and mold tends to increase under wetter conditions and is likely to lead to increased postharvest losses of forest products (Tetra Tech ARD, 2013) see proposal). Due to continued high inter-annual variability, warmer temperatures combined with erratic precipitation substantially increase the likelihood of diseases and pests because both multiply more quickly under warmer conditions and are able to migrate to higher altitudes where their presence was previously unknown. Increasing temperatures could lead to dryer conditions and more frequent and destructive fire outbreaks. Increasing frequency of severe floods due to high rainfall intensity is likely to cause social and economic hardship. Floods result in displacement of people and their livelihoods (e.g., agriculture) particularly in low-lying areas such as the Pian-Upe-Bisina-Opeta Wetlands that are important for seasonal grazing, fisheries, and agriculture. On the other hand, low surface and ground water levels are already adversely affecting livelihoods. When the water level of Lake Victoria declined significantly in 2003-2006 due to a reduction of in-flows and precipitation over the lake, water transport and tourism activities at several beaches declined significantly (Directorate of Water Resources Management [DWRM], 2013).

Adaptation to Climate Change and Variability

The poor are most vulnerable to climate variability and change and there is need to safeguard them. About 30% of Ugandans live below the poverty line and 70% depend on crops, livestock and fisheries which are sensitive to climate variability and change. A large proportion of Ugandans are therefore vulnerable and there is need to understand the impacts of climate change on these sectors and to equip, especially the poor, with knowledge and practices to adapt and become more resilient.

The climate change effects are already being felt globally and agriculture is a sector that has to adapt to the impacts of this phenomenon. Northern Uganda has the highest proportion of households most vulnerable to climate change as more than 80% of farmers rely heavily on low-productivity subsistence crops, particularly beans, sesame, sorghum, millet and groundnut. Finance, knowledge of improved farm practice and lack of access to better inputs such as improved seedlings like heat- and- drought resistant crops further increase vulnerability

2.3 CLIMATE SMART AGRICULTURE IN UGANDA

The preparation of the Uganda CSA programme stems from the concerted efforts being made by the Government of Uganda to mainstream climate change considerations into the national development planning and budget and sectoral policies, strategies, programmes and plans. In preparing this CSA Program, joint Ministries of Agriculture, Animal Industry and Fisheries and Water and Environment pursued a consultative approach under the guidance of a multi-stakeholder/multi-disciplinary National CSA Task Force. The Task Force Expert Team draws representation from relevant ministries and departments, parastatals, civil society organization (CSOs), non-governmental organizations (NGOs), community-based organized (CBOs), private sector, researchers, academia and individuals.

The preparation of the Country CSA Program was facilitated by the Expert Team with technical and financial support from the NEPAD Climate Change Fund, the Common Market for Eastern and Southern Africa (COMESA), East African Community (EAC) and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

The Vision of the CSA Program is a *"Climate resilient and low carbon agricultural and food systems contributing to increased food security, wealth creation and sustainable economic growth in line with the National Vision 2040."*

The five core objectives of the Country CSA Programme are:

1. Increase agricultural productivity through climate smart agriculture practices and approaches that consider gender

2. Increase the resilience of agricultural landscapes and communities to the impacts of climate change

3. Increase the contribution of the agricultural sector to low carbon development pathways through transformation of agricultural practices.

4. Strengthen the enabling environment for efficient and effective scaling up of climate smart agriculture.

5. Increase partnerships and resource mobilization initiatives to support implementation of climate smart agriculture.

Thus, Uganda CSA Programme aims to build resilience of agricultural farming systems for enhanced food and nutrition security through six Programmatic Result Areas, namely:

Result Area 1: Improved Productivity and incomes – a pro-growth, pro-poor development agenda that supports agricultural sustainability and includes better targeting to climate change impacts will improve resilience and climate change adaptation. Because climate change has a negative impact on agricultural production, achieving any given food and nutrition security target will require greater investments in agricultural productivity. Public and private sectors as well as public-private partnerships will play a critical role.

Result Area 2: Building resilience and associated mitigation co-benefits - CSA will help reduce vulnerability of Uganda's agriculture sector by increasing productivity, enhancing adaptation and resilience of the farming systems and reducing emissions intensity in the context of achieving sustainable development and poverty eradication.

Result Area 3: Value Chain Integration - This approach is holistic in that it considers input supply, production, agricultural services, marketing and business support services as necessary building blocks. Under the approach, both public and private sectors are seen as critical actors in the value chain. Knowledge and capacity building are critical strategic priorities to leverage innovations and increase efficiencies to reduce the greenhouse gas emissions intensity from agriculture and food systems. The approach also provides enabling framework for integrating gender and the needs of the youth in value chain businesses.

Result Area 4: Research for Development and Innovations - Although Uganda has a well-developed agricultural research system, use of modern science and climate smart technologies in agricultural production is still limited. Inadequate research–extension–farmer linkages to facilitate demand-driven research and increased use of improved technologies continue to constrain efforts to increase agricultural productivity as farmers continue to use out-dated and ineffective technologies. The role of research will be reoriented to support innovations that facilitate the transition to climate-smart agriculture by smallholder farmers. New and emerging agricultural research partnerships will identify technological advances that respond to the impacts of climate change and climate variability. A major thrust will be use of climate-smart agricultural practices, promoting improved land management and sustainable crop-livestock and fisheries intensification and integration, in order to bolster farmers' adaptive capacity and support the national vision of achieving food security.

Result Areas 5: Improving and sustaining agricultural Advisory Services - Agro-advisory services that include climate applications for agriculture will help farmers to make informed decisions in the face of risks and uncertainties, in addition to the integrated management of present and emerging pests and disease challenges. Climate applications include seasonal weather forecasts, monitoring and early warning products for drought, floods and pests and disease surveillance. These products and services will increase the preparedness of the farmers, well in advance, to cope with risks and uncertainties. In this regard, dissemination of agro-weather advisories and other climate-smart agricultural practices will be enhanced through Public Private Partnerships. Furthermore, robust agro-advisory services will catalyse private sector investment in priority areas such as weather-based index insurance and associated infrastructure.

Result Area 6: Improved Institutional Coordination - Improved institutional coordination is crucial for achievement of horizontal and vertical integration required for effective discharge of the CSA Programme. The achievement of horizontal integration requires a framework that provides high-level guidance while vertical integration is instrumental in determining the roles of various sector institutions and devolved governments in performing CSA mandates. The proposed coordination framework will improve Inter-Ministerial and local Government coordination; enhance partnerships with private sector and civil society organizations; and strengthen coordination with development partners. (Uganda Climate Smart Agriculture Programme 2015-2050).

CHAPTER THREE

3.0 LITERATURE REVIEW

3.1 INTRODUCTION

Agriculture is a fundamental instrument for sustainable development and poverty reduction, and agricultural growth can be a powerful mean for reducing inequalities. The 2008 World Development Report found that growth originating in the agricultural sector is two to four times as effective as growth originating in the non-agricultural sector in increasing incomes of the bottom third of the income distribution (WDR, 2007). Agricultural growth has been the main instrument of rural poverty reduction in the most developing countries in the recent past, and this is not a surprise that agricultural growth also has a much more direct impact on hunger than general economic growth does (Binswanger-Mkhize *et al.*, 2009). Because of that, no country has been able to sustain a rapid transition out of poverty without raising productivity in its agricultural sector, according to the recent study of Timmer and Akkus (2008). While in the long run, the way to raise rural productivity is to raise urban productivity (unless the non-agricultural economy is growing, there is little long-run hope for agriculture) and out-migration to these growth areas, historical record is very clear on the important role that agriculture itself plays in stimulating growth in the non-agricultural economy in the short and medium run (Barrett *et al.*, 2010).

3.2 REVIEW OF CONCEPTUAL ISSUES

3.2.1 CLIMATE SMART AGRICULTURE

Climate-smart agriculture is an approach to help guide actions to transform and reorient agricultural systems to effectively and sustainably support development and food security under a changing climate. "Agriculture" is taken to cover crop and livestock production, and fisheries and forest management. CSA is not a new production system – it is a means of identifying which production systems and enabling institutions are best suited to respond to the challenges of climate change for specific locations, to maintain and enhance the capacity of agriculture to support food security in a sustainable way.

Climate Smart Agriculture, which is defined by its intended outcomes, rather than specific farming practices, is composed of three main pillars: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change and reducing and/or removing greenhouse gases emissions relative to conventional practices (FAO, 2013). The agricultural technologies and practices that constitute a CSA approach are, in most cases, not new, and largely coincide with those of sustainable agriculture and sustainable intensification.

However, under a CSA approach, these are evaluated for their capacity to generate increases in productivity, resilience and mitigation for specific locations, given the expected impacts of climate change.

Pillars of CSA

1. Sustainably increasing agricultural productivity and incomes

Around 75% of the world's poor live in rural areas and agriculture is their most important income source. Experience has shown that growth in the agricultural sector is highly effective in reducing poverty and increasing food security in countries with a high percentage of the population dependent on agriculture (World Bank, 2008). Increasing productivity as well as reducing costs through increased resource-use efficiency are important means of attaining agricultural growth. "Yield gaps" indicating the difference between the yields farmers obtain on farms and the technically feasible maximum yield, are quite substantial for smallholder farmers in developing countries (FAO, 2014). Similarly, livestock productivity is often much lower than it could be. Reducing these gaps by enhancing the productivity of agro-ecosystems and increasing the efficiency of soil, water, fertilizer, livestock feed and other agricultural inputs offers higher returns to agricultural producers, reducing poverty and increasing food availability and access. These same measures can often result in lower greenhouse gas emissions compared with past trends.

2. Building resilience to climate change

According to the recently released fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), the effects of climate change on crop and food production are already evident in several regions of the world, with negative effects more common than positive ones, and developing countries highly vulnerable to further negative impacts from climate change on agriculture (IPCC, 2014). In the medium and long term, average and seasonal maximum temperatures are projected to continue rising, leading to higher average rainfall, but these effects are not evenly distributed. With globally wet regions and seasons getting wetter and dry regions and seasons getting drier (Porter, J. R. *et al*. 2014). There is already an increase in the frequency and intensity of extreme events, such as drought, heavy rainfall and subsequent flooding and high maximum temperatures. The increased exposure to these climate risks, already being experienced in many parts of the world, poses a significant threat to the potential for increasing food security and reducing poverty amongst low-income agricultural-dependent populations.

It is possible to reduce and even avoid these negative impacts of climate change – but it requires formulating and implementing effective adaptation strategies. Given the site-specific effects of climate change, together with the wide variation in agro-ecologies and farming, livestock and fishery systems, the most effective adaption strategies will vary even within countries. A range of potential adaptation measures have already been identified which can provide a good starting point for developing effective adaptation strategies for any particular site. These include enhancing the resilience of agro-ecosystems by increasing ecosystem services through the use of agro-ecology principles and landscape approaches. Reducing risk exposure through diversification of production or incomes, and building input supply systems and extension services that support efficient and timely use of inputs, including stress tolerant crop varieties, livestock breeds and fish and forestry species are also examples of adaptation measures that can increase resilience.

3. Developing opportunities to reduce greenhouse gases emissions compared to expected trends

Agriculture, including land-use change, is a major source of greenhouse gas emissions, responsible for around a quarter of total anthropogenic GHG emissions. Agriculture contributes to emissions mainly through crop and livestock management, as well as through its role as a major driver of deforestation and peatland degradation. Non-CO_2emissions from agriculture are projected to increase due to expected agricultural growth under business-as-usual growth strategies. There is more than one way agriculture's greenhouse gas emissions can be reduced. Reducing emission intensity (e.g. the CO_2eq/unit product) through sustainable intensification is one key strategy for agricultural mitigation (Smith, P. *et al*. 2014). The process involves implementation of new practices that enhance the efficiency of input use so that the increase in agricultural output is greater than the increase in emissions (Smith, P. *et al.* 2014).

Another important emissions reduction pathway is through increasing the carbon-sequestration capacity of agriculture. Plants and soils have the capacity to remove CO_2 from the atmosphere and store it in their biomass – this is the process of carbon sequestration. Increasing tree cover in crop and livestock systems (e.g. through agro-forestry) and reducing soil disturbance (e.g.

through reduced tillage) are two means of sequestering carbon in agricultural systems. However, this form of emissions reduction may not be permanent – if the trees are cut or the soil plowed, the stored CO_2 is released. Despite these challenges, increasing carbon sequestration represents a huge potential source of mitigation, especially since the agricultural practices that generate sequestration are also important for adaptation and food security.

Climate-smart agriculture thus includes proven practical techniques such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agroforestry, improved grazing and improved water management (Branca, G. et al, 2012). It includes innovative practices such as better weather forecasting, early-warning systems and risk insurance. It is about getting existing technologies off the shelf and into the hands of farmers and developing new technologies such as drought- or flood-tolerant crops to meet the demands of the changing climate.

3.2.2 MONITORING IMPLEMENTATION

Monitoring is the regular observation and recording of activities taking place in a project or programme. It is a process of routinely gathering information on all aspects of the project. To monitor is to check on how project activities are progressing. It is observation, systematic and purposeful observation. Good management practices include regular monitoring on both a short- and long-term basis. An effective monitoring process provides ongoing, systematic information that strengthens project implementation. The monitoring process provides an opportunity to compare implementation efforts with original goals and targets and determine whether sufficient progress is being made toward achieving expected results

3.2.3 PERFORMANCE MONITORING

Monitoring also involves giving feedback about the progress of the project to the donors, implementors and beneficiaries of the project. Reporting enables the gathered information to be used in making decisions for improving project performance.

Monitoring performance is a process of evaluating some sets of criteria. An effective monitoring and data management system records the performance of all institutions with implementation responsibilities. Performance is the extent to which a project reaches its targets and the degree. To assess performance, it is necessary to select, before the implementation of the project, indicators which will permit to rate the targeted outputs and outcomes.

Performance monitoring is also a strategic approach to management, which equips leaders, managers and stakeholders at various levels with a set of tools and techniques to regularly plan, continuously monitor, periodically measure and review performance of the project in terms of indicators and targets for efficiency, effectiveness and impact.

3.2.4 OUTCOMES.

Outcome monitoring is the periodic measurement of knowledge, behaviours, or practices that a program or intervention intends to change. Outcome is the result or effect of an action, the result of an intervention, the consequence of an action and the way a thing turns out to be.

3.2.5 CLIMATE SMART VILLAGES

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is working with a number of partners, including national governments and research institutions, to test a range of interventions in Climate-Smart Villages (CSVs) across West Africa, East Africa, South Asia, Latin America, and Southeast Asia. CCAFS also collaborates with local farmers, community-based organizations, national meteorological institutions, and private sector stakeholders. After potential sites are selected, a steering group of community representatives and researchers work together to identify appropriate CSA options for that village. The community chooses its preferred options through a process that is as participatory and inclusive as possible, encouraging women and more vulnerable groups to participate. For example, in 2014, in Lushoto, Tanzania, researchers worked with women and men farmers to gather local knowledge and skills and then developed CSA packages of practices appropriate for demonstration and adoption in the community.

Climate Smart Villages are sites where researchers, local partners, and farmers collaborate to evaluate and maximize synergies across a portfolio of climate-smart agricultural interventions. Sustainably increasing agricultural productivity is therefore central to the future of global food security and the realization of the Sustainable Development Goals. Now is the time for action, as practices to adapt agriculture to climatic risks take time to root and become effective. Strategies that enhance climate-smart agriculture are the most appropriate starting point for sustainable agriculture.

To address this challenge, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), in collaboration with national programmes, is partnering with rural communities to develop Climate-Smart Villages as models of local actions that ensure food security, promote adaptation and build resilience to climatic stresses. Researchers, local partners, farmers' groups and policy makers collaborate to select the most appropriate technological and institutional interventions based on global knowledge and local conditions to enhance productivity, increase incomes, achieve climate resilience and enable climate mitigation.

Setting Up a Climate Smart Village

1. Selecting the site

The location of a Climate-Smart Village is selected based on its climate risk profile, alternate land-use options, and on the willingness of farmers and local government to participate in the project.

2. Working with communities

Community involvement is integral to the success of a Climate-Smart Village. CCAFS forms, or works with existing community groups, consisting of farmers, researchers, rural agro-advisory service providers and village officials. They are briefed on the objectives of Climate-Smart Villages and encouraged to formally register with the government (if they have not already) to benefit from subsidies on government schemes.

3. Conducting the baseline survey

Researchers conduct a comprehensive baseline study to capture the current socio-economic situation, resource availability, average production and income and risk management approaches of village households. This enables an assessment of the impact of the interventions after a certain period of time.

4. Prioritizing interventions

Stakeholders convene to prioritize and test which climate-smart technologies and approaches are best suited to their local conditions. Focus group discussions involve farmers in a choice experiment using dummy money to indicate which actions they would most willingly carry out.

5. Building capacity

To promote the community's involvement and motivate farmers, a range of tools and approaches are sometimes offered up front. These include rain gauges, improved seed varieties, new livestock breeds, tree seedlings, simple machinery such as zero-till machines, subsidies on index-based insurance premiums and discounts on cellphone SIM cards. Scientists, private sector representatives, and local government organize regular training sessions for farmers on good agricultural practices. At some sites a small farm is used by the researchers to demonstrate the complete portfolio of interventions.

6. Monitoring and evaluating progress

The lead partner in the village appoints a site coordinator and assistant to provide technical inputs and liaise with CCAFS resource persons. Participating farmers maintain a daily diary of their farm activities and work with the site coordinator to monitor and evaluate the progress of their chosen interventions. These results are digitized and analysed by researchers at the end of every crop season.

7. Disseminating outcomes

To spread the message of climate-smart agriculture, participatory videos on success stories and testimonials from the pilot villages are screened in nearby villages. Success stories are also widely publicized through local, national and international media. Local government partners organize regular 'farmer field days' to motivate farmers, address their questions and improve on existing strategies. (Aggarwal *et al*, 2013)

Contributions to CSA

With a strong emphasis on inclusiveness, Climate-Smart Villages approaches lead to the identification of more appropriate CSA responses based on women and men's differing farming needs and constraints. By targeting women and youth, CSA benefits are more likely to reach different household members in both male and female-headed households.

3.3 REVIEW OF THEORETICAL ISSUES

Climate Change and food security are two of the most pressing challenges facing the global community today. Improving smallholder agricultural systems is a key response to both. The 2010 FAO report estimates that the number of chronically hungry people in the world has reached a total of 925 million people. About 75% of the worst-affected people reside in rural areas of developing countries, their livelihoods depending directly or indirectly on agriculture (FAO 2009). Strengthening agricultural production systems is a fundamental means of improving incomes and food security for the largest group of food insecure in the world (World Development Report, 2007; Ravallion & Chen, 2007). As the key economic sector of most low income developing countries, improving the resilience of agricultural systems is essential for climate change adaptation (Conant, 2009; Parry *et al*, 2007; Adger *et al*, 2003). And, improvements in agricultural production systems offers the potential to provide a significance source of mitigation by increasing carbon stocks in terrestrial systems, as well as emissions reductions through increased efficiency (FAO, 2009; Paustian *et al.*, 2009, Smith *et al*., 2008).

Agriculture has been and continues to be the most important sector in Uganda's economy. It employs about 65.6% of the population aged 10 years and older (UBOS, 2010). In 2010/11, the sector accounted for 22.5 percent of total GDP (MAAIF 2011). Agricultural exports accounted for 46 percent of total exports in 2010 (MAAIF 2011). The sector is also the basis for much of the industrial activity in the country since most industries are agro-based. Even though its share in total GDP has been declining, agriculture remains important because it provides the basis for growth in other sectors such as manufacturing and services. It is also the sector that provides equal opportunities for employment for both men and women in Uganda.

Current Production Practice

The majority of people in Uganda depend on Agriculture for their sustenance and livelihoods. The major farming systems are largely determined by the rainfall pattern (total amount and distribution per year). Farming systems cover a wide range of activities including the production of traditional cash crops (Coffee, Sugar cane, cotton and tea) and food crops (banana, cassava, maize, sorghum, finger-millet, potatoes and beans) and keeping livestock (cattle, goats, pigs and poultry). Typically, farm operations are by conventional tillage which involves land clearing first and then ploughing and finally disc ploughing using a wide range of implements, though the majority of farmers often use ox plough or the hand hoe.

However, over the years farmers have badly managed their land largely through the use of conventional tillage leading to severe degradation of their farm land. Consequently, average yields are low. The national situation indicates that land and land resources degradation accounts for over 80% of the annual cost of environmental degradation. However, over the years, farmers have badly managed their land largely through the use of conventional tillage leading to severe degradation of their farm land. Consequently, average yields are low. The national situation indicates that land and land resources degradation accounts for over 80% of the annual cost of environmental degradation (Knox *et al*, 2012). Wide spread forest clearing, continuous cultivation, crop residue burning and overgrazing have exposed land to agents of degradation thus raising serious concern about conventional tillage. Land degradation is also evident in the dry lands of the cattle corridor of Uganda where land management is threatened by overgrazing by local and mobile pastoralist herds, deforestation by excessive use of fuel wood resources and poor and inappropriate agricultural practice on marginal land. CSA offers farmers a wide range of benefits including increased productivity, better management of resource base and reduction of GHG.

3.3.1 WHY CLIMATE SMART AGRICULTURE

Climate-smart agriculture (CSA) helps address a number of important challenges:

1. CSA Addresses Food Security, Misdistribution and Malnutrition

Despite the attention paid to agricultural development and food security over the past decades, there are still about 800 million undernourished and 1 billion malnourished people in the world. At the same time, more than 1.4 billion adults are overweight and one third of all food produced is wasted. Before 2050, the global population is expected to swell to more than 9.7 billion people (United Nations 2015). At the same time, global food consumption trends are changing drastically, for example, increasing affluence is driving demand for meat-rich diets. If the current trends in consumption patterns and food waste continue, it is estimated we will require 60% more food production by 2050 (Alexandratos and Bruinsma 2012). CSA helps to improve food security for the poor and marginalised groups while also reducing food waste globally (CCAFS 2013).

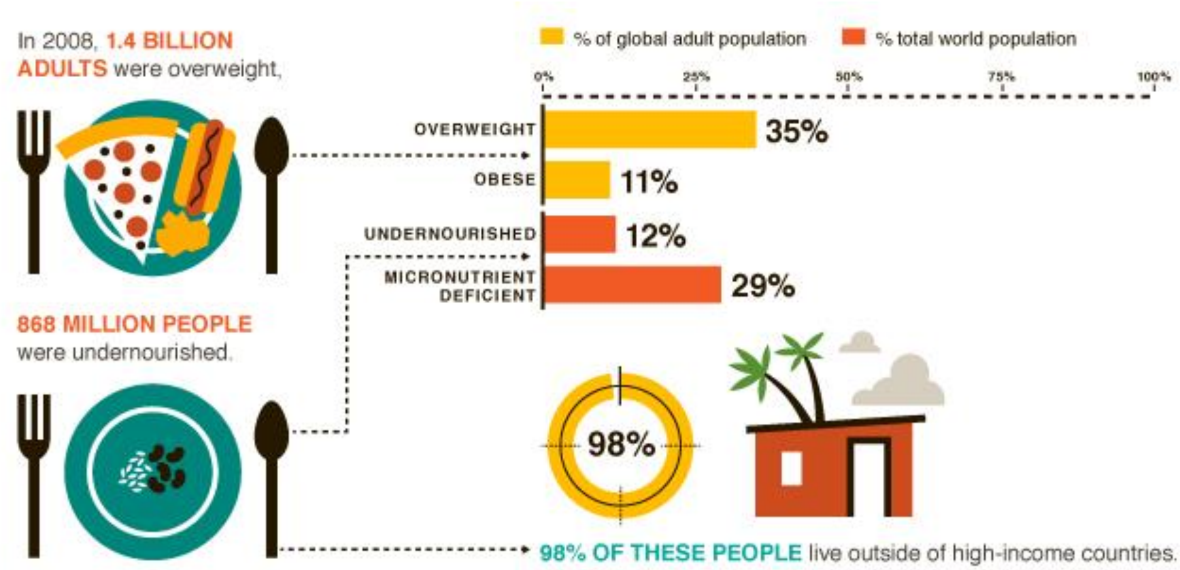

Figure 3.1: Food security, malnutrition and misdistribution
Source: CCAFS Big Facts: Food security

2. CSA Addresses the Relationship between Agriculture and Poverty

Agriculture continues to be the main source of food, employment and income for many people living in developing countries. Indeed, it is estimated that about 75% of the world's poor live in rural areas, with agriculture being their most important income source (Lipper *et al*. 2014). As such, agriculture is uniquely placed to propel people out of poverty. Agricultural growth is often the most effective and equitable strategy for both reducing poverty and increasing food security (CCAFS and FAO 2014).

3. CSA Addresses the Relation between Climate Change and Agriculture

Climate change is already increasing average temperatures around the globe and, in the future, temperatures are projected to be not only hotter but more volatile too. This, in turn, will alter how much precipitation falls, where and when. Combined, these changes will increase the frequency and intensity of extreme weather events such as hurricanes, floods, heat waves, snowstorms and droughts. They may cause sea level rise and salinization, as well as perturbations across entire ecosystems. All of these changes will have profound impacts on agriculture, forestry and fisheries (FAO, 2013a).

The agriculture sector is particularly vulnerable to climate change because different crops and animals thrive in different conditions. This makes agriculture highly dependent on consistent temperature ranges and water availability, which are exactly what climate change threatens to undermine. In addition, plant pests and diseases will likely increase in incidence and spread into new territories (Grist 2015), bringing further challenges for agricultural productivity.

While climate change will have both positive and negative impacts on crop yields - meaning that for some crops in some areas, yields will rise while others elsewhere suffer - negative impacts have outweighed positive impacts to date (IPCC 2014b). Already, it is estimated that climate change has reduced global yields of wheat by 5.5% and of maize by 3.8% (Lobell *et al*, 2011). By 2090, it is projected that climate change will result in an 8-24% loss of total global caloric production from maize, soy, wheat and rice (Elliott *et al*, 2015). Where these declines in productivity occur will vary. For example, sub-Saharan Africa will be hit particular hard; it is estimated that across Africa maize yields will drop by 5% and wheat yields by 17% before 2050 (Knox *et al*, 2012).

The relationship between agriculture and climate change is a two-way street: agriculture is not only affected by climate change but has a significant effect on it in return. Globally, agriculture, land-use change and forestry are responsible for 19-29% of greenhouse gas (GHG) emissions. Within the least developed countries, this figure rises to 74% (Vermeulen *et al*, 2012; Funder *et al*, 2009). If agricultural emissions are not reduced, agriculture will account for 70% of the total GHG emissions that can be released if temperature increases are to be limited to 2°C. The mitigation options available within the agricultural sector are just as cost-competitive as those established within the energy, transportation and forestry sectors. And they are just as capable of achieving long-term climate objectives (Smith *et al*, 2007). For this reason, mitigation is one of the three pillars of climate-smart agriculture.

In order to further support CSA, it is essential to measure progress and identify successes and problems of CSA interventions (be they pilot initiatives, projects or programmes). Monitoring will check whether activities are meeting the CSA objectives, as well as project milestones and measures of efficiency, and facilitate adjustment of activities taking account of uncertainties. Within the project or programme, accountability and wise use of resources are promoted by monitoring and evaluation. Good M&E help in such a way to improve the design of future CSA interventions and decision making by stakeholders, and constitute a long-term learning process. M&E can thereby especially contribute to the achievement of national mitigation goals, while detailed and adequate monitoring of greenhouse gas emissions can be part of accounting requirements within the framework of the UNFCCC.

3.4 REVIEW OF EMPIRICAL ISSUES

At every stage, food provisioning adds to the buildup of greenhouse gases in the atmosphere. If emissions caused by direct and indirect energy use by the agrifood chain were included, the AFOLU share of total greenhouse emissions would increase by one third (FAO, 2011). The contribution of food systems to total GHGs emissions varies among countries and regions, according to the structure of local supply chains. Estimates by the Consultative Group for International Agricultural Research (CGIAR) indicate that in high-income countries emissions from the pre- and post-production stages equal those from production. In contrast, agricultural production is still the dominant stage in terms of GHG emissions in developing countries (Vermeulen, Campbell and Ingram, 2012).

Table 3.1: CLIMATE IMPACTS ON SELECTED CROP YIELDS, GLOBALLY AND IN TROPICAL AREAS, UNDER WARMING OF 1.5 °C AND 2 °C ABOVE PRE-INDUSTRIAL LEVELS OVER THE 21ST CENTURY

Crop	Region	Increase over pre-industrial temperatures	
		1.5^{o}C	2.0^{o}C
Wheat	Global	2(-6 to +17)	0(--8 to +21
	Tropical	-9(-25 to +12)	-16(-42 to +14)
Maize	Global	-1(-2 to +8)	-6(-38 to +2)
	Tropical	-3(-16 to +2)	-6(-19 to +2)
Soybean	Global	7(-3 to +28)	1(-12 to +34)
	Tropical	6(-3 to +23)	7(-5 to +27)
Rice	Global	7(-17 to +24)	7(-14 to +27)

	Tropical	6(0 to +20)	6(0 to +24)

Note: The figures in parentheses indicate a likely (66 percent) confidence interval.

SOURCE: Adapted from Schleusner *et al*. (2016),

Climate change already affects the agriculture sectors in many parts of the world, and its impacts will be amplified in the years and decades ahead. A large body of evidence points to a prevalence of negative outcomes, with many agricultural systems becoming less productive and some plant and animal species disappearing. Those changes will have direct effects on agricultural production, which will have economic and social consequences and finally impacts on food security (Figure 3.1). The impacts will be transmitted through different channels and will affect food security in all four of its dimensions: access, availability, utilization and stability. At each stage of the transmission chain, the severity of impact will be determined by both the shock itself and by the vulnerability of the system or population group under stress (FAO, 2016a).

3.4.1 IMPACTS OF CLIMATE CHANGE ON CROPS

Climate change impacts on the yields of major crops is probably the food security related issue on which there are the most studies. A wide literature on observed and projected impacts on yields includes more than two decades of work since the global assessment by Rosenzweig and Parry (1994) of the potential impact of climate change on world food supply; some other key studies are Parry, Rosenzweig and Livermore (2005), Cline (2007), World Bank (2010), and Rosenzweig *et al*. (2014). Most studies are limited to major crops, and the effects of climate change on many other important crops are much less known. The observed effects of past climate trends on crop production are evident in several regions of the world (Porter *et al.*, 2014), with negative impacts being more common than positive ones. There is evidence that climate change has already negatively affected wheat and maize yields.

Widely cited estimates show that over the period 1980 to 2008 there was a 5.5 percent drop in wheat yields and a 3.8 percent drop in maize yields globally, compared to what they would have been had climate remained stable (Lobell, Schlenker and Costa-Roberts, 2011). The precise future effects of climate change on crop yields are very difficult to predict and will depend on many parameters. These include: physical ones, such as temperature, precipitation patterns and CO_2 fertilization; changes in agroecosystems (e.g. through loss of pollinators and increased incidence of pest and diseases); and the adaptive responses of human systems. Effects of temperature changes are generally well understood up to the optimum temperature for crop development; however, beyond these optimum temperatures, effects are much less known. Recent results have confirmed the damaging effects of elevated tropospheric ozone on yields, with estimates of losses for soybean, wheat and maize in 2000 ranging from 8.5 to 14 percent, 3.9 to 15 percent, and 2.2 to 5.5 percent respectively (Porter *et al.*, 2014).

Several other possible impacts of climate change on the functioning of ecosystems – such as the balance between crops and pests, and effects on pollinators – are difficult to assess and are generally not taken into account by the models used to make projections of crop yields. Within certain limits, a changing climate could have both positive and negative effects on crops. Indeed, increases in temperatures and levels of carbon dioxide in the atmosphere may be beneficial for some crops in some places. Yields of wheat and soybeans, for example, could increase with increased CO_2 concentrations under optimal temperatures. However, while projections of future yields vary according to the scenario, model and time-scale used, there is consistency in the main expected directions of change: yields suffer more in tropical regions than at higher latitudes and impacts are more severe with increased warming (Porter *et al.*, 2014).

Importantly, the IPCC Fifth Assessment Report provides new evidence that crop yields are expected to decline in areas that already suffer food insecurity. It presents projected estimates of changes in crop yields owing to climate change over the 21st century. The data used include results from 91 studies with 1722 estimates of changes in crop yields by Challinor *et al.*, 2014. There are wide variations among the studies, in terms of time-frame, crop coverage, crop and climate models, and emission levels. Some studies include the effects of adaptation measures, but others do not. The scales and geographical coverage also vary, with some estimates being for localities while others are national, regional or global.

In spite of the heterogeneity of the studies, their long-term projections clearly point to a prevalence of negative outcomes. They show that in the medium term – that is, until about 2030 – the positive and negative effects on yields could offset each other at the global level, the balance after this date would be increasingly negative as climate change accelerates. The data also show that projected impacts of climate change on yields of maize, wheat and rice in the second half of the 21st century are more often negative for tropical regions than for temperate regions. However, in many locations in temperate regions, as well, crop yields may decrease

(Porter *et al.*, 2014 and Challinor *et al.*, 2014). Further analysis of the same data, undertaken by FAO for this report, reveals quite distinct patterns for developing and developed countries. For the developing countries, most estimates for crop yield impacts are negative, with the share of negative estimates increasing the further into the future the study projects. Compared with developing countries, estimates for developed countries show a much larger share of potential positive changes.

Other estimates of the impact of climate change on crop yields are provided by the recent consolidated study conducted in the framework of the Agricultural Model Intercomparison and Improvement Project (AgMIP) and the Inter- Sectoral Impact Model Intercomparison Project. Both point to dramatic long-term impacts, compared to a world without climate change and in the absence of climate change mitigation. The impact on yields by the year 2100 under high emission climate scenarios ranges between -20 and -45 percent for maize, between -5 and -50 percent for wheat, between -20 and -30 percent for rice, and between -30 and -60 percent for soybean (Rosenzweig *et al.*, 2013). Assuming the full effectiveness of CO2 fertilization, climate change impacts on yields are reduced to a range of between -10 and -35 percent for maize, between +5 and -15 percent for wheat, between -5 and -20 percent for rice, and between 0 and -30 percent for soybean. If limits on access to nitrogen are explicitly considered, crops benefit less from CO_2 fertilization and negative climate impacts are amplified (Müller and Elliott, 2015).

3.4.2 IMPACTS OF CLIMATE CHANGE ON LIVESTOCK

Climate change affects livestock production in multiple ways, both directly and indirectly. The most important impacts are on animal productivity, animal health and biodiversity, the quality and amount of feed supply, and the carrying capacity of pastures. Increasing variability in rainfall leads to shortages of drinking water, an increased incidence of livestock pests and diseases, and changes in their distribution and transmission. It also affects the species composition of pastures, pasture yields and forage quality.

Higher temperatures cause heat stress in animals, which has a range of negative impacts: reduced feed intake and productivity, lower rates of reproduction and higher mortality rates. Heat stress also lowers animals' resistance to pathogens, parasites and vectors (Thornton *et al.*, 2009; Niang *et al.*, 2014). Multiple stressors greatly affect animal production, reproduction and immune status. Research in India found that a combination of climate-related stresses on sheep – for example, excessive heat and lower nutritional intake – had severe impacts on the animals' biological coping mechanisms (Sejian *et al.*, 2012). The effects of higher temperatures may be reduced in intensive cattle, pig and poultry production units, through climate control (Thornton *et al.*, 2009), provided appropriate housing and energy are available. However, projected drier conditions in the extensive rangelands of southern Africa would increase water scarcity; in Botswana, the costs of pumping water from boreholes increases 23 percent by 2050. In the Near East, declining forage quality, soil erosion and water scarcity will most likely be exacerbated in the semi-arid rangelands (Turral, Burke and Faurès, 2011). Impacts of climate change on animal health are also documented, especially for vector-borne diseases, with rising temperatures favouring the winter survival of vectors and pathogens. In Europe, global warming is likely to increase sheep tick activity, and the risk of tick-borne diseases, in the autumn and winter months (Gray *et al.*, 2009). Outbreaks of Rift Valley fever in East Africa are associated with increased rainfall and flooding due to El Niño-Southern Oscillation events (Lancelot, de La Rocque and Chevalier, 2008; Rosenthal, 2009; Porter *et al.,* 2014).

3.4.3 IMPACTS OF CLIMATE CHANGE ON INCOMES AND LIVELIHOODS

The effect of climate change on the production and productivity of the agriculture sectors will translate into mostly negative economic and social impacts, with implications for all four dimensions of food security. Climate change can reduce incomes at both the household and national levels. Given the high dependency on agriculture of hundreds of millions of poor and food-insecure rural people, the potential impacts on agricultural incomes – with economy-wide ramifications in low-income countries that are highly dependent on agriculture – are a major concern. By exacerbating poverty, climate change would have severe negative repercussions on food security. Much uncertainty surrounds the future evolution of climate change, its precise impacts and the possible responses. The implications for the environment and society depend not only on the response of the Earth system to changes in atmospheric composition, but also on the forces driving those changes and on human responses, such as changes in technology, economies and lifestyle.

Assessing climate change impacts on agriculture requires integrated use of climate, crop, and economic models to take into account the reaction to changing conditions in the sector, including management decisions, land-use choices, international trade and prices, as well as consumers.

For this reason, the climate research community has developed over the past two decades sets of scenarios that describe plausible future trajectories and represent many of the major driving forces that are important for informing climate change policy. A variety of those scenarios have been used to analyse the impacts of climate change on agroecosystems, the agriculture sectors, socioeconomic trends and ultimately food security. In order to ensure a better and more consistent analysis of future climate and its impacts, the IPCC's Fifth Assessment Report adopted a set of Representative Concentration Pathways (RCPs), which are hypothetical climate scenarios based on the magnitude of global annual greenhouse gas emissions. The IPCC also helped catalyse the development of Shared Socio-economic Pathways (SSPs), which describe alternative development futures, to be used alongside the RCPs to analyse feedback between climate change and socioeconomic factors. Nelson *et al*. (2014a) have designed a common protocol to compare results of a set of nine climate, crop, and economic models under the scenario RCP 8.5 (global annual GHG emissions continuing to rise throughout the 21st century), without accounting for CO_2 fertilization of crops.

The authors compare the effects of the exogenous climate change shock on yields of four crop aggregates – coarse grains, oil seeds, wheat and rice – which account for about 70 percent of the global crop harvested area. The mean biophysical effect of the climate change shock on yields is a 17 percent decline. The economic models transfer the shock effect to the response variables. Producers respond to the price increases associated with the shock by both intensifying management practices, which leads to a final mean yield change of -11 percent, and increasing the cropping area by a mean of 11 percent. The combined yield decline and area increase result in a mean decline in production of only 2 percent. Consumption declines slightly, with a mean decline of 3 percent. Changes in trade shares cancel out across regions, but the share of global trade in world production increases by 1 percent on average. Average producer prices increase by 20 percent. The direction of responses is common to all models, but the magnitude of responses varies significantly across models, crops and regions. Although the average consumption decline is relatively small, the price increases caused by the inelastic nature of global demand are likely to increase food costs significantly for the poor.

The key role of agriculture in supporting the livelihoods of the majority of the world's poor, and their particular vulnerability to climate change, was confirmed in a World Bank study, which compared worst-case and more optimistic scenarios with a scenario of no climate change (Hallegatte *et al.*, 2015). A scenario with high impact climate change, rapid population growth and a stagnant economy indicated that an additional 122 million people would be living in extreme poverty by 2030. With the same level of climate change impacts, but with universal access to basic services, reduced inequality and extreme poverty affecting less than 3 percent of the world's population, the number of additional poor is projected to be just 16 million (Rozenberg and Hallegatte, 2015). Under the worst-case scenario, much of the forecast increase in the number of poor occurs in Africa (43 million) and South Asia (62 million). Reduced income in the agricultural sector explains the largest share of increased poverty as a result of climate change. This is because the most severe reductions in food production and increases in food prices occur in Africa and India, which account for a large share of the world's poor. The second most important factor leading to increased poverty is health impacts, followed by the impacts of higher temperatures on labour productivity. Recent FAO studies of adaptation to climate changes in smallholder agriculture systems in sub-Saharan Africa show how dry spells, the late onset of rains and high temperatures affect incomes at the farm level. In all cases, climate shocks reduced productivity or harvest value significantly and, in turn, reduced access to food.

The shocks impinge on physical capital, when assets are destroyed – for example, through the death of livestock – or when farmers are forced to sell productive capital, such as cattle, to absorb the income shock. They also reduce farmers' capacity to invest, with negative consequences for future food security. Bárcena *et al.* (2014) summarized the results of a series of studies of the projected impacts of climate change on agricultural revenues in South America. While there is a wide degree of variation among models and scenarios, projected impacts are generally found to be negative across a wide range of locations.

At the national level, reduced production due to climate change can trigger an increase in the prices of food and feed, negatively affecting the socio-economic status of the whole population and its food security. Such impacts are particularly critical in countries where an important part of the household budget is spent on food. They can be accompanied by major macro-economic effects where agriculture makes an important contribution to national GDP and/ or employment. Lam *et al.* (2012) modelled the economic and social implications of climate-change induced modifications in the availability of marine fisheries species in 14 countries in West Africa, by

2050. Using the high range IPCC Special Report on Emission Scenarios (SRES) A1B scenario, they project a decrease in landed fish value of 21 percent, a total annual loss of US$311 million compared to values for 2000, and a loss in fisheries-related jobs of almost 50 percent, with Côte d'Ivoire, Ghana, Liberia, Nigeria, Sierra Leone and Togo suffering the most severe impacts. Most projections of the food price impacts of climate change point to increases, although the magnitude and locations vary considerably across models and climate scenarios. A study that coupled scenarios for population growth and income growth with climate change scenarios looked at the potential impacts under 15 different combinations. Using an optimistic scenario of low population growth and high income growth, and the mean results from four climate change scenarios, it plotted mean projected price increases by 2050, compared to 2010 levels, of 87 percent for maize, 31 percent for rice and 44 percent for wheat (Nelson *et al.*, 2010).

Another potential impact of climate change is food price volatility (Porter *et al.*, 2014), although the extent of volatility is greatly influenced by domestic policies, such as export bans and other trade restricting measures that exacerbate price fluctuations on international markets. Increased trade is expected to play an important role in adjusting to the shifts in agricultural and food production patterns resulting from climate change (Nelson *et al.*, 2010; Chomo and De Young, 2015).The adaptive role of trade is addressed in a study by Valenzuela and Anderson (2011), which finds that climate change could cause a substantial decline in the food self -sufficiency ratio of developing countries of about 12 percent by 2050. While trade can help in adaptation to climate change and to shifting international patterns of production, ultimately global markets will only be accessible to those countries and segments of population that have sufficient purchasing power. This makes inclusive economic growth an essential precondition for stable food security.

Climate change may also lead to changes in investment patterns that would lead to reductions in the long-term productivity and resilience of agricultural systems at household and national levels. Uncertainty discourages investment in agricultural production, potentially offsetting the benefit to food producers of higher prices. This is particularly true for poor smallholders with limited or no access to credit and insurance. Greater exposure to risk, in the absence of well-functioning insurance markets, can lead to greater emphasis on low-risk/low-return subsistence crops, a lower likelihood of applying purchased inputs such as fertilizer and adopting new technologies, and reduced levels of investment (Antle and Crissman, 1990; Dercon and

Christiaensen, 2011; Fafchamps, 1992; Feder, Just and Zilberman, 1985; Heltberg and Tarp, 2002; Kassie *et al.*, 2008; Roe and Graham- Tomasi, 1986; Sadoulet and de Janvry, 1995; Skees, Hazell and Miranda, 1999). All of these responses generally lead to both lower current and future farm profits (Hurley, 2010; Rosenzweig and Binswanger, 1993).

CHAPTER FOUR

4.0 METHODOLOGY

4.1 THEORETICAL FRAMEWORK

CSA is a continuous and iterative process that aims to combine food security, agricultural development and climate change objectives. This concept implies that the cycle of planning, implementation, monitoring and evaluation is one of continuous learning, knowledge sharing, and advancement towards solutions. As agricultural production is part of a complex food chain, many types of stakeholders must be involved in this process. Assessment, monitoring and evaluation are integral part of CSA planning and implementation. They are crucial for making decisions on the use of natural resources. CSA options is therefore assessed for their effectiveness in achieving goals related to food security, climate change adaptation and mitigation as well as other developmental objectives.

In order to further support CSA, it is essential to measure progress and identify successes and problems of CSA interventions (be they pilot initiatives, projects or programmes). Monitoring will check whether activities are meeting the CSA objectives, as well as project milestones and measures of efficiency, and facilitate adjustment of activities taking account of uncertainties. Within the project, accountability and wise use of resources are promoted by monitoring and evaluation. Good monitoring and evaluation help in such a way to improve the design of future CSA interventions and decision making by stakeholders, and constitute a long-term learning process.

The process requires communication to organize and maintain commitment of all relevant stakeholders. This research is therefore a midline survey that involves asking simple questions on Knowledge, Attitude, Skills, Interest and Practice to getting feedbacks from household farmers in order to complete the project. The approach incorporates feedback mechanism to build an evidence base that improves decision making, adoption and impact. Lessons learned from this project will provide a basis for concrete recommendations and for identifying further steps which will allow to effectively use science to inform policy, bring stakeholders together and improve efficiency of investments to successfully confront climate change.

4.2 SAMPLING DESIGN

This section covers the description of the type of survey adopted in the study. It is expected to define the population, the sample size as well as the sampling technique adopted in selecting the sample size. Sources of data collection, data analysis and data presentation are part of the research design. This research is designed to monitor performance, implementation and outcomes of CSA practices in Nwoya districts, Northern Uganda. All the sub-counties in Nwoya District, Northern Uganda constitute scope of field survey. Questionnaire was administered to smallholder farmers at household level.

4.3 DATA REQUIRED AND SOURCES

4.3.1 Population and Sample Site

This study was conducted in Nwoya district of Northern Uganda. Nwoya District is one of the newest districts in Uganda. It was established by Act of Parliament and began functioning on 01 July 2010. Prior to that date, it was part of Amuru District. The district lies in the Acholi sub region. It is bordered by Amuru District to the North, Gulu District to the NorthEast, Oyam District to the East, Kiryandongo District, Masindi District and Buliisa District to the South. Nebbi District lies to the West of Nwoya District. Nwoya, the main political, administrative and commercial center in the district, is located approximately 44 kilometers (27 mi), by road, southwest of the city of Gulu, the largest metropolitan area in the sub-region. This location is approximately 330 kilometers (210 mi), by road, north of the city of Kampala, Uganda's capital and largest metropolitan area. The coordinates of the district are: 02 38N, 32 00E. The district is predominantly rural. The 2002 national census estimated the population of the district at 41,010. The district population is growing at an estimated annual rate of 3.3%. Given those statistics, the projected population of the district in 2016 was approximately 159,500. (Uganda Bureau of Statistics (web).

Table 4.1: Nwoya District, Sub-county and Number of Villages.

District	Sub-county	No of Villages
Nwoya	Alero	12
	Anaka	16
	Purongo	14

	Koch Goma	13
	Total	**55**

Source: UNHCR

Figure 4.1 Map of Study Area.

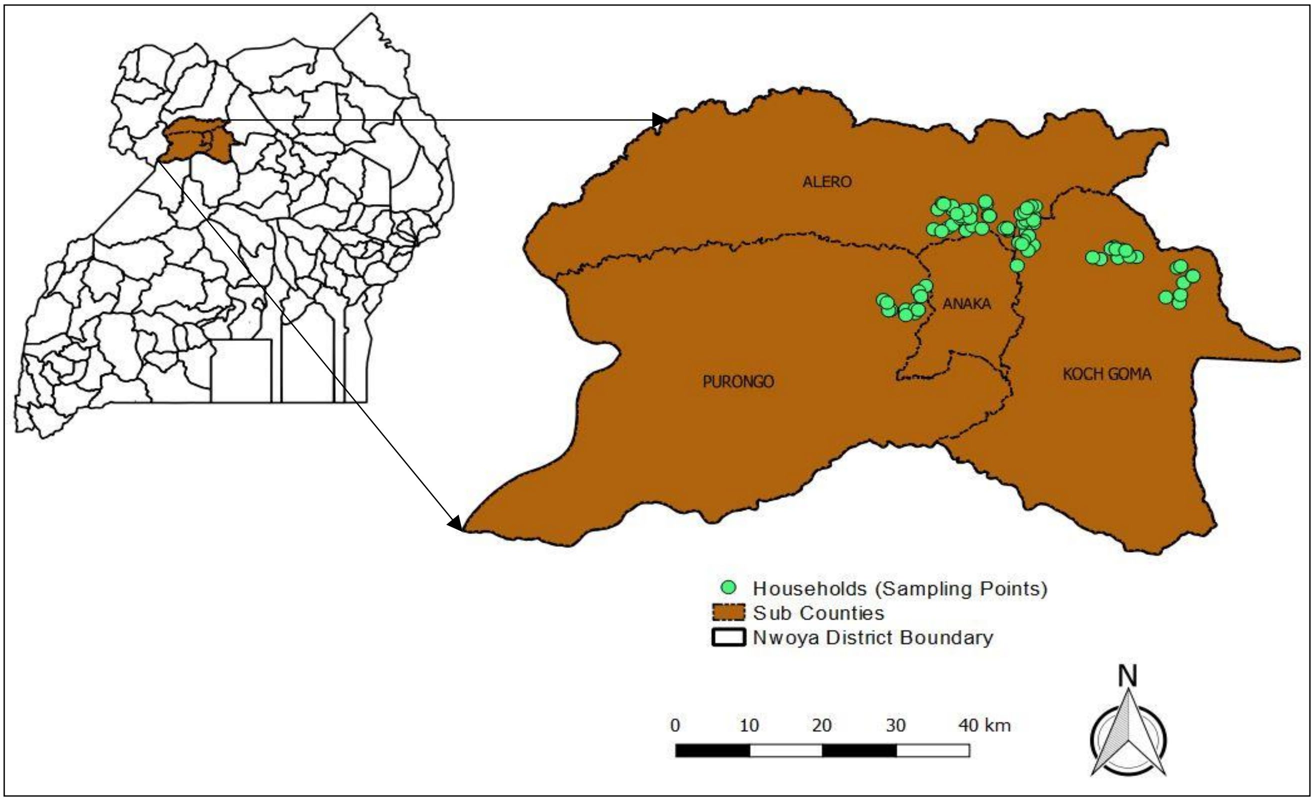

Table 4.2: Sample Locations and Sample Sizes

District	Sub-county	Sample Size (Houeshold farmers)	Total
Nwoya	Alero	37	
	Anaka	15	
	Purongo	16	
	Koch Goma	32	
			100

The target population for this study was all household farmers in Nwoya district. This sampling frame of project participants constituted the population from which a representative sample was drawn for the purpose of this study. Target of 100 household farmers, but 85 household farmers and 154 respondents was used for analysis. This sample size was distributed across the four sub-county. A multi –stage sampling method was used to select 100 household farmers.

Stage 1: In Uganda, Northern Uganda was chosen using simple random sampling.

Stage 2: In Northern Uganda, 1 district was chosen (Nwoya district) using simple sampling method.

Stage 3: In the district, 4 sub-counties were chosen

Stage 4: In the sub-counties, 37, 15, 16 and 32 households were chosen from Alero, Anaka, Purongo and Koch Goma sub-counties respectively by using simple random sampling methods.

The sample selection takes into cognizance the groups that are dual headed households and single headed households. The allocated number of farmers is shown in Table 4.2 above and was sampled in each of the 4 locations from a list of all farmers participating in farmers groups. The unit of sampling was the household (of the farmer in farmers group), using the definition for a household, as a group of individuals belonging to the same residential place.

4.3.2 Preparation of Instrument

Basically, the questionnaire is structured in such a manner that brings out maximum information about the beneficiaries of the project. The questionnaire contains a combination of closed and open ended questions. The open ended questions encourage respondents to provide detailed answers to the questions, while answers to the closed ended questions require that the researcher seeks further clarification from other sources in order to be able to use such information adequately.

4.3.3 Administration of Research Instrument

Household survey data were collected using a structured questionnaire (Annex I). The questionnaire asked about 1) Household information, 2) Farm characteristics 3) Participation project activities, 4) adoption of different CSA practices, 5) adoption benefits. Prior to data collection, a team of enumerators were trained in questionnaire administration, translation and recording of geo-referenced responses. The enumerators also participated in pre-testing of the questionnaire and shared their initial experiences. The team went through each of the questionnaires filled during pre-test and clarified issues that were unclear and the questionnaire was updated accordingly. The questionnaires were administered directly to respondents and responses were collected immediate, except where the respondent asked for more time. This ensures collection of a high percentage of responses, for analysis and results presentation. A total of 100 homesteads were visited and the household member belonging to a farmer group was interviewed using a structure questionnaire. Data were collected on household size and characteristics, livestock and crop production, adoption of specific CSA practices (Row planting, Intercropping, Improved varieties, Minimum tillage and Mulching). In addition, information was collected on adoption constraints and perceptions on benefits from the CSA practices adopted.

4.3.4 Validity and Reliability of Research Instrument

The questionnaire employed for the primary data in this study was pilot-tested at Anaka LGA a benefitting LGA. Responses were reviewed and necessary correction done to the questions and more explanation given to the enumerators where necessary. It led to rework before the main study was conducted. Although the respondents may be subjective, the questionnaire is still able to capture relevant and needed information based on their opinions.

4.4 DESCRIPTION OF RELEVANT VARIABLES

Different CSA practices

Row Planting

Row planting as applied in conventional horizontal farming or gardening is a system of growing crops in linear pattern in at least one direction rather than planting without any distinct arrangement. It is practiced in most crops whether direct seeded, transplanted, or grown from vegetative planting materials, both in monocropping and multiple cropping.

Crops are planted in rows or straight lines, either singly or in multiple rows, mainly to enhance maximum yields as well as for convenience.

The advantages of row planting over broadcasting or scatter planting include the following:

1. Light exposure is maximized. Conversely, the excessive shading effect of other plants is minimized thus favoring more efficient photosynthesis and improved crop yield
2. Wind passage along the interrows is enhanced which increases gas exchanges and prevents excessive humidity

3. Access through the interrows facilitates cultivation, weeding, and other farm operations including hauling
4. Visibility is enhanced
5. It is easy to calculate or count the plant population in a given farm area.

Intercropping

Planting of two different, though complementary, crops on the same plot of land, either in a mixed row or strip intercropping system. It requires technical knowledge and spacing between crops. Potential benefits include production diversification, reduces risk of total crop failure, reduces pest and or diseases.

Minimum Tillage

This practice is a soil conservation system with the goal of minimum soil manipulation necessary for a successful crop production. It reduces soil turnovers and structure breakdowns. Minimum tillage also limits working the soil with machinery, thus reducing erosion and soil compaction and increasing water intake. Tillage refers to all methods used to prepare soil for planting, especially the loosening and breaking up of topsoil by the use of a hoe, plough or similar tilling implement. Specifically, minimum tillage can refer to tied ridging, digging, planting, preparing pits with hand hoe, in contrast to conventional deep tillage. Crop residues are often left on the soil surface or incorporated into the soil rather than removed. Best practiced with use of ratoon crops. Ratoon crops (Pineapple) are crops that provide a second harvest and develop up from the root of the previous crops. No-till is believed to add organic matter to the soil and build soil structure, whereas plowing reduces it over time. On the other hand, a small amount of tillage can lower slug populations and warm the soil for planting, leading to higher yields.

Improved Varieties

Improved varieties are varieties that has been bred using formal plant breeding methods. They are varieties of crops that has been improved upon in order to increase yield, resistant to pests and diseases etc.

Mulching

A mulch is simply a protective layer of a material that is spread on top of the soil. Mulches can be organic like grass clippings, straw, bark chips and similar material or inorganic like stones, brick clips and plastics. Mulching saves time, money and labour.

Benefits of mulches are

1. Protects the soil from erosion
2. Reduces compaction from the impacts of heavy rains
3. Conserves moisture, thus reducing the need for frequent watering
4. Maintains a more even soil temperature
5. Prevents weed growth
6. Keeps fruits and vegetables clean
7. Reduces GHGs emissions from exposed soil surface.

Organic mulches also improve the condition of soil. As these mulches slowly decompose, they provide organic matter which helps keep the soil loose. This improves root growth, increase infiltration of water and also improves the water-holding capacity of the soil. Organic matter is a source of plant nutrients and provides an ideal environment for earthworms and other beneficial organisms.

4.5 METHOD OF DATA ANALYSIS

Objectives 1: Descriptive statistics and tabulations will be used to describe the socio-economic characteristics of the beneficiaries' households. Data was also analyzed using multivariate analysis and tested for significance using the Chi test

Objective 2: Data was analyzed using percentiles and graphs.

Objective 3: Inductive analytical method was used to analyze the responses obtained

In all the analysis, the significance level of 0.05 is utilized.

CHAPTER FIVE

5.0 RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

This chapter presents the results of the analysis. This was in line with the three objectives of the study and as indicated in the various methodologies.

We start by providing the results of the assessment of the CSAs practices.

5.2: ASSESSMENT OF THE DIFFERENT CSA PRACTICES CARRIED OUT BY THE FARMERS BASED ON THEIR SOCIO-DEMOGRAPHIC FEATURES.

In this section we provide the results of Climate Smart Agricultural Practices in Nwoya district of Uganda. We explore the situation for the five different practices including row planting, intercropping, minimum tillage, improved variety and mulching. This is done in order to understand the nature and prevalence of CSA in Uganda.

Table 5. 1 presents the CSA practices in row planting along gender lines

Table 5.1: Row Planting Practice with Gender

	Gender		Total
	Man	Woman	
Yes, currently practicing	130 (94.2%)	14 (87.5%)	144 (93.5%)
No	3 (2.2%)	0 (0%0	3 (1.9%)
Only practiced in the past	5 (3.6%)	2 (12.5%)	7 (4.5%)
Total	138 (100)	16 (100)	154 (100)

Pearson Chi-Square = 157.921 (0.000)
Significance level is in parenthesis

Our results reveal that there are more male than female in the respondents. While we have 138 male respondents, there are 16 female respondents. Starting with the male, 130 or 94.2 & of male is currently practicing row planting, 5 or 3.6% male only practiced it in the past while 3 or 2.2 % male are not practicing row planting. Fourteen (14) or 87.5 female have practiced row planting in the past, 2 or 12.5% female only practiced it in the past while none of the female is not practicing row planting.

The Chi test is 157.921 and reveals that there is no significant difference between the way male and female practiced row planting as a way of CSA.

Table 5. 2 presents the CSA practices in intercropping along gender lines

Table 5.2: Intercropping Practice with Gender

	Gender		Total
	Man	Woman	
Yes, currently practicing	121 (87.7%)	15 (93.7%)	136 (88.3%)
No	6 (4.3%)	0 (0%)	6 (3.9%)
Only practiced in the past	11 (8.0%)	1 (6.3%)	12 (7.8%)
Total	138 (100)	16 (100)	154 (100)

Pearson Chi-Square = 155.815 (0.000)
Significance level is in parenthesis

The table above reveals that out of 136 respondents or 88.3% that are currently practicing intercropping, 121 or 87.7% are male while 15 or 93.7% are female. Six (6) respondents or 4.3% are not practicing intercropping while 12 or 7.8% have only practiced it in the past with 11 or 8.0% male and 1 6.3% female respondents.

The Chi test is 155.815 and reveals that there is no significant difference between the way male and female practiced intercropping as a way of CSA.

Table 5. 3 presents the CSA practices in improved varieties along gender lines

Table 5.3: Improved Varieties Practice with Gender

	Gender		Total
	Man	Woman	
Yes, currently practicing	52 (37.7%)	5 (31.2%)	57 (37.0%)
No	71 (51.4%)	11 (68.8%)	82 (53.2%)
Only practiced in the past	15 (10.9%)	0 (0%)	15 (9.8%)
Total	138 (100)	16 (100)	154 (100)

Pearson Chi-Square = 157.723 (0.000)
Significance level is in parenthesis

In table 5.3 above, out of 138 respondents, 52 or 37.7% male are currently practicing improved varieties, 71or 51.4% male are not practicing while 15 or 10.9% male only practiced improved varieties in the past, while 5 or 31.2% female are currently practicing improved varieties, 11 or 68.8% female respondents are not practicing and none has practiced in the past.

The Chi test is 157.723 and reveals that there is no significant difference between the way male and female practiced improved varieties as a way of CSA.

Table 5. 4 presents the CSA practices in minimum tillage along gender lines

Table 5.4: Minimum Tillage Practice with Gender

	Gender		Total
	Man	Woman	
Yes, currently practicing	9 (6.5%)	1 (6.3%)	10 (6.5%)
No	121 (87.7%)	13 (81.3%)	134 (87.0%0
Only practiced in the past	8 (5.8%)	2 (12.4%)	10 (6.5%)
Total	138 (100)	16 (100)	154 (100)

Pearson Chi-Square = 156.069 (0.000)
Significance level is in parenthesis

Out of 154 respondents who responded to this question, 138 are male while 16 are female. 10 or 6.5% of them are currently practicing minimum tillage, 134 or 87.0% are not practicing minimum tillage while 10 or 6.5% have only practiced it in the past.

The Chi test is 156.069 and reveals that there is no significant difference between the way male and female practiced minimum tillage as a way of CSA.

Table 5. 5 presents the CSA practices in mulching along gender lines

Table 5.5: Mulching Practice with Gender

	Gender		Total
	Man	Woman	
Yes, currently practicing	31 (22.5%)	2 (12.5%)	33 (21.4%)
No	91 (65.9%)	12 (75.0%)	103 (66.9%)
Only practiced in the past	16 (11.6%)	2 (12.5%)	18 (11.7%)
Total	138 (100)	16 (100)	154 (100)

Pearson Chi-Square = 155.856 (0.000)
Significance level is in parenthesis

In table 5.5 above, male respondents are 31 (22.5%) and female 2 (12.5%) are currently practicing mulching, 91 or 65.9% male and 12 or 75.0% female are not practicing mulching while 16 or 11.6% male and 2 or 12.5 female have only practiced mulching in the past.

The Chi test is 155.856 and reveals that there is no significant difference between the way male and female practiced mulching as a way of CSA.

Table 5. 6 presents the CSA practices in row planting along educational level of household heads

Table 5.6: Row Planting Practice with Educational Level of Household Head

	Educational level				Total
	No Education	Primary	Secondary	Superior/Tertiary	
Yes, currently practicing	6 (85.7%)	98 (93.3%)	36 (94.7%)	4 (100%)	144 (93.5%)
No	0 (0%)	1 (1.0%)	2 (5.3%)	0 (0%)	3 (1.9%)
Only practiced in the past	1 (14.3%)	6 (5.7%)	0 (0%)	0 (0%)	7 (4.5%)
Total	7 (100)	105 (100)	38 (100)	4 (100)	154 (100)

Pearson Chi-Square = 161.691 (0.000)
Significance level is in parenthesis

Table 5.6 above shows that 7 household head respondents are with no education, 105 household head respondents have primary education, 38 household head respondents have secondary education while 4 household head respondents have superior education. Six (6) or 85.7% of the household head with no education are currently practicing row planting while 1 or (14.3%) of the household head with no education have only practiced it in the past. Ninety eight (98) or 93.3% household head respondents with primary education are currently practicing row planting, 1 or 1.0%) household head respondent have not practiced row planting while 6 or 5.7% of the household head respondents have practiced row planting in the past.

Out of the 38 household head respondents, 36 or 94.7% with secondary education are currently practicing row planting while 2 or 5.3% are not practicing row planting. Only 4 or 100% respondents with tertiary education are currently practicing row planting.

The Chi test is 161.691 and reveals that there is no significant difference between the educational level of the household head and the way they practiced row planting as a way of CSA.

Table 5. 7 presents the CSA practices in intercropping along educational level of household heads

Table 5.7: Intercropping Practice with Educational Level of Household Head

	Educational level				Total
	No Education	Primary	Secondary	Superior/Tertiary	

Yes, currently practicing	7 (100%)	91 (86.7%)	35 (92.1%)	3 (75%)	136 (88.3%)
No	0 (0%)	5 (4.7%)	1 (2.6%)	0 (0%)	6 (3.9%)
Only practiced in the past	0 (0%)	9 (8.6%)	2 (5.3%)	1 (25%)	12 (7.8%)
Total	7 (100)	105 (100)	38 (100)	4 (100)	154 (100)

Pearson Chi-Square = 158.551 (0.000)
Significance level is in parenthesis

From Table 5.7 above, 7 (100%) household head respondents with no educational level are currently practicing intercropping, 91 (86.7%) household head respondents with primary education are currently practicing intercropping, 35 (92.1%) household head respondents with secondary education are currently practicing intercropping. None of the household head respondents with no education have either practiced intercropping in the past or not practicing intercropping. 5 (4.7%) household head respondents with primary education have not practiced intercropping while 9 (8.6%) have practiced it in the past. One 1 (2.6%) respondent with secondary education is not practicing intercropping and 2 (5.3%) have practiced it in the past.

This indicates that majority of farmers have who are currently practicing intercropping have primary education and therefore shows that the respondents have a form of education to understand how CSA practices are been carried out.

The Chi test is 158.551 and reveals that there is no significant difference between the educational level of the household head and the way they practiced intercropping as a way of CSA.

Table 5. 8 presents the CSA practices in improved varieties along educational level of household heads

Table 5.8: Improved Varieties Practice with Educational Level of Household Head

	Educational level				Total
	No Education	Primary	Secondary	Superior/Tertiary	
Yes, currently practicing	2 (28.6%)	34 (32.4%)	17 (44.7%)	4 (100%)	57 (37.0%)
No	5 (71.4%)	62 (59.0%)	15 (39.5%)	0 (0%)	82 (53.2%)
Only practiced in the past	0 (0%)	9 (8.6%)	6 (15.8%)	0 (0%0	15 (9.7%)
Total	7 (100)	105 (100)	38 (100)	4 (100)	154 (100)

Pearson Chi-Square = 167.955 (0.000)
Significance level is in parenthesis

Out of the respondents, 57 or 37.0% household respondents are currently practicing improved varieties, 82 or 53.2% household head respondents are not practicing improved varieties while 15 or 9.7% household head respondents have practiced improved varieties in the past.

Seven household head respondents are with no education, 105 household head respondents are with primary education, 38 household head respondents are with secondary education while only 4 household head respondents have tertiary education.

The Chi test is 167.955 and reveals that there is no significant difference between the educational level of the household head and the way they practiced improved varieties as a way of CSA.

Table 5.9 presents the CSA practices in improved varieties along educational level of household heads

Table 5.9: Minimum Tillage Practice with Educational Level of Household Head

	Educational level				Total
	No Education	Primary	Secondary	Superior/Tertiary	
Yes, currently practicing	0 (0%)	7 (6.7%)	3 (7.9%)	0 (0%)	10 (6.5%)
No	7 (100%)	91 (86.6%)	32 (84.2%)	4 (100%)	134 (87.0%)
Only practiced in the past	0 (0%)	7 (6.7%)	3 (7.9%)	0 (0%)	10 (6.5%)
Total	7 (100)	105 (100)	38 (100)	4 (100)	154 (100)

Pearson Chi-Square = 156.929 (0.000)
Significance level is in parenthesis

Out of the 154 respondents who are currently practicing minimum tillage, 7 (100%) with no education have not practiced minimum tillage, those with primary education, 7 (6.7%) are currently practicing, 91 (86.6%) have not practiced while 7 (6.7%) have only practiced minimum tillage in the past. For secondary education 3 (7.9%) are currently practicing, 32 (84.2%) are not practicing while 3 (7.9%) respondents only practiced in the past, For those with tertiary education, only 4 (100%) have not practiced minimum tillage before.

The Chi test is 156.929 and reveals that there is no significant difference between the educational level of the household head and the way they practiced minimum tillage as a way of CSA.

Table 5.10 presents the CSA practices in mulching along educational level of household heads

Table 5.10: Mulching Practice with Educational Level of Household Head

	Educational level				Total
	No Education	Primary	Secondary	Superior/Tertiary	
Yes, currently practicing	1 (14.3%)	20 (19.0%)	12 (31.6%)	0 (0%)	33 (21.4%)
No	6 (85.7%)	69 (65.7%)	25 (65.8%)	3 (75%)	103 (66.9%)
Only practiced in the past	0 (0%)	16 (15.2%)	1 (2.6%)	1 (25%)	18 (11.7%)
Total	7 (100)	105 (100)	38 (100)	4 (100)	154 (100)

Pearson Chi-Square = 163.848 (0.000)
Significance level is in parenthesis

Table 5.10 above shows that 1or 14.3% household head respondent with no education, 20 or 19.0% household head respondents with primary education, 12 or 31.6% household head respondents with secondary education and no household head respondents is currently practicing mulching. Out of 103 or 66.9% household head respondents who are not practicing mulching, 6 or 85.7% are with no education, 69 or 65.7% are with primary education, 25 or 65.8% are with secondary education while 3 or 75% are with tertiary education. 18 or 11.7% household respondents have only practiced mulching in the past out of which 16 or 15.2% are with primary education, 1 or 2.6% is with secondary education while 1 or 25% is with tertiary education.

The Chi test is 163.848 and reveals that there is no significant difference between the educational level of the household head and the way they practiced mulching as a way of CSA.

Table 5.11 presents the CSA practices in row planting along with household type

Table 5.11: Row Planting Practice with Household Type

	Type of household			Total
	Dual headed household	Female headed household	Male headed household	
Yes, currently practicing	123 (95%)	13 (86.7%)	8 (80%)	144 (93.5%)
No	3 (2.3%)	0 (0%)	0 (0%)	3 (1.9%)
Only practiced in the past	3 (2.3%)	2 (13.3%)	2 (20%)	7 (4.5%)
Total	129 (100)	15 (100)	10 (100%)	154 (100)

Pearson Chi-Square = 165.165 (0.000)
Significance level is in parenthesis

The table above reveals that 123 or 95% respondents who are currently practicing row planting are dual headed households. Three or 2.3% respondents who are dual headed household are not practicing row planting while 3 or 2.3% dual headed household respondents have practiced row planting in the past. Thirteen (13) or 86.7% female headed households are currently practicing row planting, 2 or 13.3% female headed respondents have only practiced in the past while none of them is not practicing. For male headed household, 8 or 80% respondents are currently practicing row planting, no respondent is not practicing while 2 or 20% only practiced row planting in the past.

The Chi test is 165.165 and reveals that there is no significant difference between the household type and the way they practiced row planting as a way of CSA.

Table 5.12 presents the CSA practices in intercropping along with household type

Table 5.12: Intercropping Practice with Household Type

	Type of household			Total
	Dual headed household	Female headed household	Male headed household	
Yes, currently practicing	115 (89.1%)	14 (93.3%)	7 (70%)	136 (88.3%)
No	6 (4.7%)	0 (0%)	0 (0%)	6 (3.9%)
Only practiced in the past	8 (6.2%)	1 (6.7%)	3 (30%)	12 (7.8%)
Total	129 (100)	15 (100)	10 (100)	154 (100)

Pearson Chi-Square = 163.422 (0.000)
Significance level is in parenthesis

From the table above, of the 136 (88.3%) respondents who are currently practicing intercropping, 115 (89.1%) respondents from dual headed household, 14 (93.3%) respondents are from single headed household while 7 (70%) are from male headed household. Six (4.7%) respondents are not practicing intercropping and they are all from dual headed household. Twelve (7.8%) respondents have only practiced intercropping from the past and 8 (6.2%) are dual headed, 1 (6.7%) is female headed while 3 (30%) are male headed household.

The Chi test is 163.422 and reveals that there is no significant difference between the household type and the way they practiced intercropping as a way of CSA.

Table 5.13 presents the CSA practices in improved varieties along with household type

Table 5.13: Improved Varieties Practice with Household Type

	Dual headed household	Female headed household	Male headed household	
Yes, currently practicing	53 (41.1%)	3 (20%)	1 (10%)	57 (37.1%)
No	61 (47.3%)	12 (80%)	9 (90%)	82 (53.2%)
Only practiced in the past	15 (11.6%)	0 (0%)	0 (0%)	15 (9.7%)
Total	129 (100)	15 (100)	10 (100)	154

Pearson Chi-Square = 167.121 (0.000)
Significance level is in parenthesis

For the practice of improved varieties, 129 respondents are from dual headed household, 15 respondents are form female headed household while 10 respondents are from male headed household.

The Chi test is 167.121 and reveals that there is no significant difference between the household type and the way they practiced improved varieties as a way of CSA.

Table 5.14 presents the CSA practices in minimum tillage along with household type

Table 5.14: Minimum Tillage Practice with Household Type

	Dual headed household	Female headed household	Male headed household	
Yes, currently practicing	9 (7.0%)	1 (6.67%)	0 (0%)	10 (6.5%)
No	113 (87.6%)	12 (80%)	9 (90%)	134 (87.0%)
Only practiced in the past	7 (5.4%)	2 (13.3%)	1 (10%)	10 (6.5%)
Total	129 (100)	15 (100)	10 (100)	154 (100)

Pearson Chi-Square = 157.308 (0.000)
Significance level is in parenthesis

From Table 5.14 above, 154 respondents are from dual headed, female headed or male headed households. For dual headed household, 9or 7.0% respondents are currently practicing minimum tillage, 113 or 87.6% respondents are not practicing it while 7 or 5.4% respondents have practiced it in the past. For female headed household, 1or 6.67% respondent is currently practicing minimum tillage, 12 or 80% respondents are not practicing minimum tillage while 2 or 13.3% respondents have only practiced it in the past. For male headed household, no respondent is currently practicing minimum tillage, 9 or 90% respondents are not practicing minimum tillage while only 1 or 10% respondent have practiced it in the past.

The Chi test is 157.308 and reveals that there is no significant difference between the household type and the way they practiced minimum tillage as a way of CSA.

Table 5.15 presents the CSA practices in mulching along with household type

Table 5.15: Mulching Practice with Household Type

	Dual headed household	Female headed household	Male headed household	
Yes, currently practicing	31 (24.0%)	2 (13.3%)	0 (0%)	33 (21.4%)
No	86 (66.7%)	10 (66.67%)	7 (70%)	103 (66.9%)
Only practiced in the past	12 (9.3%)	3 (20%)	3 (30%)	18 (11.7%)
Total	129 (100)	15 (100)	10 (100)	154 (100)

Pearson Chi-Square = 162.457 (0.000)
Significance level is in parenthesis

Table 5.15 above shows that 31(24.0%) dual headed household respondents, 2 (13.3%) female headed household respondents and no male headed household respondent is currently practicing mulching. Eighty six (66.7%) dual headed household respondents, 10 (66.67%) female headed household respondents and 7 (70%) male headed household respondents are not practicing mulching, while 12 (9.3%) dual headed household respondents, 3 (20%) female headed household respondents and 3 (30%) male headed household respondents have only practiced mulching in the past.

The Chi test is 162.457 and reveals that there is no significant difference between the household type and the way they practiced mulching as a way of CSA.

Table 5.16 presents the CSA practices in row planting along with owning a phone

Table 5.16: Row Planting Practice with Owning a Phone

	Owing Phone		Total
	Yes	No	
Yes, currently practicing	88 (97.8%)	56 (87.5%)	144 (93.5%)
No	0 (0%)	3 (4.7%)	3 (1.9%)
Only practiced in the past	2 (2.2%)	5 (7.8%)	7 (4.5%)

Total	90 (100)	64 (100)	154 (100)

Pearson Chi-Square = 162.260 (0.000)
Significance level is in parenthesis

Table 5.16 above shows that 88 or 97.8% respondents who own a phone are currently practicing row planting, none of the respondents with phone is not practicing row planting while 2 or 2.2% respondents with phone only practiced row planting in the past. Fifty six or 87.5%respondents without phone are currently practicing row planting, 3 or 4.7% respondents without phone are not practicing row planting while only 5 or 7.8% respondents without phone have practiced row planting in the past.

The Chi test is 162.260 and reveals that there is no significant difference between owning a phone and the way they practiced row planting as a way of CSA.

Table 5.17 presents the CSA practices in intercropping along with owning a phone

Table 5.17: Intercropping Practice with Owning a Phone

	Owning phone		Total
	Yes	No	
Yes, currently practicing	79 (87.8%)	57 (89.1%)	136 (88.3%)
No	3 (3.33%)	3 (4.7%)	6 (3.9%)
Only practiced in the past	8 (8.89%)	4 (6.3%)	12 (7.8%)
Total	90 (100)	64 (100)	154 (100)

Pearson Chi-Square = 155.521 (0.000)
Significance level is in parenthesis

Table 5.17 above showed that 136 or 88.3% respondents with or without a phone are currently practicing intercropping out of which 79 or 87.8% respondents own a phone while 57 or 89.1% respondents do not own a phone. Six or 3.9% respondents are not practicing intercropping out of which 3 or 3.33% own a phone while 3 or 4.7% do not own a phone. Twelve or 7.8% respondents have practiced intercropping only in the past out of which 8 or 8.89% respondents own a phone while 4or 6.3% do not own a phone.

The Chi test is 155.521 and reveals that there is no significant difference between owning a phone and the way they practiced intercropping as a way of CSA.

Table 5.18 presents the CSA practices in improved varieties along with owning a phone

Table 5.18: Improved Varieties Practice with Owning a Phone

	Owning phone		Total
	Yes	No	
Yes, currently practicing	37 (41.1%)	20 (31.3%)	57 (37.0%)
No	40 (44.4%)	42 (65.6%)	82 (53.2%)
Only practiced in the past	13 (14.4%)	2 (3.13%)	15 (9.7%)
Total	90 (100)	64 (100)	154 (100)

Pearson Chi-Square = 164.113 (0.000)
Significance level is in parenthesis

Table 5.18 above shows that of the 154 respondents, 90 respondents owned at least a phone while 64 respondents who do not own a phone. Thirty seven or 41.1% respondents with at least a phone are currently practicing improved varieties form of CSA practice, 40 or 44.4% respondents who owned at a least a are not practicing improved varieties while 13 or 14.4% respondents with phone have practiced improved varieties in the past. Twenty or 31.1% respondents without phone are currently practicing improved varieties, 42 or 65.6% respondents without phone are not practicing improved varieties while 2 or 3.13% respondents without phone only practiced improved varieties in the past.

The chi test is 164.113 and reveals that there is no significant difference between owning a phone and the way they practiced improved varieties as a way of CSA.

Table 5.19 presents the CSA practices in minimum tillage along with owning a phone

Table 5.19: Minimum Tillage Practice with Owning a Phone

	Owning Phone		Total
	Yes	No	
Yes, currently practicing	6 (6.67%)	4 (6.25%)	10 (6.49%)
No	79 (87.8%)	55 (85.9%)	134 (87.0%)
Only practiced in the past	5 (5.56%)	5 (7.8%)	10 (6.49%)
Total	90 (100)	64 (100)	154 (100)

Pearson Chi-Square = 155.320 (0.000)
Significance level is in parenthesis

As presented in Table 5.19, 90 respondents own at least a phone while 64 respondents are without phone. Out of the 90 respondents with at least a phone, 6 or 6.67% respondents are currently practicing Minimum Tillage, 79 or 87.8% respondents are not practicing minimum tillage while 5 or 5.56% respondents have practiced minimum tillage in the past. From the 64 respondents without phone, 4 or 6.25% respondents have practiced minimum tillage in the past, 55 or 85.9% respondents are not practicing minimum tillage while 5 or 7.8% respondents have practiced minimum tillage in the past.

The chi test is 155.320 and reveals that there is no significant difference between owning a phone and the way they practiced minimum tillage as a way of CSA.

Table 5.20 presents the CSA practices in mulching along with owning a phone

Table 5.20: Mulching Practice with Owning a Phone

	Owning Phone		Total
	Yes	No	
Yes, currently practicing	21 (23.3%)	12 (18.8%)	33 (21.4%)
No	61 (67.8%)	42 (65.6%)	103 (66.9%)
Only practiced in the past	8 (8.89%)	10 (15.6%)	18 (11.69%)
Total	90 (100)	64 (100)	154 (100)

Pearson Chi-Square = 156.857 (0.000)
Significance level is in parenthesis

Table 5.20 above shows that 21(23.3%) respondents with phone are currently practicing mulching, 61 (67.8%) respondents are not while 8 (8.89%) respondents only practiced mulching in the past. From the 64 respondents without phone, 12 (18.8%) respondents are currently practicing mulching, 42 (65.6%) respondents are not while 10 (15.6%) respondents have practiced mulching in the past.

The chi test is 156.857 and reveals that there is no significant difference between owning a phone and the way they practiced mulching as a way of CSA.

Table 5.21 presents the CSA practices in row planting along with rearing of livestock

Table 5.21: Row Planting Practice with Rearing of Livestock

	Rearing livestock		Total
	Yes	No	
Yes, currently	135 (93.8%)	9 (90%)	144 (93.5%)

practicing			
No	3 (2.08%)	0 (0%)	3 (1.9%)
Only practiced in the past	6 (4.17%)	1 (10%)	7 (4.5%)
Total	144 (100)	10 (100)	154 (100)

Pearson Chi-Square = 155.928 (0.000)
Significance level is in parenthesis

From the 154 respondents, 144 or 93.5% respondents that are currently practicing row planting have either reared or still rearing livestock. One hundred and thirty five or 93.8% currently practicing row planting are rearing livestock while 9 or 90% who are not rearing livestock are practicing row planting. Three or 2.08% respondents rearing livestock are not practicing row planting while 7 or 4.5% respondents from which 6 have practiced row planting in the past are rearing livestock.

The chi test is 155.928 and reveals that there is no significant difference between rearing of livestock and the way they practiced row planting as a way of CSA.

Table 5.22 presents the CSA practices in intercropping along with rearing of livestock

Table 5.22: Intercropping Practice with Rearing of Livestock

	Rearing livestock		Total
	Yes	No	
Yes, currently practicing	126 (87.5%)	10 (100%)	136 (88.3%)
No	6 (4.17%)	0 (0%)	6 (3.9%)
Only practiced in the past	12 (8.33%)	0 (0%)	12 (7.79%)
Total	144 (100)	10 (100)	154 (100)

Pearson Chi-Square = 156.425 (0.000)
Significance level is in parenthesis

From the table above, out of the 154 respondents, 144 respondents are rearing livestock while 10 respondents are not rearing livestock. Ten or 100% respondents currently practicing intercropping are not rearing livestock whereas, 126 or 87.5% respondents currently practicing intercropping are rearing livestock.

The chi test is 156.425 and reveals that there is no significant difference between rearing of livestock and the way they practiced intercropping as a way of CSA.

Table 5.23 presents the CSA practices in improved varieties along with rearing of livestock

Table 5.23: Improved Varieties Practice with Rearing of Livestock

	Rearing livestock		Total
	Yes	No	
Yes, currently practicing	53 (36.8)	4 (40%)	57 (37.0%)
No	78 (54.2%)	4 (40%)	82 (53.2%)
Only practiced in the past	13 (9.03%)	2 (20%)	15 (9.7%)
Total	144	10 (100)	154 (100)

Pearson Chi-Square = 156.544 (0.000)
Significance level is in parenthesis

Table 5.23 above shows that of the 154 respondents, 144 respondents are rearing livestock while 10 respondents are not rearing livestock. 53 or 36.8% respondents rearing livestock are currently practicing improved varieties form of CSA practice, 78 or 54.2% respondents who are rearing livestock are not practicing improved varieties while 13 or 9.03% respondents rearing livestock have practiced improved varieties in the past. Four (4) or 40% respondents not rearing livestock are currently practicing improved varieties, 4 or 40% respondents not rearing livestock are not practicing improved varieties while 2 or 20% respondents not rearing livestock only practiced improved varieties in the past.

The chi test is 156.444 and reveals that there is no significant difference between rearing of livestock and the way they practiced improved varieties as a way of CSA.

Table 5.24 presents the CSA practices in minimum tillage along with rearing of livestock

Table 5.24: Minimum Tillage Practice with Rearing of Livestock

	Rearing livestock		Total
	Yes	No	
Yes, currently practicing	9 (6.25%)	1 (10%)	10 (6.49%)
No	125 (86.8%)	9 (90%)	134 (87.0%)
Only practiced in the past	10 (6.9%)	0	10 (6.5%)
Total	144 (100)	10 (100)	154 (100)

Pearson Chi-Square = 155.914 (0.000)
Significance level is in parenthesis

Out of 154 respondents who responded to this question, 144 are rearing livestock while 10 are not rearing livestock. 9 or 6.25% of those rearing livestock are currently practicing minimum tillage, 125 or 86.8% are not practicing minimum tillage while 10 or 6.9% have only practiced it in the past. Nine (9) or 90% respondents who are not practicing minimum tillage are not rearing livestock while 1 or 10% respondent who is not rearing livestock is currently practicing minimum tillage.

The chi test is 155.914 and reveals that there is no significant difference between rearing of livestock and the way they practiced minimum tillage as a way of CSA.

Table 5.25 presents the CSA practices in mulching along with rearing of livestock

Table 5.25: Mulching Practice with Rearing of Livestock

	Rearing livestock		Total
	Yes	No	
Yes, currently practicing	29 (20.1%)	4 (40%)	33 (21.4%)
No	98 (68.1%)	5 (50%)	103 (66.9%)
Only practiced in the past	17 (11.8%)	1 (10%0	18 (11.69%)
Total	144 (100)	10 (100)	154 (100)

Pearson Chi-Square = 157.217 (0.000)
Significance level is in parenthesis

Table 5.25 above shows that 33 or 21.4%respondents who are rearing livestock and not rearing livestock are currently practicing mulching. 103 or 66.9% respondents who are rearing and not rearing livestock are not practicing mulching while 18 or 11.69% respondents who are rearing and not rearing livestock have practiced mulching in the past.

The chi test is 157.217 and reveals that there is no significant difference between rearing of livestock and the way they practiced mulching as a way of CSA.

This shows that more household farmers rear livestock together with farming and therefore practice mixed farming. The mean number of livestock owned by an average household was two types of livestock. According to Uganda Climate Smart Agriculture Programme, 2015-2020, livestock share to the GDP is currently projected at 1.7%. In recent years livestock population growth rates have been estimated to grow at 1.4, 2.5, 4.3 and 3.0 for cattle, sheep, goat and chicken respectively.

5.3 : MONITORING IMPLEMENTATION, PERFORMANCE AND OUTCOMES OF CLIMATE SMART AGRICULTURE.

5.3.1 MONITORING IMPLEMENTATION OF CLIMATE SMART AGRICULTURE

Indicator for monitoring implementation of the climate smart agriculture is number of household framers carrying out the different CSA Practices

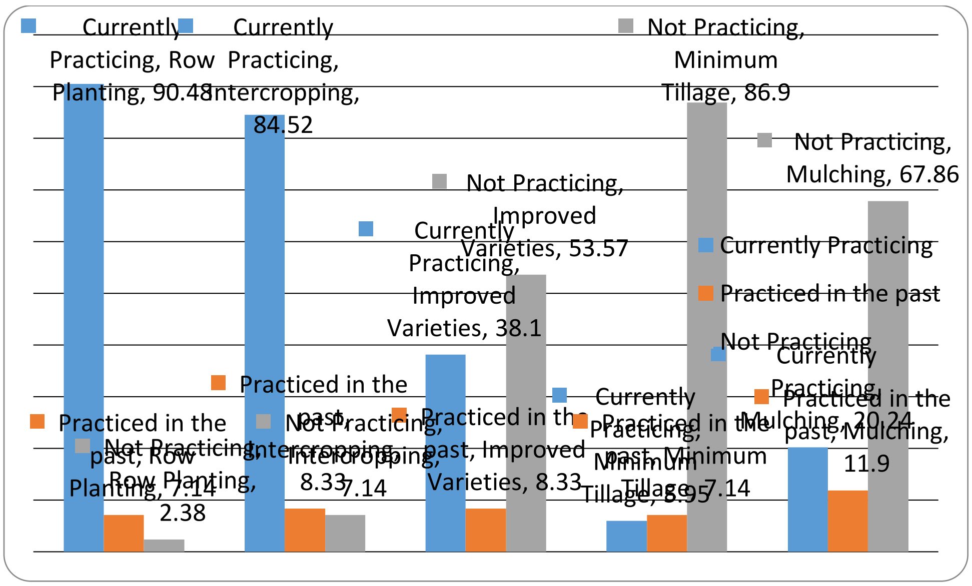

Figure 5.1: Percentage of Household Farmers carrying out the Different CSA Practices. Field Survey 2017

All farmers who were interviewed had adopted at least one practice within the portfolio of CSA practices. Figure 5.1 above shows that 90.48% of farmers are currently practicing row planting, 7.14% practiced row planting in the past while 2.38% are not practicing row planting. 84.52% of farmers are currently practicing intercropping, 8.33% only practiced intercropping in the past while 7.14% of farmers are not practicing intercropping.

38.1% of farmers are currently planting improved varieties of seedlings, 8.33% of farmers only planted improved varieties in the past while 53.57% of respondent farmers are not planting improved varieties.

5.95% of respondents are currently practicing minimum tillage, 7.14% of respondents practiced in the past while 86.9% of respondents are not practicing minimum tillage. 20.24% of respondents are currently practicing mulching, 11.9% only practices in the past while 67.86% are not practicing.

From above, it shows that majority of the farmers are practicing row planting and intercropping more than the other CSA practices. The level of adoption for minimum tillage and mulching were lower because they were newer practices to farmers that required changes in the farming system.

5.3.2 MONITORING PERFORMANCE OF CSA PRACTICES

Indicators for measuring performance include increase in yield, increase in income and control of pests and diseases as a result of the different climate smart agriculture practices.

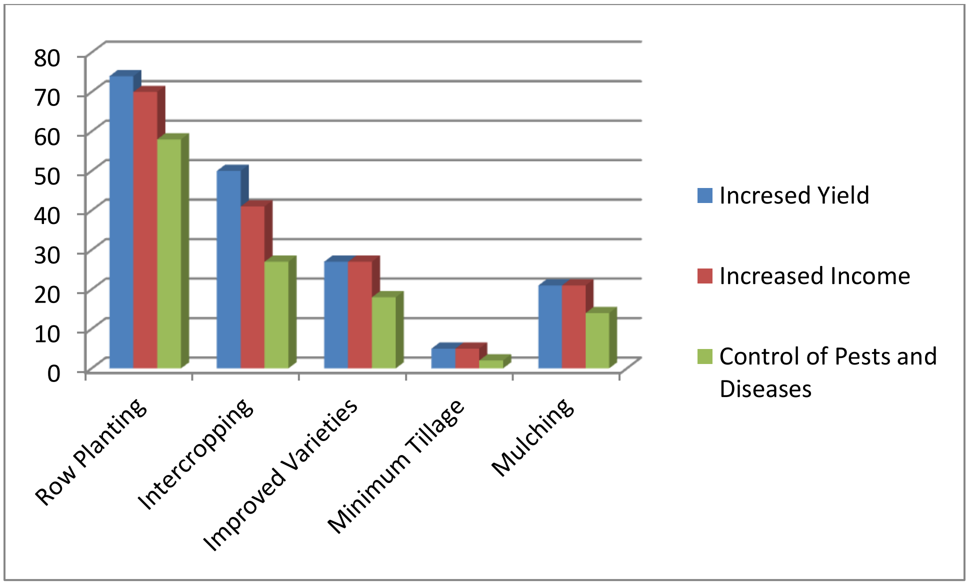

Figure 5.2: Percentage of increased yield, increased income and control of pest and diseases since implementation of the different CSA practices

Field Survey 2017

Figure 5.2 above shows that row planting has higher percentage for high performance in terms of yield, income and control of pests and diseases. Under certain conditions, CSA has been found to increase crop yields, enhance carbon content in soils and maintain soil moisture (FAO, 2014). When CSA is used in highland areas, it may further enhance crop production and resilience, even in highly degraded soils due to the interactive effects of improved plant nutrition and soil moisture (FAO, 2014).

5.3.3 Monitoring Outcomes of CSA Practices

Indicator for measuring outcome is the reduced time spent on the field since the implementation of the different climate smart agriculture practices.

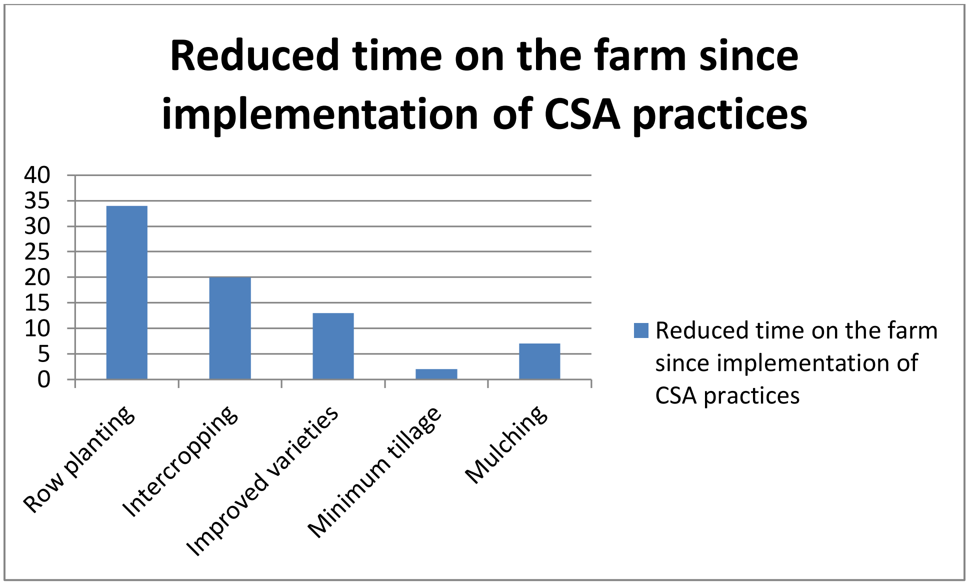

Figure 5.3: Percentage of Reduced Time Spent on the field since the implementation of CSA Practices

Field Survey 2017

Figure 5.3 above indicates that of all the different CSA practices practiced by the farmers, row planting has helped farmers spend less time on the field, followed by intercropping, improved varieties, mulching and minimum tillage. The respondents confirmed that they spend more time on the field when practicing intercropping as against reduced time spent when practicing row planting because in planting different crops in intercropping, it means that each crop takes its time and therefore implied more time on the field.

The respondents responded that improved varieties has been difficult to get and when gotten to purchase, most times they are bad seedlings which does not give much yield as expected and therefore makes them prefer to use their local seedlings. They acknowledged that it is stressful getting mulch and it takes time to gather. If at all mulch is gotten, it sometimes allowed for attack of insects and different pests on the crop been mulched. Minimum tillage did not give enough yields as expected so they prefer to dig and plant.

5.4 BARRIERS FOR WIDESCALE ADOPTION OF THE CSA PRACTICES

The adoption of CSA practices in Uganda is fraught with certain barriers. These include:

1. Gender inequality
2. Lack of capital and limited farm inputs
3. Limited access to information

Gender Inequality

Gender inequality can hinder adoption of climate-smart strategies. Men, especially heads of household, make the broad management decisions of land allocation, labour organization, cropping/animal rearing patterns and income expenditure. From the study, majority of the women indicated that they have little or no say when it comes to decision making in the family which in turn affects decision on what is done on the farm. The women also complained that they are not allowed to take ownership and implement changes at the farm level, and do not have the resources to do so. For instance, women in Africa often have less access than men to resources such as land, inputs, credit, education, and extension services, all of which may be important to support transitions to CSA.

Lack of Capital and Limited Farm Inputs

Non-availability and poor access to high-yielding seeds and breeds are also important barriers to the adoption of CSA. Often, CSA requires special seeds for cover crops or intercrops, which are more difficult to obtain if they are species that have not traditionally been grown locally. Unless efficient and reliable input supply chains are established, input barriers will continue to be a hindrance to adoption of CSA.

Smallholder farmers aiming to adopt CSA practices often are constrained by inadequate cash to invest in the land, equipment, labor, seeds, breeds and other farm inputs. As noted by Milder, *et al*. (2011), CSA is generally more profitable in the long-term compared to conventional farming, but achieving these long-term benefits requires initial investment, which is often prohibitively expensive or risky for small farmers to undertake on their own. Vulnerable farmers are especially risk averse due to household food security concerns, and there is little room for error. In addition, while many farmers reap benefits in the first year of practicing CSA, others do not realize increased yields or profitability for 3-7 years (Hobbs, 2007). During this time, farmers sometimes choose to abandon CSA. Thus, long-term adoption is more likely when CSA provides significant benefits in the first or second year. Such immediate benefit is more likely when CSA is promoted in conjunction with good agronomic practices, improved seeds, and sometimes inorganic fertilizers.

Limited Access to Information

The farmers identified that they have limited availability to information and also lack access to information and knowledge about the short- and long-term benefits of CSA practices. Information is a powerful tool for enhancing adaptation to climate change and variability. However, African smallholder farmers either do not have access to appropriate information or are unable to fully utilize existing information. Successful adaptation requires recognition of the necessity to adapt, knowledge about available options, the capacity to assess the options, and the ability to choose and implement the most suitable ones. In terms of climate change, this can be demonstrated through acquisition and dissemination of information on weather hazards. Once such information becomes more available and understood, it is possible to analyse, discuss, and develop feasible adaptation measures. Building adaptive capacity requires a strong unifying vision, scientific understanding of the problems, openness to face challenges, pragmatism in developing solutions, community involvement and commitment at the highest political levels. Inadequately trained and skilled personnel can limit a community's or a nation's ability to implement adaptation options.

CHAPTER SIX

6.0 Conclusion and Recommendation

6.1 Summary of Findings

From the study conducted at Nwoya District of Northern Uganda, it was observed that quiet a number of household farmers have adopted at least one of the assessed climate smart agricultural practice. Adoption of these practices has increased yield, increased income, controlled pests and diseases and also reduced time spent on the farm land if implemented properly. It was observed that more male respondents are practicing the CSA practices compared to women respondents; the household head have a form of educational level which is mostly primary education. The respondents are more of dual-headed household type and are rearing livestock.

There are more farmers practicing row planting and intercropping compared to the practice of improved varieties, minimum tillage and mulching.

6.2 Conclusion

CSA contributes to a cross-cutting range of development goals. It needs to be implemented using an integrated, cross-sectoral approach to agriculture and food security that links it to other aspects of sustainable development, poverty reduction and economic growth. CSA policies and programmes, as with all cross-sectoral development programmes, need to be developed so that they are aligned among all levels of government. This requires an understanding of the structure and functioning of each level of government. Comprehensive capacities need to be developed because in many countries, local-level capacity development has not been included as part of the decentralization processes.

This study showed that majority of the farmers are implementing row planting and intercropping because it is most beneficial to the farmers indicators (Crop yield, Income, control of pests and diseases and reduced time).

One of the great strengths of the Climate-Smart Village approach is its inclusiveness in bringing together farmers, policy makers, scientists and local organizations to work on a portfolio of practices to adapt agriculture to climate change. Integrating the model into existing or proposed government policies can ensure the food and livelihood security of millions of farmers living in regions vulnerable to climate change.

To create an enabling environment for the development and mainstreaming of CSA in the overarching national plan, appropriate institutions with effective and transparent governance structures are needed. These institutions would coordinate the division of sectoral responsibilities and the work done by national local institutions that will incorporate CSA strategies into legal and regulatory frameworks. Regulations need to be adapted to country environments and accompanied by other supporting incentives if CSA interventions are to be successful in changing behaviour and providing additional incentives for advancing CSA.

Investment in CSA brings long-term gains in productivity, builds resilience, reduces GHG emissions and increases carbon sequestration. The most successful programmes often blend sources of funding. Incentive measures need to focus on overcoming barriers to adoption of CSA practices. Price and non-price measures are needed to support transition to CSA. Behavioural change is also an important element. Price support certainly has a role to play in countries affected by climate change, but often other forms of support (regulations, incentives, capacity development, investments in technology, innovation, efficiency gains and infrastructure, connectivity or the broader enabling environment, social protection and safety nets, and use of social capital) are more effective in paving the way for CSA.

Civil society, the private sector and financial institutions all play vital roles in implementing CSA. These groups should work jointly with key national line ministries and development agencies and donors through an efficient stakeholder consultation process.

6.3 Policy Recommendation

1) Creating awareness about climate change and what CSA can do

Many African smallholder farmers and farm communities experience low crop and animal yields but are unaware that this is partly as a result of climate change. Many are not aware of what to do to remedy the situation. The current climate change discourse is very much promoted by international NGOs and some civil society organizations with little contribution from local farmers and communities. An indigenous (African) critical consciousness to climate change is still lacking. It is therefore important that this consciousness is cultivated and raised at all levels in order to change perceptions of climate change for Africa to take responsibility for addressing the challenges it presents. Most of the challenges can be addressed through adoption of CSA.

Whereas resource constraints may limit the practice of CSA, increased consciousness about climate change can enable farmers and farm communities to generate the resources to enable them practice CSA.

2) Facilitating access to finance and credit

Several approaches have been used to overcome the dual financial constraints of the initial investment required for CSA and the potential for negative returns for several years after adoption. Both of these constraints can be overcome by providing low-cost inputs, extending credit to farmers through direct loans or establishment of community financing operations, and educating farmers about the benefits of CSA and ways to improve its profitability. Other rural finance mechanisms can also help farmers overcome the short-term investment hurdle to adopt CSA practices that are more profitable and sustainable in the longer term.

3) Mainstreaming Gender Equality in CSA Initiatives

Climate-smart agricultural initiatives are much more likely to achieve their desired outcomes if they encourage women to take ownership and implement changes at the farm level, ensure that women have the resources to do so by reforming institutional arrangements (structure), and work with men to ensure that they value the contributions and ideas of women in regard to this role (relations)

4) Facilitating Information and Knowledge use in Climate Change and CSA

Farmers and farm communities need to appreciate the need to adopt CSA practices. This appreciation in turn necessitates availability of information explaining the need for CSA adoption. Provision of information and knowledge about the short- and long-term benefits of CSA practices, for example CSA's ability to increase yields by fostering biological processes and management practices that enhance soil fertility, pest and weed control regardless of use of agrochemicals, is a good strategy. Strengthening the capacity of farmers and local communities to understand climate change as well as appreciate the benefits of CSA requires an initial critical mass of personnel capable of instilling into farmers information and knowledge about climate change. People need to be trained to collect, collate and disseminate information about weather hazards and to facilitate analysis, discussion and development of feasible adaptation measures. Nonetheless, building overall adaptive capacity requires a strong, unifying vision, scientific understanding of challenges, openness, pragmatism in developing solutions, community involvement and commitment at the highest political levels.

5) Enhancing the Capacity of Farmers to adopt and use New Technologies and Innovations

The ability of farmers to apply new technologies and innovations is an important determinant of CSA adoption. Farmers need to be sensitized on existing technologies and innovations to appreciate and adopt them. Sensitization and awareness creation on existing new technologies and innovations is key to promoting adoption and strengthening adaptive capacity. However, new technologies and innovations are costly and sometimes complicated to apply; so farmers must either have the resources, receive subsidies or are given incentives to adopt them. Availability of markets, especially for value added products can spur investment in new CSA technologies and innovations and therefore promote adoption.

Slow adaptation to climate change in Africa is partly attributed to low technology adoption. Most agrarian communities are used to traditional technologies that were over generations inculcated into them informally within household and community settings. Any technology not inculcated through early socialization or seen to disrupt the existing livelihood systems will not be accepted and assimilated easily. Therefore, building the capacity of farmers through demonstration, exchange visits and incorporation of socio-cultural aspects is an essential component of any technology transfer package. Technology dissemination should embrace participatory and cross-sector approaches to ensure effective smallholder involvement and sustainability. Overall, enhanced farmer education can speed up technology dissemination and adoption of CSA.

6) Making Farm Equipment, Inputs and Materials affordable to Farmers

Lack of or inadequate financial resources have been identified as a limiting factor to the acquisition of farm inputs and materials needed for successful practice of CSA. This barrier can be removed by making farm inputs and materials affordable to farmers in various ways including:

a) Facilitating access to finance: Compared to conventional farming, some CSA practices require substantial investments that need to be made upfront. Such investments are generally more profitable in the long-term (3-7 years) than in the short-run. Yet, majority of smallholder farmers in Africa are financially constrained to undertake such initial investments on their own. Considering that adoption is more likely when benefits are anticipated in the short-run, smallholder farmers need financial assistance to enable them practice CSA. Such assistance can be in the form of provision of credit at low interest rates.

b) Provision of subsidies that are eventually phased out gradually over time.

c) Removal of or reduction in import duties on farm equipment, tools and other inputs.

d) Educating farmers about the benefits of CSA and ways to improve its profitability.

e) Linking farmers to community micro-credit finance institutions

7) Promoting CSA Success Stories and Opportunities

For a farmer, life is filled with calculated and uncalculated risks. Therefore they will be naturally risk averse in their adoption of new ideas. For CSA to be successfully adopted by farmers, it will be important to remember this concept in the presentation of opportunities. Particular emphasis should go on the successes of CSA and opportunities for farmers to limit risk. There are many successes of CSA both from research and in the field. Identifying and promoting successes will engage adoption.

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