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1. INTRODUCTION

Climate change and food security are two of the most pressing challenges facing the global community today. Improving the smallholder agricultural system is a key response to both. The number of chronically hungry people in the world reached a total of 925 million in 2010 (FAO, 2010) and not much has changed since then. About 75% of the worst-affected people reside in rural areas of developing countries, their livelihoods depending directly or indirectly on agriculture. Strengthening agricultural production system is a fundamental means of improving incomes and food security for the largest group of food-insecure people in the world (McCarthy et al., 2011). As the key economic sector of most low-income developing countries, improving the resilience of agricultural systems is essential for climate change adaptation. Improvements in agricultural production systems offer the potential to provide a significant source of mitigation by increasing carbon stocks in terrestrial systems, as well as emissions reduction through increased efficiency.

One important way to ensure nutrition security and economic growth in Africa is to promote agricultural practices that help farmers to adapt as well as reduce agriculture's contribution to climate change. Climate smart agriculture (CSA) has been identified as an important pathway to achieve agricultural development priorities in the face of climate variability and change, and serves as a bridge to other development priorities, including gender inequality. Climate smart agriculture (CSA) is agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes greenhouse gases (mitigation) where possible, and enhances achievement of national food security and development goals (FAO, 2010). As a result, the use of CSA technology has been widely campaigned for because it is considered to be an efficient way of achieving high productivity in agriculture and is said to be an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change (Kitsao, 2016).

CSA technologies help to increase adaptive capacity through efficient use of resources and create agricultural systems that can withstand the threats of climate change. The focal point in CSA is proper use of land, soil and water conservation, as well as residual management, since these are the factors that determine productivity and are affected by climate change.

In spite of the development of several CSA technologies and the positive gains arising from them, wide scale adoption and practice remain problematic in Africa. There are several barriers to the adoption of CSA technologies by smallholder farmers in Africa, and so far, existing policies and actions to remove these barriers remain inadequate. A good understanding of what these barriers are, how they impinge on adoption of CSA practices by women and men farmers as well as the impact on nutrition security are essential.

This report identifies the level of adoption of CSA practices by gender, barriers to scaling up/out of CSA by gender and proposes strategies and practical actions to remove the barriers and enhance adoption in Africa. Section one of the report provides the background, rationale and objectives. Section two presents the African context of climate change, CSA technologies adoption and practices. Section four identifies and discusses the level of CSA adoption, barriers that limit up-scaling of CSA practices and the impact on nutrition security. Section five presents a summary of findings, conclusion reached, and outlines possible recommendations.

1.1 BACKGROUND TO THE STUDY

Uganda is an agro-based, land-locked country with a fast growing population of an estimated 34 million people and high population growth rate of 3.2% per annum. It is well endowed with natural resources and salubrious climate, though with low industrialization and value addition. The challenges facing the country include poverty, high population growth rate, low science and technology, environmental impacts and climatic change. This trio constitutes an issue of global concern to which the world is seeking lasting solutions and has seriously affected Ugandan smallholder farmers and undermined progress in agriculture.

The Inter-Governmental Panel on Climate Change (IPCC) forecasts that agricultural production, including access to food, in Africa and other regions, would be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in these regions. In some countries, yields from rain-fed agriculture could be reduced by up to 50 percent by 2020. Local food supplies would be negatively affected by reduced productivity of livestock (feed and fodder availability) and decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued over-fishing (Bernard et al., 2015).

Many actors are promoting key agro-ecological farming technologies and practices that are highly-suited to enable farmers to adapt to climate change. These include agro-forestry, crop rotation, intercropping, minimum tillage, soil cover maintenance, residue retention, water conservation, rice systems that reduce methane emissions, improved management of livestock and soil carbon as well as breeding plants and animals adapted for future climate conditions. These practices have been documented to generate higher and more stable crop yields and incomes as they also enhance resilience to climate change in some countries compared to conventional agricultural production methods.

CSA has been identified as a way to achieve short and long term agricultural development priorities in the face of climate variability and change, and serves as a bridge to other development priorities, including gender inequality. It seeks to support countries and other actors in securing the necessary policy, technical and financial conditions to enable them to sustainably increase agricultural productivity and income generation in order to meet national food security and development goals. It also attempts to build resilience and the capacity of agricultural and food systems to adapt to climate change; mitigate emissions of greenhouse gases and increase carbon sequestration (FAO, 2010).

CSA practices in general encompass conservation agriculture, integrated soil fertility management, small scale irrigation, agro-forestry, crop diversification, improved livestock feed and feeding practice, early warning systems as well as improved weather information. This study will focus on the five CSA practices that were introduced to farmers during a climate change adaptation programme organized by the International Centre for Tropical Agriculture (CIAT-Kenya) in collaboration with the International Institute of

Tropical Agriculture (IITA-Uganda) and which were the preferred practices by farmers. This report seeks to strengthen resilience of smallholder farmers and increase nutrition security by fostering wide scale adoption of climate smart agricultural practices in Uganda. The goal is to improve the livelihoods of poor rural smallholder farming households in Nwoya District, Northern Uganda and may be generalized to other parts of Uganda and other regions in Africa.

1.2 RESEARCH PROBLEM

Climate change poses new challenges to the fight against poverty and sustainability of agrarian livelihoods in sub-Saharan Africa. Predictions indicate that climate change will adversely affect agricultural production in Africa through declining crop yields and livestock productivity caused by rainfall variability, rising temperatures, drought and increased incidence of pest/disease. This situation is compounded by increase in population while production is struggling to keep up in Africa, where many smallholder farmers (who make up bulk of the population) are dependent on natural resources and agriculture for livelihood. They have low level of coping capabilities and are facing food insecurity, poverty, the degradation of local land and water resources. These vulnerable farmers depend on agriculture for income generation, food and nutrition security and as a way of coping with climate change.

If agricultural systems are to meet the needs of these farmers, they must evolve in ways that lead to sustainable increases in food production, at the same time strengthen the resilience of farming communities and rural livelihoods. In 2014, 12.9% of the population in developing countries was undernourished, while 2016 estimates show that one in nine people suffers chronic hunger (FAO, 2015). Uganda is one of these developing countries. Food and nutrition security remains Uganda's most fundamental challenge for human welfare and economic growth. Women, who are primary nutrition providers, continue to face discrimination and often have less access to power and resources, including those related to nutrition.

Gender and nutrition are inextricable parts of the vicious cycle of poverty. Gender inequality can be a cause as well as an effect of hunger and malnutrition. The food security challenge will only become more difficult if problems of gender inequality that reduce women's role as primary nutrition providers are not addressed urgently. Food demand is projected to rise by at least 20% over the next 15 years (WBG, 2017). Women smallholder farmers have for a long time been known to be the backbone of many families in developing countries and their main source of income is agricultural products. This makes it important to look at the CSA adoption on gender basis since it will identify the adoption level of and unique challenges to adoption that each gender group faces, particularly women, and provide solutions to upscale CSA, not just in Uganda but also in other developing countries.

Evidence shows that CSA is one of the ways of enhancing sustainable increase in food production and income generation, promoting gender equity, increasing nutrition security while strengthening the resilience of farming communities to adapt to climate change (Rioux et al. 2016). However, despite the development of several CSA technologies and the positive gains arising from its practice, wide scale adoption remains low among smallholder farmers in Africa, and its impact on household nutrition is not fully realised. There are further indications of a downward trend in adoption levels if urgent actions are not taken to identify the differences in the level of adoption by women and men farmers as well as factors responsible for such adoption levels, which are a prerequisite to understanding the barriers that each group faces in order to foster wider adoption and increased impact on nutrition security.

Much of the research reports on CSA have been focused on challenges to adoption with little or no regard to the differences in the level of adoption by gender groups. These partial assessments often consider challenges to adoption with respect to smallholder farmers in general, without consideration to gender differences that exist in CSA adoption and its impact on nutrition. This research has filled this knowledge gap by analyzing gender disparities in the adoption of CSA practices as it has systematically determined the specific challenges to wider adoption that is common to women, men and youth farmers as well as how the adoption rate has impacted household nutrition of farmers, using Uganda as a case study.

1.3 OBJECTIVES OF THE STUDY

The overall objective of this study is to examine the impact of gender disparities in the adoption of climate smart agricultural practices on the improvement of the livelihoods of poor rural smallholder farming households in Nwoya District, Northern Uganda while the specific objectives are to:

1. Determine the level of adoption of climate smart agriculture by women and men farmers in Nwoya District, Northern Uganda;
2. Identify factors limiting wide scale adoption of climate smart agriculture among smallholder farmers (women and men);
3. Assess the impact of climate smart agriculture on nutrition security.

1.4 SIGNIFICANCE OF THE STUDY

The continued increase in global population, especially in Africa, and increased incidents of climate change to which smallholder farmers are vulnerable with limited coping capabilities have resulted in reduced productivity, acute food shortage, pronounced poverty and nutrition deficiency. The effect of these, which constitutes Uganda's most fundamental challenge for human welfare and economic growth, necessitated this study. This study is important in that it reveals the gender factors limiting wider adoption of CSA practices, challenges faced in the adoption of CSA practices and the impact of these on food and nutrition security. This report is a useful tool to agricultural policy makers; local and international institutions, government at all levels and NGOs who seek to foster wider adoption of CSA by up-scaling the practice for sustainable development.

1.5 RESEARCH SCOPE

The focus of this study was Ugandan smallholder farmers who are highly vulnerable to climate variability and have least coping capabilities, particularly in the war-ravaged northern region that is still struggling to cope with the aftermath of the crises that lasted over a decade. To enhance the research results, the author examined successfully implemented CSA projects from other African and Asian countries. Focus was on the five implemented CSA practices (row planting, intercropping, improved varieties, minimum tillage and mulching) which were used to train farmers on various demonstration plots. Practices on the demonstration plots were compared with current implementation practice. The study compared farm practices of seventy-nine households from four sub-counties in Nwoya District.

2. LITERATURE REVIEW

To give a deeper understanding on CSA, this chapter provides a review on the discussion of CSA technology, adoption, and challenges, with focus on Africa.

2.1. The Climate Challenge

Adapting to anthropogenic climate change presents new and important challenges. Because the impacts of climate change increase daily in new ways, there is need to evolve new and efficient ways of responding to them. While everyone will be affected, there are certain groups whose adaptation to climate change will be critical to the survival of others. One such group is smallholder farmers. Smallholder farms are small farms, often less than one acre, which are typically owned and operated by a family. In developing countries, the farmers are often subsistence farmers who rely on the farm for their food. Many are also able to produce enough to provide food for others and make a small income. More than 90% of Africa's agricultural production depends on subsistence or local food production; 65% of the population are themselves smallholder farmers who depend on food and income from their farms (IFPRI, 2004). Not much has changed till date.

According to Nhemachena, climate change impact studies have shown that the productivity of agricultural activities is highly sensitive to climate change. The effects of changes in climate on agricultural activities, both physical and economic, have been shown to be significant for low input farming systems, such as subsistence farming in developing countries in sub-Saharan Africa that are located in marginal areas and have the least capacity to adapt to changing climatic conditions. The effect of climate change on agricultural systems can be seen in the interaction between climate variables and the stress that result from actions taken to increase agricultural production. Impacts on crop yield, agricultural productivity and food security vary, depending on the types of agricultural practices and systems. The study mentions growing evidence of further increase in global warming leading to changes in main climate variables – temperature, precipitation, sea level rise, atmospheric carbon dioxide content, and incidence of extreme events which may significantly affect African agricultural production with the result that the livelihoods of subsistence farmers and pastoral peoples, who make a large population of rural people in sub-Saharan Africa, could be negatively affected.

According to Ansalem et al (2012), the Intergovernmental Panel on Climate Change, IPCC's Fourth Assessment Report summary for Africa describes a trend of warming at a rate faster than the global average, and increasing aridity in many countries. Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production. That is, socio-economic factors, international competition, technological development as well as policy choices will determine the pattern and impact that agro-climatic changes will have on agriculture. In all, the patterns of impact of climate change were classified into biophysical and socio-economic impacts. The biophysical impacts include physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise, causing fish to inhabit in different ranges. The socio-economic impacts result in decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity as well as migration and civil unrest.

Ansalem et al. also highlights some of the direct impacts of climate change on agricultural system as: (a) seasonal changes in rainfall and temperature, which could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations; (b) alteration in evapo-transpiration, photosynthesis and biomass production; and (c) alteration in land suitability for agricultural production. Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions. When temperatures exceed the optimal level for biological processes, crops often respond negatively with a steep drop in net growth and yield.

The study also states that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop. The negative effects on agricultural yields will be exacerbated by more frequent weather events. For example, the rising atmospheric CO_2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the volume, quality, quantity, stability of food production and the natural environment in which agriculture takes place. Climatic variations will have consequences for the availability of water resources, frequency of pest and diseases, and soil quality, leading to significant changes in the conditions for agriculture and livestock production. In extreme cases, the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question. This is likely to increase the dependence on food importation and the number of people at risk of famine.

2.2 Climate Smart Agriculture as A Solution

Barnard et al. (2015) notes that agricultural production and productivity depend on the genetic characteristics of crops, fish, forests, livestock, soils, enabling climate and the availability of needed nutrients and energy (bio-physical). Agricultural production and productivity further depend on people, values, goals, knowledge, resources, monitoring opportunities and decision making processes within farming households. Climate is also a key resource in agricultural production. Climate change has altered ecosystems, impacted negatively on humans and livestock that rely on a given landscape for food crops, pastures and water, leading to reduced yields of desirable crops while encouraging proliferation of weeds and pests.

Bernard et al. further notes that faced with these multiple challenges, smallholder farmers should be the first target for developing strategies that increase food production under variable climatic conditions, without stressing natural resources and the climate system, and that this can be achieved through adoption of climate smart agriculture. Climate-smart agriculture (CSA) refers to practices that optimize synergies among three inter-linked objectives: food security, resilience of farming systems, and climate change mitigation. System level CSA practices such as agro-forestry, conservation agriculture, or silvo-pastoralism have the potential to increase whole farm performance, including livelihood and climate benefits (FAO, 2010). A specific example is an improved crop-livestock-tree system with more resilient livelihoods and food security through diversified production, carbon sequestration in rehabilitated land and reduced methane emissions per unit of meat or milk (mitigation), through feeding improvements.

2.3 Benefits of Climate Smart Agriculture

Climate-Smart Agriculture (CSA) is an approach to help the people who manage agricultural systems respond effectively to climate change and guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. It is aimed at developing agricultural strategies to ensure sustainable food security under climate change. CSA provides the means to help stakeholders from local to national and international levels identify agricultural strategies suitable to their local conditions.

Climate smart agriculture seeks to increase productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change, and reduce agriculture's contribution to climate change by reducing greenhouse gas emissions and increasing carbon storage on farmland. It includes proven practical techniques such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agro-forestry, improved grazing, and improved water management but also 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.

According to Green Africa Directory publication (2014), there are multiple benefits of taking **a** climate-smart approach to agriculture in Africa**.** As Africa's population continues to grow and is expected to double by 2050 (reaching the 1 billion mark), the continent will be challenged to meet the food security and nutritional requirements of its people, while also ensuring continued economic growth and sustainable livelihoods on a continent where agriculture is the backbone of many of its countries' economies.

Meeting these demands should be seen in the context of regional climate change – Africa is predicted to be the region that will be most affected by climate change, due to changes in mean temperatures and rainfall, as well as increased variability associated with both. These changes in climate could have impacts on water availability, growing seasons, flooding and drought, as well as plant and animal diseases and pest patterns – among others.

Shifting world agriculture to a "climate-smart" approach will not only help prevent future food security crises but also holds the promise of sparking economic and agricultural renewal in rural areas where hunger and poverty are most prevalent. On the one hand, the magnitude and scope of climate change's impacts on agricultural systems mean that boosting rural communities' resilience and adaptive capacities is essential to safeguarding world food security.

Rising temperatures and an increased frequency of extreme weather events will have direct and negative impacts on crops, livestock, forestry, fisheries and aquaculture productivity in the years to come, as clearly indicated in the most recent report by the Intergovernmental Panel on Climate Change (IPCC). Vulnerable, farming-dependent populations in the developing world are particularly at risk. But at the same time, the compelling need to deal with the challenges posed by climate change offers an opportunity to transform the way food systems use natural resources, improve agriculture's sustainability and promote poverty reduction and economic growth.

Highlighting case studies in "climate-smart agriculture" from around the globe, FAO's document shows that many rural communities are already successfully making the transition to new forms of farming better suited to the rigours of a warmer world. A shift to climate-smart agriculture will not only help shield farmers from the adverse effects of climate change and offer a way to reduce greenhouse gas emissions, but can also improve farm yields and household incomes, leading to stronger, more resilient communities.

According to Kearney et al. (2017), agriculture, especially as practiced by smallholder farmers in Ethiopia, is particularly vulnerable to climate change. Expanding farmers' adoption of climate-smart agricultural practices not only reduces risk from climate change events but also contributes to enhanced productivity and hence enables sustained investment in adaptation technologies. Their findings were based on analysis of data collected from 734 randomly selected farm household heads and field observations. Their study first employed Heckman sample selection model to analyze the two-step process of adaptation to climate change (perception and response). Then it employed nearest-neighbour matching techniques to measure the impact of adopting climate-smart agricultural practices. Their results reveal that farmers' decision to use the practices is influenced by agro-ecology, specifically physical, natural and social factors. Their results also suggest that households which adopted the practices experienced higher productivity by 22.2% over non-users, implying that climate related risks that lead to yield variability are significantly reduced. They conclude that climate smart agriculture practices are knowledge-intensive. Therefore, scaling up adaptation benefits of climate-smart agricultural practices requires public investment to raise awareness and provide technological support.

2.4 Rate / Level of CSA Adoption

Quinn (2016) views climate smart agriculture as an approach to agriculture that can offer farmers in Africa substantial benefits in terms of increased productivity and income, better risk management, and improved resilience to climate change. As such, CSA is a key development goal, championed by donors and government alike. From his findings, Quinn states that in spite of the advantages of CSA, its adoption and practice by farmers have been slow, piecemeal and largely un-sustained. He states that the common narrative is that adoption depends on accessibility, promotion and training around specific CSA technologies and increased access to markets. According to him, this narrative misses a number of behavioural change factors, including the wider social, political and institutional environment in which agriculture is embedded. To address this substantial knowledge gap, he conducted a rigorous and systematic analysis of the factors shaping the adoption of CSA through a triangulation of a comprehensive literature review, expert interviews and farmers' survey in Burkina Faso and Kenya. He emerged with the following three themes:

1. Economics do matter to adoption but nuances also matter. The economic narrative is well known and includes barriers such as high initial cost, high long-term cost, diseconomies of scale, and poor access to credits and inputs. However, disaggregating these costs reveal some key and overlooked differences between farmer perspectives and conventional wisdom of practitioners. Farmers cited initial cost over twice as often as a barrier to adoption than technical experts, while long-term costs are not a significant factor of farmers' decision-making around CSA adoption. This points to the need for a better understanding on behalf of practitioners of different CSA costs, as well as the seasonal decision-making

processes that underpin farmers' livelihood and CSA decisions.

2. To be adopted, CSA needs to align with societal and cultural values and norms. Agriculture, as a livelihood activity, is a deeply socially embedded approach and farmers understand CSA through their own formal and informal systems and norms that govern factors such as labour, gender, identity and beliefs. According to him, such factors create often unseen opportunities and risks for farmers that shape their CSA adoption but are often overlooked by the CSA literature and expert interviews. The issue of short-term climate risk, for example, was the second highest cited barrier by farmers but is completely overlooked by practitioners. He further opines that farmers might not likely adopt any CSA practice that lowers their capacity to address immediate risks of climate variability, even if that practice might be well targeted at future climate change.

3. Market forces and institutions form the foundation for CSA adoption. In many African countries, structural constraints within markets and supporting institutions severely constrain the adoption of CSA approaches. These constraints are not unique to CSA but instead define and influence the entire agriculture sector. They include poorly functioning markets, dysfunctional government institutions and weak land tenure systems. In order for CSA to be adopted in a sustained and collective way at a national scale, there are basic foundational conditions and good

agricultural practices that are required within the agricultural sector which go beyond any specific farm technology. Achieving these conditions require integrated programming that draws upon wider efforts in democracy and governance, economic growth, agriculture and food security, and disaster risk reduction.

2.5 Barriers to CSA Adoption

Empirical evidence supports the multi-faceted benefits of CSA at the global level. However, information on how to identify, verify, and target CSA innovations at the local level and understand the mechanisms to enable wide-scale adoption is fragmented. Considering the rapid pace of climate change and the threat of its impact on global food security, adaptation and mitigation measures must be put in place with an urgency to match. The aim is to facilitate the adoption of CSA practices that enable farmers to both adapt to and mitigate the effects of climate change while improving food security. In particular, they aim to identify practices that maximize adaptive capacity, mitigate climate change and increase food security in smallholder agricultural systems, analyze the environmental benefits of these practices using real-time land and soil health survey data and improved crop/climate modeling, discern the social, political, economic and environmental barriers to adoption in East Africa, and implement locally appropriate CSA practices at project sites.

According to Mukoto (2014), Climate-Smart Agriculture (CSA), as defined by FAO, comprises three main pillars: 1) sustainably increasing agricultural productivity and incomes, 2) adapting and building resilience to climate change, and 3) reducing and/or removing greenhouse gases emissions, where possible. CSA is designed to implement sustainable agricultural development while addressing the food security and climate change challenges. CSA is therefore recognized as a way of mitigating climate change in agriculture by gradual transformation of agricultural productivity through implementation of climate-smart agricultural policies and practices (FAO, 2012). It also involves talks about successful promotion of such policies and practices within the context of sustainable management of land, water and genetic resources to improve farmers' responsiveness to climate change challenges affecting agriculture, livelihoods and poverty alleviation.

Mukoto examined the incentives and constraints to adoption of the promoted climate smart agricultural practices and mainly focused on smallholder dairy farmers, with the aim of integrating climate smart agriculture into the system in Kaptumo, Nandi County of Kenya. Findings and insights from the study provide useful knowledge on the dynamics of adoption of the CSA practices and lessons learnt to further inform extension, projects and up-scaling. The study considers wider policy, institutional and social structures and processes that may affect adoption. In addition, the assessment also provides farmers' perceptions on initial benefits of those practices in terms of agricultural production, livelihoods diversification, overall resilience to climatic risks and household food security.

Akinbamijo (2014) indicates that climate-smart agriculture includes practices and technologies that sustainably increase productivity, support farmers' adaptation to climate change, and reduce levels of greenhouse gases. It can also help governments to achieve national food security and poverty reduction goals. Climate-smart approaches can include many diverse components from farm-level techniques to international policy and finance mechanisms. Many innovative climate-smart agriculture practices take place in Africa with the capacity to increase productivity and build resilience, yet they remain largely unknown at the continental, or even regional and national levels. These good practices are not only unknown, but their wide-scale adoption remains a challenge, especially amongst smallholder farmers in Africa.

Akinbamijo mentions several barriers that prevent smallholder farmers in Africa from adopting CSA practices and technologies. He also notes that existing policies and actions to remove these barriers remain inadequate. He states that a good understanding of what these barriers are and how they impinge on adoption of CSA practices are essential. Equally essential are actions that favour the removal of these barriers, while at the same time promote adoption of CSA practices. His study report attempts to identify the barriers and strategies to enhance adoption of CSA practices. These barriers, according to him, can be classified under two broad categories. The first relates to the physical means or resources required to practice CSA. These can be considered as the hardware barriers and include physical inputs such as land, human resources, equipment, infrastructure and finances as well as limited access to appropriate farm equipment and tools, and inadequate farm inputs and materials. The second, referred to as the non-physical or software barriers, relates to the institutional, cultural, policy and regulatory environment; information, knowledge and skills; technologies and innovations; and governance, among others, also known as inadequate CSA relevant information, knowledge and skills.

In a bid to identify factors affecting the adoption of multiple climate change adaptation strategies in Southern Malawi, a study was carried out by Maguza-Tembo (2016) and his group. The findings of the study reveal that age of household head, total land area owned, petty trading and formal employment reduce the probability of adopting more than two CSA strategies. Farmers who reported observing changes in moisture levels in their areas over a 20-year period prior to the survey were found to have lower probability of adopting four CSA strategies as compared to those who reported not observing any changes in moisture in the same time period. Factors like ample access to climate smart agriculture, extension messages and training, acreage used in agricultural production and observing an increase in incidents of floods in a 20-year period prior to the study increased the probability of adopting more than two CSA strategies, while household income was found not to affect number of CSA strategies adopted. The study recommends that relevant stakeholders should provide farmers with CSA-related extension messages if more farmers are to adopt multiple CSA techniques.

Kelvin et al. (2015) gathered data showing a gap between farmers' knowledge of climate-smart agriculture and implementation. The awareness-use gap can be interpreted in two important ways. The first is, there is a difference between awareness exposure – that is, a farmer having heard about a practice – and knowledge exposure – that is, a farmer having the technical know-how of that practice. In making a decision about whether or not to undertake a specific CSA practice, farmers reported that they consider their knowledge of and skills in actual implementation of the practice. Therefore, moving beyond just making farmers aware of CSA to actually training them on how to use the practices might increase uptake. Second, besides knowledge, yield, income, costs, availability of labour and equipment, size of the farm, time, and availability of inputs are equally important indicators that farmers use to prioritize CSA adoption.

According to Murray et al. (2017), climate change and variability present a major challenge to agricultural production and rural livelihoods, including livelihoods of women smallholder farmers. There are significant efforts underway to develop, deploy, and scale up Climate-Smart Agricultural (CSA) practices and technologies to facilitate climate change adaptation for farmers. However, there is a need for gender analysis of CSA practices across different farming and cultural systems to facilitate adoption by, and livelihood improvements for women smallholder farmers. Climate change poses challenges for maintaining and improving agricultural and labour productivity of women smallholder farmers. The labour productivity of many women smallholders is constrained by lack of access to labour-saving technologies and the most basic of farm tools. Poorer smallholders face a poverty trap, due to low agricultural and labour productivity, from which they cannot easily escape without access to key resources such as rural energy and labour-saving technologies.

Their research highlights that many women smallholders have either limited or no access to basic agricultural tools, transport, and rural energy. This, according to them, raises the question of whether the future livelihood scenarios for such farmers will consist of barely surviving or "hanging in"; or whether such farmers can "step up" to adapt better to future climate constraints; or whether more of these farmers will "step out" of agriculture. They argue that for women smallholder farmers to become more climate-change resilient, more serious attention to gender analysis is needed to address their constraints in accessing basic agricultural technologies, combined with participatory approaches to develop and adapt CSA tools and technologies to their needs in future climates and agro-ecologies. They conclude that analysing the current situation of men and women farmers (i.e., their current roles, access to resources and technologies, and their decision-making power) is necessary, so that both women and men farmers can better identify the opportunities they have as well as the challenges they face in relation to climate change adaptation.

In his analyses of gender differences in awareness and adoption of climate-smart agricultural (CSA) practices, Quinn (2016) examines the factors associated with the likelihood of adoption of a wide range of CSA practices for 376 women and 375 men in two different areas of Kenya. The study was aimed at improving the design of interventions that are targeted at achieving greater and more equitable agricultural development in East Africa and elsewhere. The findings of the study reveal that contact with extension agents, agri-service providers, farmers' organizations and other conventional sources of agricultural and climate-related information has not significantly increased the awareness of CSA practices. Providing information for a spouse (usually the husband) does not mean that the other spouse will learn about options and opportunities that meet their needs. Though women are usually integrally related to whether the household is food/nutritionally secure or notthey are less aware of CSA practices than men. If women know about the practices, they are no less likely to adopt them. One of the findings of the study is that women's access to credit is positively associated with the adoption of CSA practices, although the household's access to credit does not influence the uptake of CSA practices, and thus is likely being used for non-farm purposes. Access to weather forecasts, though limited, has no positive impact on adoption of most technologies that could enhance resilience to a changing climate. Use of information channels favoured by agricultural development programmes — extension services, farmer organizations, and agri-service providers – does not significantly improve awareness of CSA.

His results suggest that there is still much work to be done in increasing awareness of improved agricultural practices that enhance livelihoods and resilience to change, including a changing climate. He then recommends the need to reach out to, and better target women (in particular) and young people in the dissemination of CSA-related information. Traditional bearers of information need to be better trained on CSA practices, and new ways for reaching target groups need to be identified. These new ways include cell phones, radio, television and targeted messaging at meeting places, such as markets or places of worship.

He concludes that factors affecting the adoption of CSA practices include norms of cooperation and trust, social and economic factors, attitudes and orientation of individuals, and access to a variety of information types. Some of these factors, such as improving information channels, are amenable to interventions that can increase awareness and adoption of CSA.

3. METHODOLOGY

This chapter highlights the specific methodologies and procedures that were used in the study. The methodologies include the description of the study area, sampling criteria and study instruments used. Data collection methods, data analysis and data interpretations for the study are also described.

3.1 STUDY AREA

The study was conducted in Nwoya district which is one of the districts in the Acholi Sub-region of Northern Uganda. The district has a total area of 4,736km^2, a density of 33.68km^2 with latitude $2^{o}30^{I}35.1^{II}$ (2.5097^{o}) N, longitude $31^{o}53^{I}4.1^{II}$ (31.8845^{o}) E and an elevation of 928 metres (3,045 feet) (Mapcarta, 2017). It has two agricultural seasons (March-June & August-November). The main crops grown include cassava, sweet potato, beans, groundnuts, sesame, sorghum and millet. The district has a population estimate of 159,500 (UBS, 2016) with 50.4% (that is 67,279) of the population as women while 49.6% (that is 66,227) are men. In terms of urbanization, 89.8% (119,913) of the entire population are rural dwellers while 10.2% are urban dwellers (Brinkhoff, 2016).

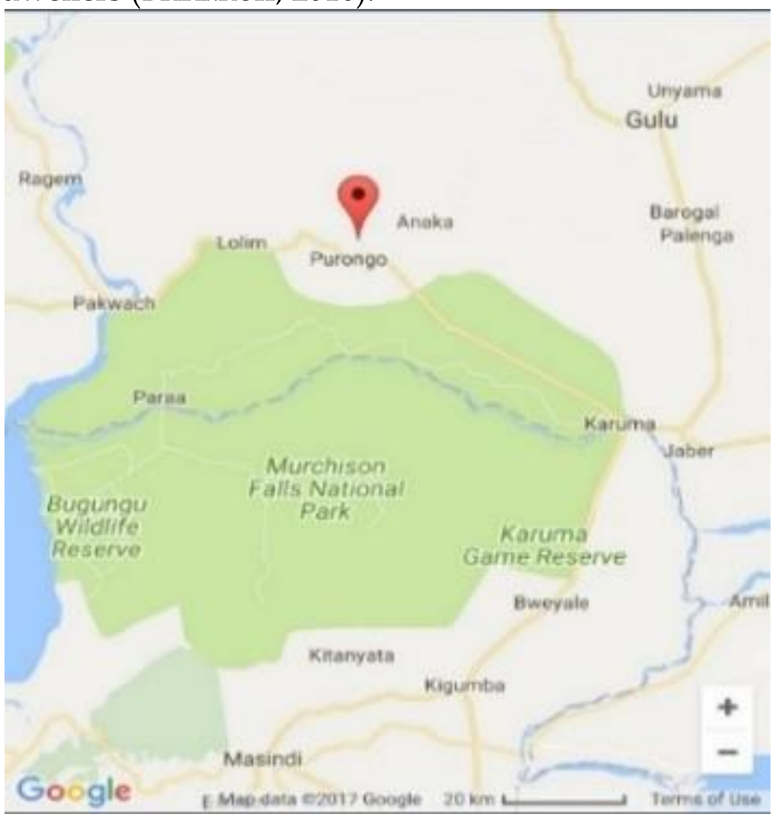


Fig. 1: Map of Nwoya District

3.2 DATA COLLECTION

Multiple data collection methods were employed to collect data from the primary and secondary data sources. For the primary data, the methods used included questionnaire administration, interviews and conversations with stakeholders, and focus group discussions.

3.2.1. Secondary data

An extensive literature review from a wide range of selected articles from journals, government and international agencies policies and publications, technical documents, reports and books was carried out to inform both the approach used, the focus of the work and analysis of the content. This involved conceptual and literature review on agriculture, climate change and climate smart agriculture. This led to an in-depth understanding of the topic and helped in identification of the problem and the mitigating factors to improve the situation in Uganda. The analysis also informed the design and conduct of interviews and surveys.

3.2.2 Primary data collection

Primary data collection covered surveys and interviews methods used. Expert opinions and informal group discussions between the researcher and supervisor, International Centre for Tropical Agriculture (CIAT) - Kenya and International Institute of Tropical Agriculture (IITA) - Uganda in different meetings attended introduced the research topic and the scope applied. Semi-structured questionnaires for the interviews and surveys were developed, pretested and used to collect data face-to-face from the stakeholders in Nwoya. This was to enable the collection of in-depth quantitative and qualitative information, that is, views and experiences from farmers, farmers' association, extension/support service providers (Uganda) and experts from CIAT and IITA. Informal sessions were organized whereby stakeholders were randomly selected and interviewed according to the set questionnaires. Site visits were made to the demo plots and some farmlands in all the four counties.

Data for this study was collected from 100 randomly selected households. Of the 100 randomly selected households, responses from 21 households were discarded because of poor quality of data. Four focus group discussions were held at four villages of the three sub-counties. Four key informants' interviews were also conducted. In order to have a good representation of all the relevant groups, purposive sampling techniques were used in selecting the respondents for FGD and key informant interview. A structured questionnaire was administered to smallholder farmers to collect information on farmers' perceptions of climate smart agricultural practices adoption, constraints/barriers, productivity, income generation, impact of adopted CSA on food and nutrition security as well as willingness and ability to adopt more CSA practices. In addition, the key informant interviews were conducted as part of in-depth interviews to acquire more information on the subject matter. This technique was used to acquire more information on the perception of smallholder farmers and the view of the key people in the community. A total of two FGDs, were conducted. Besides, field observation was also used to collect additional data and used to verify some of the information collected.

3.3 Sampling Size and Sampling Procedure

3.3.1 Sampling size for households

According to Uganda Bureau of Statistics (UBS, 2016), the total population of Nwoya District is 159,500. A total of 84 farming households with an average of 5 people per household were surveyed.

3.3.2 Sampling procedure for households

Sampling procedure was predetermined based on the approach used during the climate smart agriculture demonstration programme held in 2014. The field officer from IITA directed the researcher and his assistant to farmers who were trained on CSA implementation and who took part in the demonstration programme.

3.3.3 Sample size for key informant interview

Table 3-1 shows the distribution of key informants per section. The pool of professional key informants comprised of sub-county officials, extension officers and farmers.

Table 1: The sample size of key informants

Section	Number of Key Informants
Sub-county officials	4
Extension officers	8
Farmers	20
Total	**32**

Positive responses were received from four sub-county officers, eight extension officers and twenty farmers.

3.3.4 Sampling of Key Informants

Purposive sampling was used to select those to be interviewed for key informant interview. This sampling method was used because it could give in-depth understanding and valid points for recommendation purposes. Key informant interview thus helped in getting detailed information on agricultural yield capacity of the preferred CSA practices implemented, frequency and reliability of information received on agricultural activities, types of constraint faced by women and men farmers and effectiveness of farmers' association and government/donor agencies support.

3.4 DATA ANALYSIS

Data analysis was used to organize, inspect and transform data with the aim of highlighting required information, suggest conclusion and support decision. Analysis of the data collected helped to develop strong evidence from the investigations. A multi-stage sampling method was used with a sample size of 100 households and an average of 20 households sampled from each of the four sub-counties. Due to additional information added to the questionnaire to improve on the quality of the survey outcome, only 79 questionnaires were considered suitable for the purpose of the study and were analyzed. Data was analyzed using Stata and Microsoft Excel while data description was done using descriptive statistics, percentiles and graphs.

3.4.1 Data Management, Analysis and Presentation

Procedures were put in place to ensure accurate and complete record of the respondents. Questionnaires were screened to identify incomplete, incorrect and inaccurate data and errors were corrected. The data were entered into a

Microsoft Excel spreadsheet in a standard format. Each study participant was entered with a unique code and variable name. The data was imported into Stata version 4.0 for further analysis.

3.4.2. Descriptive Statistics

Descriptive statistics was used to simplify large amounts of data in a sensible way. Descriptive statistics was used in this research due to its effectiveness in reducing huge amounts of data in a simple way (Otieno, 2016). This helped in generating a summary of the collected data in terms of frequencies, tables, graphs and charts.

4. RESULT AND DISCUSSION

The study was undertaken to examine the level of adoption of climate smart agricultural technology and practices among smallholder farmers in northern Uganda in order to understand their challenges and barriers to wider adoption for an upscale of CSA. The purpose of this chapter is to present the general findings based on careful analysis of survey information and discuss the results. This thesis has indicated a wide range of issues that are related to the desired upscale of CSA in Uganda.

4.1. DEMOGRAPHY OF RESPONDENTS

Survey was carried out on 145 respondents from 79 randomly selected households. This comprised of 65 men and 80 women. About 24 (17%) of the respondents are youths less than 40 years. The higher number of women farmers from the households surveyed implied that there are more women practicing small scale agriculture than men. All respondents were household heads and their spouses (for dual-headed households) and male or female household heads for single-headed households. The total household size for the 79 households was 515 while the average household size was 6.51.

The two types of households identified among the 79 households surveyed are single-headed and dual-headed household as highlighted above. These comprised of 63 dual-headed households, where the home is headed by two people, a husband who in most cases is the household head and his wife. 16 single-headed households were surveyed where either a male or a female heads the household. The single-headed households were sub-divided into male-headed households (3 in total) and female-headed households (13 in total). The reason for more female-headed single households was because most of the women concerned had lost their husbands, leaving them with children.

Total number of children less than 5 years in all households surveyed was 100 while the average number of children less than 5 years per household was 1.27. This implied that there is at least one child in each household who is in need of good nutrition for proper growth and development. The total farm size of the sampled household was 393.3acres while the average farm size per household is 4.44 acres. This confirms the findings of Sarah et al. (2016) that the respondents were smallholder farmers with small land size of less than 2ha for cultivation.

4.1.1. Villages surveyed

The survey was carried out in 3 sub-counties (Purongo, Alero and Koch Goma), 8 parishes (Pawatomero, Paibwor, Bwobonam, Orum, Agonga, Coorom, Paramo and Patira) and 11 villages (Pawatomero East, Lulyango, Bwobonam A, Goro, Agonga A, Okir, Obul, Nwoya, Patira East and Lodi). Survey locations were predetermined based on previous baseline study carried out during the demonstration project in 2015.

4.1.2 Education level of respondents

Survey result on education indicates more male farmers with at least primary school education than their female counterparts. Of the 65 male respondents, 44 had primary school education, 18 had secondary school education and 1 had a superior education (higher institution of learning). Only 2 male farmers had no form of education. Also, of the 80 female respondents, 56 had primary education, 4 had secondary education and 1 had a superior education. Here, 19 female farmers had no form of education. See Figure 2.

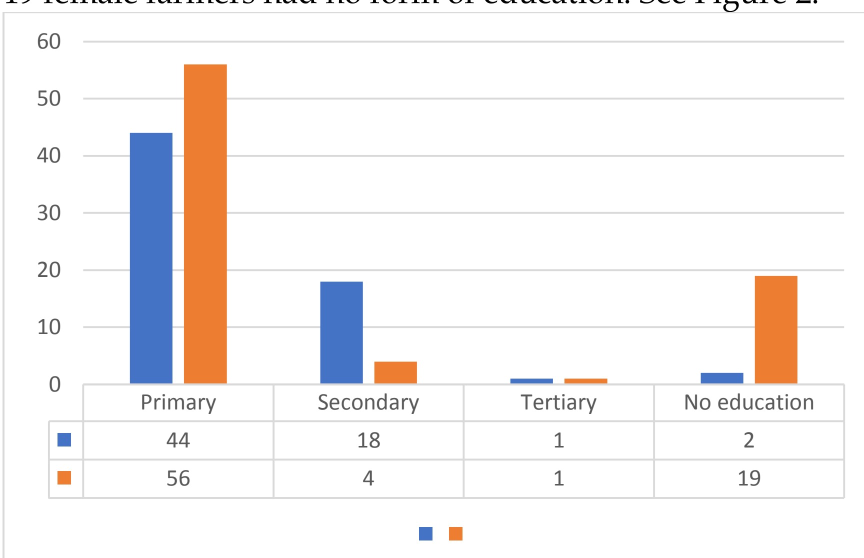


Fig. 2: Education level of respondents

4.1.3. Respondents' access to cell phone

Use of cell phone by farmers was considered vital as it is one of the means of receiving important information about weather, for instance, and on pests and diseases, among others; from agricultural institutions, government agencies and donor agencies. Of the 145 sampled population, 40 out of 65 men had access to cell phone and 21 out of 80 women had access to cell phone. The percentage of men with access to cell phone was 61.5% while the percentage of women with access to cell phone was 26.3%. See Table 2.

Table 2: Showing respondents' access to cell phones

Access to cell phone		
Gender	**Yes**	**No**
Men	40	25
Women	21	69

This implied that more male farmers have access to direct information such as text messages than female farmers. Thus, less than half of the male farmers relied on word-of-mouth information while about two-third of the female farmers also relied on word-of-mouth information. This mode of information transmission affects the credibility and accuracy of information received.

4.1.3. Household decision making

How decisions are made in the households was considered vital as it would help to understand the pattern of decision making as well as the role of gender in decision making. It looks at how decisions are made on size of farm to be cultivated, type of crops to plant, choice of CSA practice to implement, what to do with harvested produce – what quantity to sell and what to do with the income. The aim was also to understand if decisions were made solely by household heads or with contributions from their spouses or other members of the family, and if the decisions can help improve the livelihood of the households. Out of the 63 dual-headed households, 48 make decisions jointly with their spouses, while in 10 households, decisions were made by household heads and their spouses. In 5 households, the women were not part of the decision making.

4.2 COMMON TYPES OF CROPS CULTIVATED

The three main crops commonly grown within the survey location were maize, beans and groundnut. All 79 households planted maize, beans and groundnuts this planting season. However, during the survey, it was discovered that only 58 households had maize in the farm, 75 households had beans in the farm while 42 households had groundnuts in the farm. The reduction in the number of households that still had all three crop types was primarily due to the effects of climate change. Respondents stated that the rains did not come at the appropriate time this season and this badly affected their groundnut farms. Farmers also complained of infestation of maize and beans by army worms. See Figure 3 below.

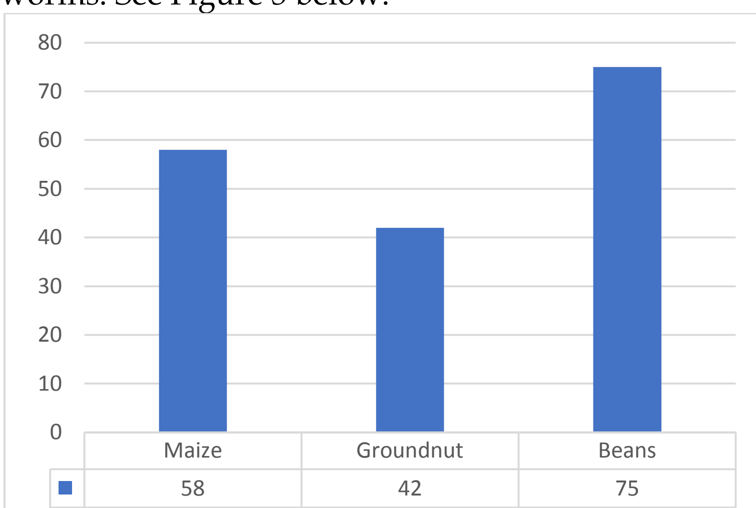


Fig. 3: The three common crops cultivated

4.3 ADOPTION RATE OF CSA PRACTICES BY GENDER

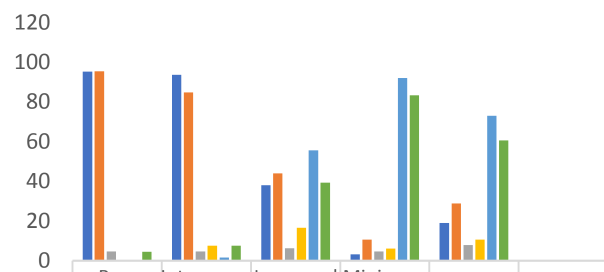
The study revealed that smallholder farmers have adopted various agricultural practices to overcome several environmental problems such as diminishing soil fertility as well as the effects of climate change and variability. The aim was to enhance productivity and food security as well as improve household income. In all the study areas, smallholder farmers practiced climate smart agriculture. This was as a result of the training they had received during CSA demonstration programme two years earlier. However, most farmers were not fully aware of the benefits of the selected practices as they relied on third party information and observation from friends, neighbours and other family members' farms to adopt a technology.

Based on key informant interviews and household survey, farmers practiced the methods which were perceived to be feasible, less stressful, least costly and could increase yield and food security. The study's findings reveal that row planting and intercropping were the most widely adopted practices (95.24% women, 95.45% men and 93.65% women, 84.85% men). See Figure 4. These were followed by other practices such as improved varieties (38.1% women and 43.94% men), mulching (19.05% women and 28.79% men). The least adopted practice is minimum tillage (3.17% women and 10.67% men). One of the findings is that farmers had acquired knowledge through experience.

Furthermore, the low adoption of minimum tillage and mulching was due to complaints by farmers over low yield from minimum tillage and the associated difficulty in securing mulch to practice mulching. Both women and men had almost the same adoption rate for row planting because of the perceived ease of weeding and monitoring as well as possibility of higher yields; while women were reported to adopt intercropping more than men because of the desire to have two or more crops in one garden and increase household food variety and to ease their activities on the farm. Improved varieties were adopted by almost half of the respondents who highlighted high cost of procuring seedling as well as the need to always fumigate and monitor the crops as their major challenges.

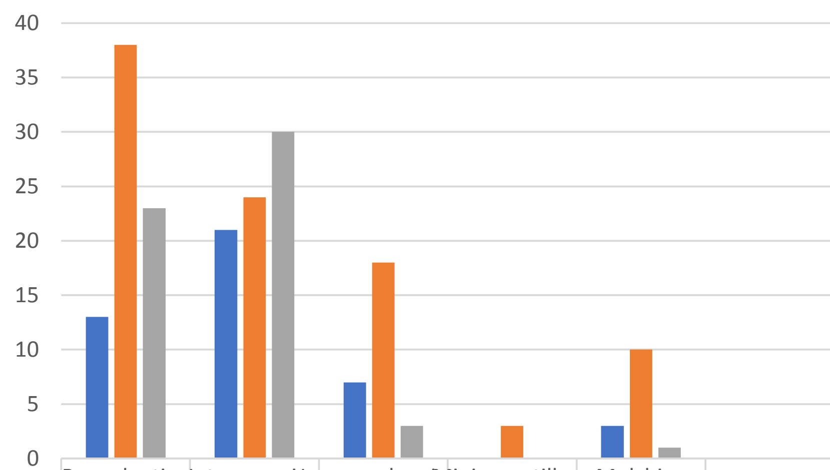
4.4. SOURCES OF KNOWLEDGE AND INFORMATION ON CSA PRACTICES

The survey reveals the sources of knowledge and information on selected CSA practices by households. This shows how farmers got knowledge and information on the selected practices and how it affects their ability to implement the CSA practices effectively. For example, it was determined during focus group discussions and key informant interviews that farmers who got their knowledge about CSA practices from demonstrations by CIAT/local partners were able to implement the practices better than farmers who had learnt the practice from family, neighbour or through existing knowledge or tradition. See Figure 5.



	Row planting	Intercropping	Improved varieties	Minimum tillage	Mulching
Currently practiced (%)	95.24	93.65	38.1	3.17	19.05
Currently practiced (%)	95.45	84.85	43.94	10.67	28.79
Practiced in the past (%)	4.76	4.76	6.35	4.76	7.94
Practiced in the past (%)	0	7.58	16.67	6.06	10.61
Not practiced at all	0	1.59	55.56	92.06	73.02
Not practiced at all	4.55	7.58	39.39	83.33	60.61

Fig. 4: Adoption level of CSA practices by gender



	Row planting	Intercropping	Improved variety	Minimum tillage	Mulching
	13	21	7	0	3
	38	24	18	3	10
	23	30	3	0	1

Fig. 5: Sources of knowledge and information about CSA practices

4.5 RATING OF BARRIERS/CHALLENGES TO IMPLEMENTING CSA PRACTICES

The five major constraints to CSA practice implementation are poor knowledge and information about practice (78.5% women and 46.7% men), followed by factors of production- (31.6% women and 26.7% men) including land, labour, access to capital, modern tools and machinery as well as improved seedlings; this is followed by lack of technical know-how and skills (26.6% women and 18.7% men); and difficulty with implementing CSA practices (20.3% women and 16% men); while the least constraint is poor yields (11.4% women and 10.7% men), see Fig 4-5.

Figure 6 shows that the majority of smallholder farmers have limited knowledge and information on CSA technologies. This is due to their low level of education (over 65% of farmers have either primary education or have never attended school), reduced access to cell phone (38.5% men and 73.7% women), inadequate and inaccurate information on CSA technologies and lack of effective extension service. Farmers' knowledge about the practices was grossly inadequate. Most of the farmers do not know how to properly implement row planting and intercropping because of poor knowledge and inadequate information about the practices. A lot of farmers depend on information from family members, friends and neighbours on the various practices and this information was found to be grossly inaccurate and inadequate.

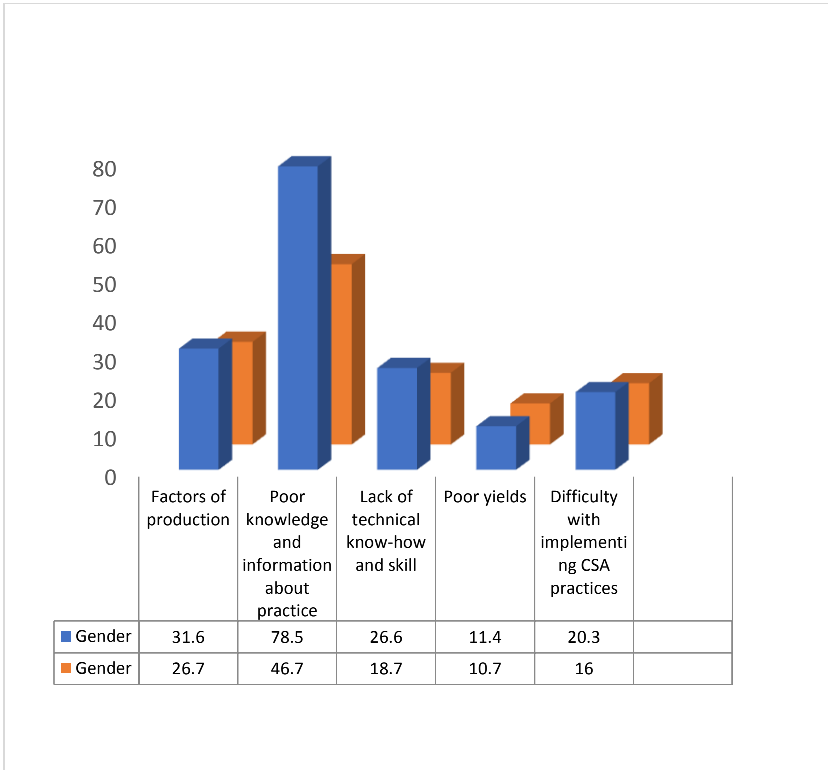


Fig. 6: Rating of barrier/challenges to implementing CSA practices

Factors of production was another challenge that farmers' encountered because of the small size of their farmland, labour deficiencies to increase size of cultivated land, and lack of access to credit to purchase inputs like improved seedling, farm tools and hire farm implements like tractors. So they cultivate only the small portion of land available. Local seedling germination rate is sometimes poor, giving little output. Inability to hire tractors makes them resort tobush burning which reduces the soil's nutrient over time, as well as cause other environmental damages. With small family size, many smallholder farmers have difficulties getting the needed labour to help cultivate their fields and this further contributes to a reduction in the size of cultivated land.

From the survey, 26.6% of female respondents and 18.7% of male respondents lack technical knowledge and skill to implement the practices adequately. But through in-depth interviews and focus group discussions, it was discovered that nearly all the farmers are implementing their preferred CSA practice inappropriately due to lack of technical know-how and skills. Explanations from farmers who claimed to understand the practices and can appropriately implement them (especially row planting, intercropping and mulching) negate the actual way these farm practices are implemented. Most of them still apply these techniques by the age-long traditional ways handed down to them by their ancestors.

The study indicates that 11.4% female respondents and 10.7% male respondents cite poor yields as constraints to implementing some of the CSA practices and increasing adoption. Findings reveal that most of these farmers refused to implement practices reported to have resulted in poor yields for some particular crops by other farmers, especially from families, friends and neighbours.

20.3% female respondents and 16.0 male respondents cited difficulty in implementing some of the CSA practices as their major constraints to increased adoption. Their major constraint in practising row planting is that it requires much time, especially during measurements. Others cited difficulty in weeding on intercropped farm, difficulty in sourcing and preparing mulch as well as lack of access to credit facilities to purchase improved seedlings and the problem of having to always spray improved seedlings as their major constraints.

It was discovered that women encountered more challenges than men in all five CSA practices. Part of the reason for this was because of some level of discrimination against women in the society which limited their participation in some beneficial activities. Although the demonstration programme factored in some of these challenges, there still persists some level of discrimination, as only 21.5% of women farmers as against 53.3% men had mobile phones from which they can receive message about weather forecast and other vital information. Women are also disadvantaged when it comes to access to means of production (land, labour, credit facilities); training and so on. Because of the additional burden of taking care of the household, women are easily fatigued and might not be able to fully implement some of the practices.

4.6 RATE OF DIFFICULTIES WITH IMPLEMENTING CSA PRACTICES

This study's findings reveal mulching (32.9% women and 36% men) as the most strenuous CSA practice (Fig. 7) because of the associated difficulty in getting and preparing mulch. This is followed by intercropping (31.6% women and 25.3% men) because it brings about overcrowding, stunted growth (as crops compete for nutrients), difficulty in weeding and one crop outgrowing the other. This is followed by row planting (10.1% women and 20.0% men) due to sourcing for material to carry out measurement, getting the actual measurement as well as too much spacing required which limits the quantity of crops that can be planted on a farm. Others such as minimum tillage and improved varieties are not considered strenuous by both women and men farmers.

According to the study the 10.1% female respondents and 20.0% male respondents who found row planting as the most strenuous CSA practice said so because of the associated stress in carrying out accurate measurements on a straight line, spacing of each crop and having to plant just one crop on the farm. 31.6% female respondents and 25.3% male respondents find intercropping as the most strenuous activities because of difficulties with weeding and planting on same field at different times. 1.3% female respondents and 2.7% male respondents cite improved varieties as the most strenuous activity because of having to spray and monitor the crops at regular intervals. 6.3% female respondents and 2.7% male respondents cite minimum tillage as the most strenuous CSA practice, though, according to them much tilling is not required which makes it labour and time conserving. However, it is still considered strenuous because of the need to frequently check the crops during the early stages to ensure they germinate 32.9% female respondents and 36.0% male respondents cite mulching as the most strenuous activity because of the difficulty associated with gathering and preparing mulches.

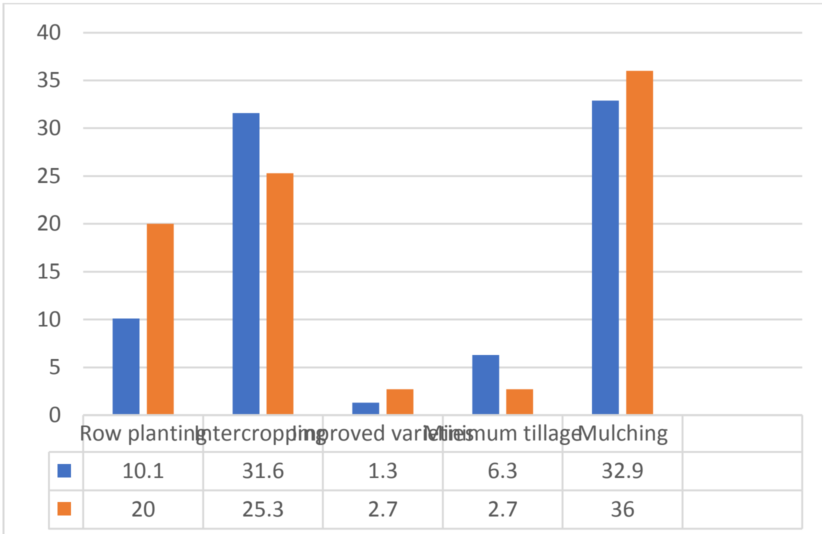


Fig. 7: Rate of difficulties in implementing CSA practice

4.7. INCOME FROM SELECTED CSA PRACTICES

From the Figure 8 below, out of the 73 households that implemented row planting, 72 had increase in income while 1 household had no increase. Of the 74 households that implemented intercropping, 42 had increase in income while 32 had no increase. Of the 27 households that implemented improved variety, 21 had increased income while 6 had no increase. All 3 households that implemented minimum tillage had increase in income. Also, all 14 households that implemented mulching had increase in income. This goes to show that climate smart agriculture has the potential to help farmers cope with climate change as well as increase productivity and income generation.

4.8 HOUSEHOLD FOOD AVAILABILITY

Climate smart agriculture was introduced in Nwoya District by 2015 and has been implemented by smallholder farmers since then. It has actually helped to improve the living condition of majority of the farmers. The report of the survey carried out on food availability and security indicates that about 66% of the households surveyed always had some form of food available while 34% (Table 3) of the households were sometimes without food. This means that more than half of the farmers have some food to eat daily. When compared with what was obtainable before the introduction of CSA, it is obvious that CSA has contributed to ensuring food security.

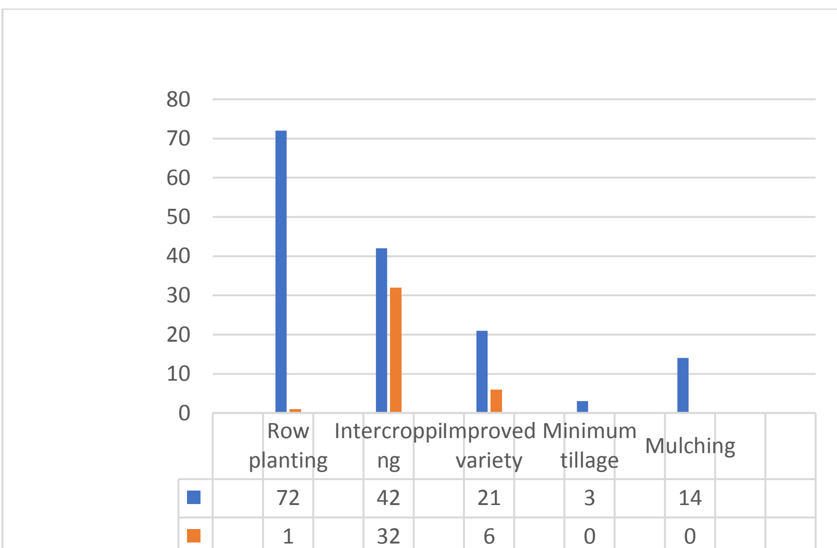


Fig. 8: Data on income increase from selected CSA practices

Table 3: Determination of household food availability

Was food always available in your household in the last four weeks?	
Food was always available	**Food was not always available**
66%	34%

Table 4 reveals the number of households who had expressed worry over lack of food in the household in the last four weeks. It can be observed that 22 of the 79 households have had situations where they worried because there was no food in the household, also because there was no means of getting food for the household. This was confirmed during focus group discussions with female farmers.

Table 4: Households who expressed worry because of lack of food in the last four weeks

Did your household express worry because of lack of food in the last four weeks?	
Yes	**No**
22	57

Table 5 shows that 23 households have suffered food shortage in the last four weeks due to lack of resources. This confirms that even though farmers have recorded some increase in crop production and income generation, it still has not enabled them to attain food security. It was also noted that some households with smaller farm sizes experience food shortages more than households with larger farm sizes. This can be further attributed to unequal access to resources and means of production which could help increase crop yield.

Table 5: Food shortages due to lack of resources in the last four weeks

Did your household suffer food shortages due to lack of resources in the last four weeks?	
Yes	**No**
23	56

From Figure 9, it can be seen that majority of the households eat at least a meal per day. It was observed that almost all the farmers had at least cassava which is a staple in Nwoya; it can be eaten raw as well as eaten for the whole day as a meal. However, 13 of the 79 households surveyed had days and nights without any food to eat. It was observed that some smallholder farmers are still doing well in terms of farm size, access to farm inputs and other resources necessary for increase in yields than others. These 13 farmers were observed to be more deficient in terms of resources needed to increase productivity and yield.

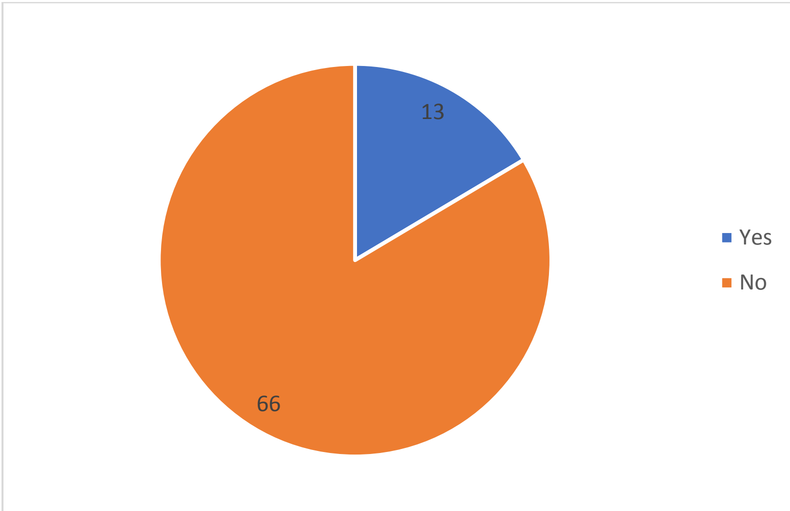


Fig. 9: Households without any food to eat in a whole day and night in the last four weeks

4.9 NUTRITION SECURITY

Results indicate that majority of the farmers are still not nutrition secured. Findings reveal that most farming households are unable to cultivate all the crops that are needed to meet their nutritional needs and cannot afford to buy other types of food from the market to supplement the small varieties that are cultivated, due to lack of finance. Thus, they only rely on foods harvested from their farms for most of their diets. Only 19% of households were nutrition secured and had access to diverse kinds of food when needed while the remaining 81% relied absolutely on their farm for food and had limited varieties. Varieties available in a particular season are based on the type of crops that they can grow in that season (see Fig. 10).

However, when looking at nutrition security, none of the households could be said to be nutrition secured. This is because nutrition looks at both having not just diverse kinds of food available, but eating the right quantity and quality at the right time; as well as having access to clean water, good sanitation and preparing meals in a hygienic environment.

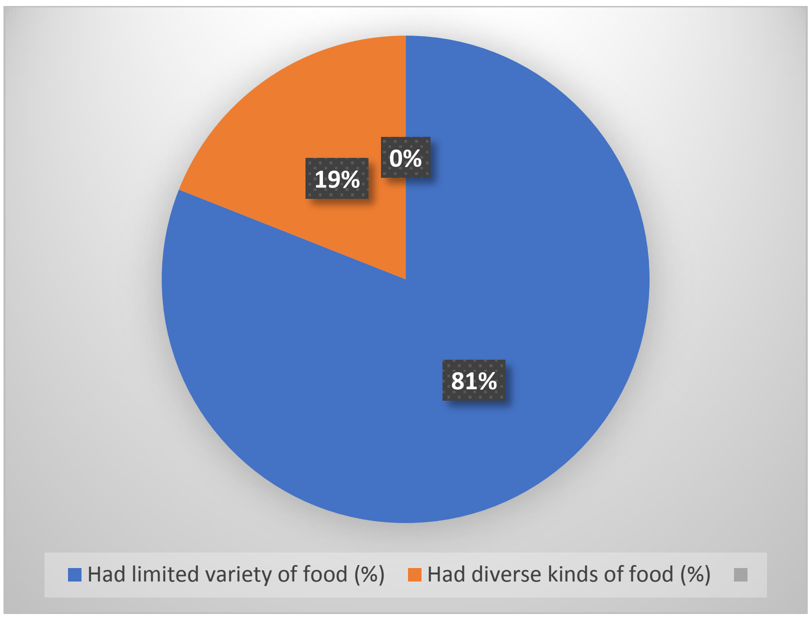


Fig. 10: Determination of household food diversity

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

Agricultural production has been low as crop yields have fallen in many parts of the world, especially in developing countries of Africa, where farmers depend largely on traditional farming practices which are vulnerable to climate change. This has resulted in tragic crop failures, reduced agricultural productivity, increased hunger, gender imbalance, malnutrition and diseases. The situation has been made worse by the increase in global demand for food and agricultural products due to a growing global population, changing diets and technology advancement.

Climate smart agriculture (CSA) has been identified as an important pathway to achieve agricultural development priorities in the face of climate variability and change because it has the capacity to fully accommodate the needs of a growing population and serves as a bridge to other development priorities, including gender inequality. Despite the gains arising from CSA however, adoption is low among smallholder farmers and its impact on nutrition security is not fully known in Africa. This research was initiated to investigate gender disparities in the adoption of CSA practices and the impact on household nutrition of smallholder farmers, using Uganda as a case study.

Findings indicate farmers' awareness of CSA practices but adoption is low among male and female farmers. Most widely adopted practices are row planting (95.24% women and 95.45% men) and intercropping (93.65% women and 84.85% men) with very little disparities in adoption level among the gender groups, while least adopted practices are improved varieties (38.1% women and 43.94% men), mulching (19.05% women and 28.79% men) and minimum tillage (3.17% women and 10.37% men) respectively. Most households adopt one or two practices on their farms, whereas for effective adoption, up to three or more of the five CSA practices introduced should be fully practiced on diverse crops all year round.

The barriers to adoption for the five preferred CSA practices were identified to be poor knowledge and information about practices (78.5% women and 46.7% men); factors of production (31.6% women and 26.7% men) such as land, capital and labour; lack of technical know-how and skill (26.6% women and 18.7% men); difficulty implementing CSA practices (20.3% women and 16.0% men) and poor yields from previous planting seasons (11.4% women and 10.7% men). Also, the impact of CSA on food and nutrition security was observed to be lower than expected as 74% of households expressed worry because of lack of food; 32% of households lacked food because of lack of resources; 17% of households had periods whereby there was no food in a day while 81% of households had limited variety of food to meet their nutritional needs.

Adopted practices were found to be poorly implemented by farmers, thus does not have expected impact on productivity as well as food and nutrition security. Knowledge deficiency, technical know-how, unreliable weather information and lack of adequate factors of production (land, labour and capital) were observed as major reasons for low adoption among farmers.

5.2 CONCLUSION

Smallholder farmers in Nwoya District are aware of climate smart agriculture and have been implementing it since 2015 when it was first introduced to them through training and demonstration as a way to increase adaptation and coping strategy with the ensuing impacts of climate change and variability. They are also keen to adopt new technologies and interventions that would transform their agricultural practices into a relatively more productive, higher-income earning, and low-carbon activity as well as to improve food and nutrition security.

All the respondents are implementing at least two types of CSA practices, namely row planting and intercropping, among the five types of CSA practices identified in the district. Row planting and intercropping are the two most widely adopted practices because of farmers' belief that both are easy to implement, cost effective and can double yields and income.

Adoption of CSA technologies and practices among women and men farmers was observed to be almost at the same rate for all practices (especially row planting, intercropping and improved variety), with more women adopting intercropping than men because of the added benefits of growing two or more crops on the same plot and having varieties for home consumption as well as income generation. However, the rate of adoption between men and women farmers in terms of minimum tillage and mulching differs considerably when compared to others. This is because women find these practices to be more strenuous, thus requiring more time and energy which most of them do not have because of other activities like taking care of the family and other doing domestic chores.

In terms of constraints and barriers to adoption, more females had one or more constraints to adopting a particular CSA practice than their male counterparts. Constraints such as factors of production, poor knowledge and information about practice, lack of technical know-how and skill, as well as poor yields from previous planting season affects women more than men. One of the reasons is women's lack of access to resources and inputs. Since about 61% of men and less than one-quarter (23.6%) of women have access to cell phones, it will be an uphill task for the over 70% women and 38% men who do not have access to cell phones to get first-hand information. Lack of access to trainings hinder women from acquiring sufficient knowledge and skill needed to increase productivity. Also, more women tend to drop a practice that does not bring about noticeable increase in yields and might remain unwilling to try such practice in the future.

CSA adoption is still low among smallholder farmers in Nwoya District of Uganda, notwithstanding the tremendous benefits associated with the practice. The low adoption rate is due to lack of sound technical know-how, training deficiencies, poor extension services, poor information about the benefits of CSA practices, poor access to resources and inputs, lack of access to markets and credit facilities, and inadequate knowledge about various CSA practices.
Even the few adopted practices are not properly implemented by the farmers. This is due to infrequent weather information and wrong implementation pattern of

CSA technology. Their knowledge on CSA practices and implementation is still low in the area and most farmers implement selected practices with their traditional knowledge. This is mostly evident in their method of implementing row planting and intercropping, which are the most widely adopted practices. Huge losses are recorded due to improper implementation of these two practices and have not impacted positively on productivity and income, as well as food and nutrition security.

5.3 RECOMMENDATIONS

To ensure up-scaling and out-scaling of CSA practices in Uganda, there is the need to critically look at the challenges farmers face as documented here to have better understanding of necessary steps to take that will benefit farmers and facilitate adoption. This will require government, donor agencies and agricultural institutions working together to address the challenges farmers face when trying to adopt a particular CSA practice and then proffering localized solutions to the people. Such localized solutions should take environmental issues, gender related factors, socioeconomic and climate variability factors into account. Developing appropriate and feasible climate smart and climate resilient agricultural practices will enable farmers readily adopt more CSA practices which will lead to increase in productivity, yields, income generation as well as food and nutrition security.

Farmers' awareness of the benefits of CSA practices as well as trainings on land management and CSA practice implementation should be a top priority of development partners. Land should not just be assumed to be fertile in one area or region alone even though it appears to be so.

Practices that encourage sustainable land management which includes soil, nutrient and water management to reduce degradation, as well as rehabilitation of agricultural land should be part of the training modules for farmers.

There should be continuous education, trainings and information on CSA practices through extension services. The unique challenges that men and women farmers face should be taken into consideration when designing programmes to further enhance CSA uptake among smallholder farmers. Intervention programmes must give considerations for gender from the period of conception of such programmes till full development with focus on how these programmes will be fully accepted by the farmers for ease of adoption. This can only be achieved if the farmers are totally carried along throughout the entire process. Regular extension services should be provided to educate and give farmers current relevant information, and priority should be given to women groups who have less access to information and other means of agricultural productivity.

Farmers' perception and socio-economic factors are important in developing a feasible and appropriate practice. Availability of new technologies alone is not a sufficient condition to bring about the change. Effective institutions and sustained policy support to bring the technologies within the reach of farmers, taking into considerations their perceptions and socio- economic factors play a significant role in the adoption of technology and practices. Equally important is the need to periodically appraise CSA technologies and practices with a view to understanding which practices or technologies are working as expected and which ones are not. This should include action steps to correct or bridge identified gaps that will further increase the success and adoption of good practices and technologies.

Thus there is need to consider capacity building and ensure that farmers fully understand the climate problems and can apply climate information effectively through education, trainings and strong monitoring to identify successes and failures. Strong and enabling local environment should be established to support strong and innovative rural institutions that will increase the uptake of good practices as well as facilitate access to credits and markets. This will need to consider appropriate and sustainable technologies to increase production while taking into consideration local and traditional knowledge. The extension services need to address and incorporate smallholder farmers to make use of the local knowledge and essential experiences for improving agricultural production, land productivity and improve income.

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Centre for Sustainable Development

ABOUT CENTRE FOR SUSTAINABLE DEVELOPMENT (CESDEV)

The Centre for Sustainable Development (CESDEV) was established by the University of Ibadan through Senate paper 5386 in May 2010 as a demonstration of the University's commitment to Sustainable Development. It was based on the need to provide intellectual platform for identification of issues germane to sustainable development, critically analyse them, and provide leadership in finding enduring solutions that will enhance sustainable development.

The establishment of CESDEV was sequel to series of events, paramount among which was the winning of a USD 900,000 grant from the MacArthur Foundation to establish the Master's in Development Practice (MDP) Programme. The University of Ibadan was one of the ten original Universities that won the grant in a global competition involving over 70 Universities. Further brainstorming led to defining the composition of the emerging Centre beyond the MDP Programme. It was resolved that a number of development programmes that were "hanging in the balance" be moved to the Centre. The **Centre for Sustainable Development** (CESDEV) thus became a Teaching and Research Centre with a mandate in multi- and inter-disciplinary approach to Sustainability issues affecting not just our continent but the whole universe. The Centre is designed to be a Teaching, Research and Development unit in the University. Presently, CESDEV has the following academic and outreach programmes:

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