

**HOUSEHOLD HEADSHIP AND CLIMATE CHANGE ADAPTATION AMONG
SMALLHOLDER FARMERS IN SOROTI DISTRICT, EASTERN UGANDA**

BY

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DECLARATION

This study is original and has not been submitted for any other degree award to any other university.

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LIST OF ACRONYMS

ACCCA	Advancing Capacity to Support Climate Change
CAADP	Comprehensive African Agriculture Development Programme
DSIP	Agricultural Sector Development Strategy and Investment Plan
EU	European Union
FTF	Feed The Future
GDP	Gross Domestic Product
GHG	Green House Gases
IFPRI	International Food Policy Research Institute
IPCC	Inter-Governmental Panel on Climate Change
IUCN/WEDO	World Conservation Union/ Women's Environment and Development Organization
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MDGs	Millennium Development Goals
MFPED	Ministry of Finance, Planning and Economic Development
MWLE	Ministry of Water, Lands and Environment
NAPA	National Adaptation Programmes of Action
NDWR	National Directorate of Water Development
ROU	Republic of Uganda.
UBOS	Uganda Bureau of Statistics
UNDP	United Nations Development Programme
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development

ABSTRACT

Climate change adaptation is considered an appropriate response to climate change and variability, especially for smallholder farmers to enhance resilience or reduce vulnerability to its effects. However, the response decisions and actions of male and female farmers may be influenced by various factors and factor combinations that are not adequately understood and therefore not well supported. This in turn affects management and ultimately output from their farms. It is hypothesized that both male and female farmers are climate change conscious and responsive; but may have different response behavior. This study sought to investigate what the factors were responsible for climate change adaptation decisions for male and female headed households, and possible benefits, and the extent to which these households might be impacted by their climate change adaptation options. We utilized a combination of descriptive statistics, cross tabulations and logistic regression analysis to analyse the factors that influence the choice decision to adapt to climate change. Gross margin analysis was used to understand the benefits of adaptation and the Trade Off Analysis-Minimum Data model was applied to study the possible impacts of adaptation.

Using cross-sectional data collected from 136 households, analysis was undertaken at two levels: pooled sample analysis and a gender disaggregated analysis. Majority of the farmers strongly agreed that there have been observed changes in climate over the past 15 years, and have responded to these changes. Contrary to some evidence from other empirical studies, the results of this study suggest that the number and type of factors that influence the climate change adaptation decision vary considerably between male and female household heads. We found that the climate change adaptation decisions of female heads depended on and were sensitive to more covariates compared to the decisions of male heads of household. The results of this study further suggest that climate change adaptation decisions of female heads

are influenced by more liquid household assets and resources such as transport facilities, purchased inputs, information sources and credit while those of male heads are influenced by real estate, especially land. Furthermore, beyond gender, other demographic factors appear to play no significant role in the decision to adapt to climate change. Interestingly, Gross margins from use of adaptation strategies were, overall, found to be similar between male and female headed households while using similar adaptation responses although the area under crop production was significantly different, with female headed households having smaller cropping areas. Results also showed that farmers not using any adaptation practices would be more severely affected by weather changes than those adapting. Female headed households would experience greater negative impacts than male headed households even with the climate change adaptation practices studied, and will be much worse off without adaptation.

This study reaffirms the need of gender disaggregated analysis to provide insights into gendered climate change adaptation covariates for improved policies and strategies to effectively respond to climate change. The study recommended timely planting as a sustainable climate change adaptation practice compared to other practices in the area.

CHAPTER ONE: INTRODUCTION

1.0 Background

The Intergovernmental Panel on Climate Change (IPCC) has defined climate change as a fluctuation between normally experienced climate conditions (rainfall, temperature, wind) and a different, but recurrent, set of climate conditions over a given region of the world. It is brought about by the increase in emission of green house gases (GHGs) in the atmosphere that destabilize the ozone layer, leading to global warming (IPCC, 2001). Higher temperatures affect yields of crops, and encourage weed and pest proliferation. Studies by the International Food Policy Research Institute (IFPRI) have showed that increased floods and droughts increase the likelihood of short-run crop failures and long-run production declines in both crops and animals (IFPRI, 2009). If left unchecked, climate change is expected to lower global per capita Gross Domestic Product (GDP) by 20% in 2200, threatening global food security (Stern, 2006). Recent reports for Uganda have also shown that while in the past decades, the frequency of droughts in Uganda averaged one per decade, in the last decade alone, over seven have been experienced (MWLE, 2007). Similarly, the erratic swings in seasons have caused an increase in frequency of food and water shortages in the country, with the worst hit area being the dry cattle corridor that stretches from the Uganda-Tanzania border to Karamoja region. Other country surveys have also reported death of livestock from lack of water, migration of traditional pastoralists and herders to neighboring districts or game reserves (NDWR, 2005) escalating land conflicts.

And while the primary manifestations of climate change are of a physical nature such as changes in temperature, rainfall, sea levels, and increased frequency of extreme weather events, the consequences or secondary manifestations are much more varied, including ecological, social, and economic impacts. Developing countries have especially been

vulnerable to climate change because of their geographic exposure, low incomes, and great reliance on climate sensitive sectors such as smallholder agriculture (Hepworth and Goulden, 2008). In Uganda particularly, it is very likely that climate change will slow progress toward achievement of the Millennium Development Goals (MDGs) either directly through increased exposure to adverse impacts of climate change or indirectly through erosion of farmers' capacity to adapt.

Agriculture in Uganda, being predominantly rain fed, is highly vulnerable to climate variations. The importance of this vulnerability cannot be overemphasized; 80% of Uganda's population is rural and 73% of the working population are employed in agriculture and related activities (MAAIF, 2010). Uganda's agricultural productivity is also featured as one of the lowest in Africa by a Feed the Future (FTF) report, (2010) of the USAID. Over 60% of households in rural areas are net buyers of food meaning that they purchase more food by value than they produce (MAAIF, 2010). And now with climate change, if food production levels do not stabilise, food shortages and food insecurity are expected to become more acute in the near future.

The Stern review (2006) calls for collective action against climate change which involves mitigation, innovation and adaptation options. Mitigation investments have greater potential to avoid climate change in the longer period than adaptation options, which are midterm, to minimize the negative effects of climate change. However, adaptation seems to be the only option before mitigation measures can have any impact. Mitigation strategies are those that seek to reduce the carbon emissions in the atmosphere. They include tree planting, air pollution standards, reduction of GHGs, green technologies (IPCC, 2007) among others.

Some studies have shown that farmers all over the world have taken on adaptation options to build resilience to impacts of climate change. Adaptation approaches reportedly used by

farmers include changing planting dates, use of new crop and livestock species with more adaptive traits, and use of mixed crop and livestock systems, shifting between grazing or cultivated areas and supplementing livestock feed among others (Thornton 2006; Majaliwa *et al.*, 2009; Gbetibouo *et al.*, 2009; Daressa and Hassan, 2009).

1.1 Climate Change and Gender In Agriculture

Gender plays a significant role in agriculture. By gender, we refer to the social roles and identities associated with what it means to be a man or woman farmer in this case. And these roles are shaped by ideologies, religion, ethnicity, cultural and economic factors, and determine responsibilities and distribution of resources between men and women (FAO, 2010).

World over, women are the main producers of staple foods contributing 60-80% of food in most developing countries. They are responsible for 70-80% of food production in sub-Saharan Africa, 65% in Asia and 45% in Latin America and the Caribbean. Women have been reported to use indigenous knowledge to maintain biodiversity which is vital in adapting to climate change more effectively as food sources become scarce. Women achieve all this despite their unequal access to capital such as land, information and inputs such as improved seed and fertilizer (CIDA, 2009) compared to men. With climate change affecting food production directly especially on rainfall dependent farms, women's response to climate change will depend on the needs, challenges and resources they can access (Meinzen-Dick *et al.*, 2010). Differential vulnerabilities of women stem from illiteracy, minimum mobility due to heavy household responsibilities and longer distances, and fewer opportunities outside the home. Issues around ownership and access to productive and complementary resources such as land, inputs are also often very different for women. Differences also emerge in roles and

contributions to food security, health and livelihoods, access to and control of resources (CIDA, 2009), and particularly decision making (WEDO, 2007) compared to men.

Other existing inequalities such as income generation, dependence on natural resources, and decision-making power (WEDO, 2007; Rohr and Hemmati, 2007) create differences in women and men's vulnerability, adaptations and adaptive capacities. Others are their perceptions of, contributions and reactions to climate change across age groups, ethnicity, education and income. Interventions that create greater awareness and understanding of the complex links between gender equality and the environment can help to build the capacity of the poor to adapt to impacts of and take action on climate change (Meinzen-Dick *et al.*, 2010).

In Uganda, the NAPA has particularly identified food insecurity and malnutrition of both humans and animals, as being exacerbated by climate change (ROU, 2008). Interestingly, these fall under the key roles of women in providing basic needs particularly food, water, health and energy, similar to a case study in South Africa (Babugura *et al.*, 2010) among others. Almost 60% of rural women have “cropping” as their occupation, as opposed to only 49% of men as revealed by an analysis undertaken by Gender and Growth Assessment for Uganda by the MFPED (2005). Even with livestock, the women own the smaller species such as goats, poultry, sheep and pigs which require lower initial costs while the men own dairy cattle in most cases (IFPRI, 2001). The decreased availability of water for both livestock and household needs requires women to move longer distances to collect water. Men on the other hand are normally responsible for irrigation. Decreased availability of firewood for household energy increases workload for women and children. This leaves less time for income generating agricultural activities such as backyard gardening, and food production. Hunger

and malnutrition follow decreased food production. Duncan (2004), suggests that decreased agricultural productivity is supposed to increase malnutrition and hunger by 10%.

1.2 Problem Statement

Adaptation to climate change is generally costly, largely revolving around adoption of new or improvement of technologies such as improved varieties and hybrids or use of improved crop husbandry practices (Kalungu *et al.*, 2013; Antle 2010) but is a response many resource poor farming households have embraced (Thornton 2006; Gbetibouo *et al.*, 2009; Daressa and Hassan 2009; Majaliwa *et al.*, 2009; ROU-NAPA, 2010). The level of vulnerability of individual farming households is a key component to decision making when considering adaptation to climate change (Stern, 2006). Efforts to describe climate change adaptation of communities should include understanding of components and direction of vulnerability (adaptation capacity, exposure, and sensitivity) of households.

Climate change has been reported to magnify existing inequalities within communities (Dankleman, 2008). While exposure to climate variations may be the same for men and women in a given location, there are varied gender based differences in vulnerability and consequently adaptive capacity and adaptation (Adger *et al.*, 2005). These differences are highlighted through the decisions households make to implement climate change adaptation practices on their farms. But the gender disaggregated analyses are non existent for the region. Furthermore, although studies such as (Gbetibouo *et al.*, 2009; Daressa and Hassan 2009) have identified the socioeconomic influences on climate change adaptation such as access to credit (to finance adaptation and agro-inputs), formal and informal training and agricultural advisory services, land ownership, access to labour saving technologies (Koru and Holden, 2008; Blackden and Wodon, 2006; Blackden *et al.*, 2006) etc., little is known for Eastern Uganda. There is paucity of information on how these key social, institutional and

economic factors influencing climate change adaptation, and their the short and long term gender differentiated impacts on agriculture production in Uganda.

1.2.1 Research Objectives:

The overall objective of the study was to investigate key social, institutional and economic factors influencing climate change adaptation, and long term impacts of adaptation on agriculture production in male and female headed households of Soroti district, Eastern Uganda. Specifically, the study aimed to:

- 1) Determine factors influencing climate change adaptation, specifically if gender at household headship level is an influence
- 2) Establish the profitability of popular climate change adaptation strategies in male and female headed households;
- 3) Examine economic feasibility of popular climate change adaptation strategies by gender.

1.2.2 Hypotheses

The study was underpinned by the following hypotheses:

- 1) Gender of the household head is a key influence in adaptation to climate change
- 2) Male-headed households are more likely to benefit from adaptation practices than female headed
- 3) The adaptation practices are economically feasible for both male and female headed households in the long run

1.3 Importance of the Study

Uganda is still highly vulnerable to climate change (Thornton *et al.*, 2006) and her small holder farmers are generally poor. Vulnerability studies, particularly gender based studies are

relevant in providing grass root information on constraints that may possibly hinder climate change adaptation. This is useful for drafting gender policies geared towards improving adaptive capacities of men and women for overall growth of agricultural sector.

Profitability analysis of adaptation is important because farmers will only use adaptation strategies on a larger scale only when they are convinced that they are the best bet for income generation. The benefits of adaptation can then be better exploited by all farmers without increasing costs for others since there are few resources to draw upon in times of crisis especially for the female headed households. Also knowledge of profitable climate change adaptation practices can provide a basis on which innovations may be built later for a given region

Analysis of impacts of adaptation to climate change will help guide investment priorities for the study area, which if implemented will build resilience, that is, the ability to withstand, adapt to, and quickly recover from climate stress and shocks. Also, it will enable the design of appropriate interventions and shed more light on scaling up of best climate change practices by rural communities, who are the major food providers in Uganda.

On the other hand, the gender specific analyses on climate change adaptation and its impacts for a given area will also contribute to availability of gender disaggregated data, which will assist in fully integrating gender in policy research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Climate Change in Perspective

Climate change is real but there is uncertainty on the exact nature and consequences making decision making on how to respond difficult (Rao 2013). Recent studies suggest that climate change is happening faster than had been reported by the IPCC assessment of 2007. IPCC (2007), as cited by Rao (2013), in its analyses concluded that current global mean surface temperatures were about 0.42°C to 0.54°C above the period 1955-1990; 1955-2006 being among the warmest on record. Recently, it was reported that 2000-2009 has been warmer than any other decade. The temperatures are expected to increase by $1.1-2.9^{\circ}\text{C}$ under low emission and $2.4-6.4^{\circ}\text{C}$ under high emission by the end of the century. Even if the GHG emissions are reduced to zero, it is expected that the climate will get warmer until an equilibrium situation is arrived at.

At local level, more uncertainty looms as global predictions on regional and national climate changes in terms of magnitude and timing of these events are unclear because of difficulties in simulations at a small scale. So it is unclear – at least not with precision, how the climate will be in the next 50 years at any given location.

But for the East African region, it has been projected that under medium emission, annual temperatures will increase by 3.2°C and rainfall by about 7% towards the end of the century through studies from a set of global models. The region will be warmer by about 1°C by 2030 and 2°C by 2050 with slightly higher rainfall especially during September to February, increase in frequency of both extreme wet and dry seasons and rainfall variability across seasons is expected to increase (Rao 2013).

2.2 Impacts of Climate Change on Agriculture

Recent studies on impacts of climate change on growing periods and agricultural systems, and possible livelihood implications show that mixed rain-fed and highland perennial systems in the great lakes region and in other parts of East Africa have been severely and will be affected (Thornton *et al.*, 2006), in seasonality of rainfall, onset of the rain days and intensity of rainfall. Food crises, water shortages and disease outbreaks have been brought about by prolonged droughts since rainfall and temperature regimens are key in determining potential productivity (Rao 2013).

Similarly direct impacts on agriculture are the increased demand for water due to higher temperatures suitability, rate of growth and potential yield of crops (Rao 2013; Oxfam 2009). Unlike the C3 plants such as rice, potato, beans, wheat, which are expected to benefit from higher temperatures, C4 plants such as maize, sorghum, millet will not (Rao 2013; Thornton *et al.*, 2006). Instead, the shortened growing period as a result of higher temperatures may cause early maturity which may lead to loss in biomass production. The projected climate changes will make agriculture more difficult and require raising the levels of management (Rao 2013).

Poverty is also linked to or can be induced by climate change; lower yields mean less food and income. Studies on southern African agricultural impacts indicate that crop net revenues will be likely to fall by as much as 90% by 2100, with small scale farmers being most severely affected (Benhin, 2006). Moreover, even as the farmers adapt to the changing climate, the costs of production have raised as they struggle to increase productivity, (with more expense on inputs such as labor for irrigation, use of fertilizers, and control of pests and disease) a situation that cannot be achieved under low management (Rao 2013).

Similar to many other areas, it is expected that climate change will have a net negative impact on resource poor subsistence farmers in Uganda, who comprise the majority of the rural population (Majaliwa *et al.*, 2009). These farmers also depend predominantly on rainfed agriculture. 24% of Uganda's land area is classified as dry lands, with only 9150 ha of arable land under irrigation, representing only 10% of irrigable land compared to 30% in Kenya (FAOSTAT, 2007) which puts into question the productive potential. This is critical because Uganda's economy is heavily dependent on agriculture, which accounts for over 20% or more of the Gross Domestic Product (GDP) and over 60% of her population are employed in the agricultural sector. The impacts discussed above could result in lower food security, higher food prices, lower domestic revenues, and export earnings for the farmers (Orindi and Eriksen 2005).

2.3 Climate Change Adaptation in Agriculture and Its Determinants

Many functional definitions of adaptation to climate change have been fronted. Among these, Antle, (2008) defines adaptation to climate change as the adoption of practices that are relatively less vulnerable under the changed climate; while Wannasai *et al* (2013) call it 'the process through which societies are taking measures to reduce the negative effects of climate change'. It has been referred to by IPCC report (2001) as adjustments in natural, or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities. Adaptation is one of the policy options for reducing the negative impacts of climate change (Adger,2003; Deressa et al,2009); adaptation practices reduce loss due to climate change, or increases gains. Considering the higher vulnerability of poor people in developing countries, adaptation practices are needed to strengthen their resilience to the impacts of climate change. An EU, 2006 report suggests that the most effective way to promote adaptation to and mitigation of climate change is to

integrate objectives, such as reduction of carbon emissions through reforestation, reducing industrial emissions, into strategies for poverty reduction and sustainable development. However, adaptation is the immediate strategy before mitigation measures can have any impact. It also attaches great importance to ensure that these strategies are owned and driven by the farmers themselves. The right strategies to adapt to climate change will also be the right strategies for truly sustainable development, and to reduce poverty, if properly implemented. In an attempt to adapt to climate change, Rao (2013) posits that the following should be included: addressing current challenges, strategic and tactical decision making, strengthening sustainable management of natural resources and risk, strengthening early warning systems, risk recovery options and strengthening capacity to make better assessments using new science tools.

T. Wheeler *et al*, 2009, asserts that key to the ability of farmers to adapt to climate change and variability will be access to relevant knowledge and information but other studies such as (Wannasai *et al.*, 2013) further suggest that adaptive capacities should be established earlier on. He suggested land size, cropping intensity, poverty incidence and literacy rate as indicators of vulnerability of this process. Farming households' ability to adapt to climate change likewise depends on a variety of factors including availability of resources (both state and individual) for adaptation, motivation, and information about the changing state of the environment and the links between human decisions and the environment.

Several studies on climate change adaptation and its determinants have been documented for different parts of sub-Saharan Africa. Although similarities do exist for different areas, differences have also emerged on which factors are more crucial and directly affect agricultural productivity for a given area largely due to differences in cultural roles, economic influences, experiences and expectations.

Gbetibouo, *et al.* (2009) documents a multinomial logit of key determinants of adaptation to climate change in the Limpopo region. Results showed household size, wealth, farm size, farming experience, perception of soil fertility, access to credit, extension services and off farm activities, tenure security and climate variables as significantly influencing this decision. Daressa *et al.* (2009) showed similar results citing education of the household head, gender of the head being male, livestock ownership and temperature as among the determinants for climate change adaptation in the Nile basin in Northern Ethiopia. A study by Wanjiku *et al.* (2007) using multinomial logit also found that gender, formal and informal training of the household head significantly influenced the choice of mechanization technology on small farms in Nyanza province of Kenya. Land size was another variable though not specific to women, was found highly positively correlated with vulnerability to climate change in terms of adaptive capacity of farmers in Thailand (Wannasai 2013).

Other studies (Babugura *et al.*, 2010; Orindi and Eriksen, 2005) also show factors such as age, education, gender roles, farming experience, social and physical capital, wealth and property ownership, access to credit among others as important determinants for adaptation to climate change.

2.4 Gender and Climate Change Adaptation

“The trade-offs forced upon people by climate shocks reinforce and perpetuate wider inequalities based on income, gender and other disparities.” UNDP, 2007

Several reports (World Bank, 2001; FAO, 2010;) document gender gaps in agriculture as related to land ownership and agricultural land size, livestock, mechanical tools, farm inputs and financial and extension services such as agricultural credits and technical training in every region of the planet. Women's agricultural activities are also reported to be under resourced and undercapitalized compared to men, a gap that reduces efficient investments in new technologies aimed at facilitating adaptation to climate change.

Evidence exists in research findings on gender differences in adoption of different technologies between male and female headed households that expose vulnerabilities of women to climate change . Ownership and control over land was lower in female headed households in sub-Saharan African countries (Doss and Morris 2001; Blackden ., 2006; Koru and Holden 2008), which implies restricted access to loans and social services and education opportunities. Koru and Holden, 2008 in their assessment of differences in maize productivity on male and female headed households in Masaka district of Central Uganda found that productivity was significantly lower on female headed households using matching estimators. Similarly, a probit analysis found male headed households more likely to adopt fertilizer use and to have better market access than females. Tenge *et al.*, (2004) found that female headship negatively influenced adoption of soil and water conservation technologies in the west Usambara highlands of Tanzania because female heads had less access to land, and other resources due to traditional social barriers. Gender studies by Meinzen-dick *et al.* (2010) and IFPRI (2001) have also highlighted unequal distribution of assets between men and women in rural households, which favour or constrain their adaptive capacities.

Analysis of impacts of gender specific constraints on productivity and marketing of high value crops in Uganda (Hill and Vigneri, 2009) showed that dissimilar access to resources resulted in different levels of participation, methods of production and modes of marketing for men and women headed households which affected cultivation of these crops. Also, levels of education were found to be lower among female headed household compared to the males.

Women have also been reported to face time constraints associated with heavy burdens of household tasks and large families, with long distances to move to their farms and market centers (Blackden and Wodon, 2006.). Time constraints were also linked to inefficiency of resource use including family labour and animal traction in a gender differentiated analysis of alternative farm mechanization choices on small farms in the Nyanza province of Kenya

(Wanjiku *et al.*, 2007). Also, presence of bicycles in the household reduces the transport burden by easing mobility to distant farms. This factor was indeed found to influence marketing of high value crops in Uganda among male and female headed households (Hill and Vigneri, 2009). Women heads also had smaller farms, less access to credit and inputs and lower levels of education, a factor that facilitates access to and proper use of technologies. A study by the Ministry of Finance, Planning and Economic Development (MFPED), (2002) found that female headed households in Soroti district had inadequate access to/control and ownership of land, realized poor crop yields, owned fewer animals and had limited access to social services particularly due to cultural influences such as patrilinear inheritance, a key feature of vulnerability to climate change. On the contrary, Nhemachena and Hassan (2008) found that female headed households were more likely to take up climate change adaptation methods in the Nile basin of Ethiopia. This seems to suggest that the influence of gender on climate change adaptation varies among cultures and social structures.

Indeed a case for gender in climate change adaptation is pertinent. Citing Rohr 2007, Mula *et al.*, 2010 asserts that women not only possess untapped skills for understanding causes and consequences of changes in climate changes-though many times at local level, they have adaptive skills for the same, by virtue of their involvement in these processes and unique capacities. They should therefore be brought in the main stream of decision making (Mula *et al.*, 2010), and initiatives especially in the implementation of appropriate adaptive technologies (Kalungu *et al.*, 2013), a knowledge on which adaptation largely revolves. The invisibility of women in climate change adaptation and mitigation has been fronted as one of main concern (UNISDR, 2008) especially limited attention to women's livelihood adaptation strategies; and judging from the above literature, these concerns are not baseless.

2.5 Climate Change Adaptation and Perceived Benefits

Profitability is a key factor affecting farmers' adaptation decisions besides their perceptions of and capability to adapt to climate change (Antle 2010). They will choose crop varieties for their resilience to stresses, or plant according to site specific conditions e.t c but working together with the enabling household characteristics in ways that take advantage of the changed conditions. This assertion is inline with the IPCC assessment report (IPCC 2001) that posits an inverse relationship of vulnerability to climate change with the resource endowments of the households. In a study that quantifies such vulnerabilities (Antle *et al.*, 2004 cited by Antle 2010) using field level and farm level data, places where mitigation and adaptation efforts were present showed a positive relationship between gains from adaptation and resource endowments.

In general, subsistence farmers have a low tolerance for risk because 'they are close to the borderline'(FAO 1995) in terms of savings and liquid assets and wouldn't risk their family welfare on untrusted technologies. Studies of climate change scenarios of future impacts (until 2050) such as by IFPRI (2010) have concluded "that families with higher incomes are better able to experiment with new technologies and management systems that might be costly upfront but offer big productivity and resilience pay offs in the future". First, such analyses highlight the increased challenges of the more vulnerable, low income groups in society, such as women, in the climate change fight as revealed in the literature. The lack of gender specific data and indicators on gender issues (UNISDR 2008) does not help at all. Infact, it contributes to the lack of gender specific adaptation policies which would otherwise have paid attention to their priorities. Secondly, the analyses are usually done at global level and regional level therefore would not highlight challenges at a lower level; analysis at micro level on what to expect where possible is helpful.

The analyses also further predict a rise in agricultural prices among other negative effects on productivity due to climate change (IFPRI, 2010) advocating for early action on adaptation and mitigation to ensure food security.

Since climate change is here to stay, to more closely we look (at micro level) to make strategies and policies more applicable, the better for their implementation by the end users.

2.6 Climate Change Adaptation Assessment

In regard to adaptation to climate change, Singh *et al* (2014) suggests that adaptation measures should be evaluated continuously, and learning should be complemented by experience gained from micro-level (households/village/community). It is at this level that a depository of farmer constraints and opportunities can be generated and tracked to quantify their vulnerabilities. Singh *et al* (2014) further suggests that since areas have a long historical perspective on evolution, perceptions and challenges, cultural, socio economic and agricultural set up, villages should be considered as units of analysis to create sufficient information for understanding a region both long and short term.

To study such areas such as river basin, watershed, villages as a farming system, Stoorgvel *et al* (2004) in their studies on environmental impact assessment, developed a model that could assess economic impacts of climate change adaptation. The Trade Off analysis studies the interrelations of different parameters (interactions between social, economic, environmental and health indicators. From these they generated easy to understand two dimensional curves that quantify the concept of sustainability. This provides support for decision making because productivity can be simulated even before farmers get to work.

CHAPTER THREE: METHODOLOGY

3.1 Description of study area

The study was undertaken in Gweri sub county of Soroti district, in Eastern Uganda. The region was purposively selected owing to its fragility and sensitivity to climate variability. The terrain is generally flat, traversed by numerous swamps and other ravine wetlands. Annual rainfall averages 1100-1200 mm distributed between two seasons of March to July and September to November. Late November to late February or early March is traditionally the long dry season and mid June to late July is the short one but this has become variable with frequent drought spells causing famine (MWLE, 2007). The soils are of sandy sediments and sandy loams, well drained and highly friable with alluvium deposits in the bottomland. The farming system is predominantly annual cropping and cattle Teso system. Small scale farming has been predominant in the area for long, which has greatly reduced vegetation cover, and is suggested to be a likely trigger for negative environmental effects such as intensity of floods and droughts, soil nutrient and biodiversity loss due to habitat conversion (Egeru and Majaliwa 2009).

3.2 Conceptual framework

The analytical framework for this study is based on the theoretical understanding of the problem and existing research on the climate change and related aspects; the level of vulnerability of any system is inversely related to the resource endowments of the region (IPCC 2007; Antle *et al.*,2004), which also determine the gains from climate change adaptation efforts.

Farmers being rational will make land management decisions to manage climate change based on how affordable the climate change adaptation practices are, the opportunity cost of adapting, and the expected outcome on productivity. From this perspective, the climate

change response decisions and actions of male and female headed household farms are assumed to be different as influenced by various factors and resource endowments that work together to create the desired production outcome i.e farm yields, and farm income. Noteworthy is that because the complexity of interactions between men and women within the household, household headship was used as a proxy for gender in this study. These factors, as hypothesized may include demographic variables such as age, household size, education level, gender of the household head, and household characteristics such as wealth, farming experience, membership to farmer organisations, access to credit and extension, land ownership, access to climate information and household assets. These influences are to various extents.

It is also assumed that over time if the farmers do not benefit as expected from the climate change adaptation practices they have chosen, they are bound to make changes to adaptation practice, or give it up completely. It is from this inference that examining the impacts or benefits of the adaptation practices in the long run becomes important so that farmers make sustainable farming decisions in ways that take into consideration the associated costs, and risks; knowing that climate is a key factor of production. When the net benefits are positive, farmers will continue adapting to climate change.

3.3 Econometric Analysis: Theoretical, empirical models and justification

In studies where the dependent variables are qualitative in nature, regression modeling approaches are used. They include the linear probability model (LPM), Logit, Probit and Tobit models (Gujarati,2004). The simplest of these is the LPM but it has problems of heteroscedasticity and non-normality of the error term with a possibility of the estimated probability lying outside the 0-1 range. The tobit is used to estimate linear relationships where a threshold level is involved thus censoring below or above. The probit and logit

models are similar in that they are both binary response regression models. However, the logit regression was selected for this study because 1) the coefficients can be interpreted in terms of odds ratios and 2) it is widely used in gender studies for factors influencing decision making status of men and women.

3.2.1 Logistic regression:

To answer the first objective a logit regression was used to determine the factors influencing the farmers' decision to adapt to climate change. Gujarati (2004) provides a theoretical exposition of the model that can be estimated as a probability. Following Gujarati (2004) we:

Let $Y = 1$, be the probability of dependent variable happening, $Y = 0$, the probability of not happening. This relationship ($Y = 1$) can also be presented as $P_i = E(Y = 1/X_i)$ or $p(Y = 1/x_i)$; where E is expectation. $Y = 0$ can be expressed as $p(Y = 0)/x_i$ or as $(1 - P_i)$;

The odds ratio (likelihood) in favor of $Y = 1$ are given as

$$(P_i / 1 - P_i) \dots \dots \dots (1)$$

If $(1) > 1$ - increased odds; $(1) < 1$ - reduced odds; $(1) = 1$ - equally likely odds

Thus taking natural log of equation (1) above, we obtain the logit Y as

$\ln p(Y = 1/x_i) / p(Y = 0)/x_i = \ln (P_i / 1 - P_i)$, so that

$$Y = \ln P_i / 1 - P_i = \beta_0 + \beta_1 X_1 + \dots \beta_n X_n + u \dots \dots \dots (2)$$

Where Y_i is the dependent variable, X_{i-n} are explanatory variables and β_0 is the intercept, the probability of the dependent variable when all explanatory variables are zero; β_{1-n} are coefficients to be estimated in the analysis.

The empirical model can be reduced to:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} \dots \dots \dots (3)$$

Where Y_i is a dichotomous dependent variable (farmer using any climate change adaptation technology or not, specified as yes=1, 0=otherwise). β_0 is the Y- intercept whereas β_1 - β_{10} is a set of coefficients to be estimated. X_1 - X_{10} are explanatory variables hypothesised, based on theory and related emperical work, to influence adaptation to climate change (Table 3.1).

Table 3.1: Table showing the hypothesized explanatory variables and the expected outcome

Variable	Description	Expected sign	Reason
X_1	Gender of household head, 1 (female), 0 (male)	-	Female heads have less access to resources for adaptation
X_2	Household size (number of family members that provide labour)	+	More family labour enhances adoption of labour intensive strategies
X_3	Land holding/ size in acres	+/-	Land size increases adoption of technologies, or reluctance
X_4	Access to modern inputs e.g. improved breed of crop and animals	+	Improved breeds more resistant to adverse effects of climate
X_5	Education level (years of schooling)	+	More education favours adaptation due to faster knowledge acquisition
X_6	Access to credit;1=yes, 0 otherwise	+	Facilitates adoption of technologies
X_7	Land ownership1 owns the land, 0 otherwise	+	Land ownership fosters decision making on technologies to adopt
X_8	Possession of bicycle(s)1 yes; 0 otherwise	+	A bicycle acilitates movement of harvest from field and quicker access to markets
X_9	Possession of radio(s)1=yes, 0 otherwise	+	A radio facilitates access to information on weather/ climate,
X_{10}	Possession of animals	+	Animals such as oxen are a labour saving technology in the field. They also shield against impact of climate change

This analysis was done at two levels. At the first level, the factors influencing farmers' adaptation decisions for the whole sample were examined. At the second level the sample was disaggregated into male and female headed households. Multi-collinearity tests were performed for a number of variables including farmer group membership and access to extension services, number of phones and bicycles in the household, land size and phones, age and farming experience, household size and members (14-60 years), hoe, panga, phone and oxen numbers. As a result, one of each pair was omitted from the logit model.

3.2.2 Gross Margins

To achieve the second objective of assessing profitability of two most commonly used adaptation methods, that is the use of new drought tolerant plant varieties and timely planting, gross margins were estimated. It involves estimation of total revenue and total variable costs; the difference between the two gives the gross margin, which is a measure of profit. An enterprise was considered profitable if the total revenue was greater than the total variable costs. Such an estimate provides a guide to the farmers' investment decision. Gross margins were established where the adaptation practice was employed as follows:

$$GM=TR-TVC.....(4)$$

Where , GM= Gross margin;

TVC= Total variable costs (land preparation, planting, weeding, fertilizer application, harvesting and transportation to market centres)

TR=Total revenue (Total output *price in shillings)

The variable costs that relate to production at a given level of output is computed as:

$$TVC= W_iX_i; \text{ for } i=1,2,3,4,...n.....(5)$$

Where, W_i =unit cost of given input

X_i = level of input use (labour, seed, fertilizers, transportation, etc)

The respondents were disaggregated into female and male households to establish any differences in respective productivities and profitability.

The gross margin provide a simple method for comparing performance of different enterprises on farms of male and female headed households using the different adaptation practices for a given period of time, in this case, a year. In the present study, gross margins of two most important climate change adaptation practices were analysed. A comparison in

productivity was made between plots of male and female headed households to establish any differences.

3.2.3 Trade off Analysis Minimum Data (TOA-MD) model

We use the Trade Off Analysis (TOA) model to answer the third objective of simulating the impacts of climate change adaptation on the agricultural system (production) and gender differentiated impacts.

Yield losses as a result of climate change have been predicted to possibly go up to 50% for some regions by global climate change models (IPCC, 2007). Given that nobody really knows for sure the likely yield losses attributed to climate change in the study area, we simulate climate change impacts in form of yield losses of 10%, 30% and 50% from the present yields under three scenarios of no adaptation, adaptation using drought tolerant crop varieties with timely planting, and timely planting alone. It was not possible to obtain data for farmers using drought tolerant crop varieties alone.

The TOA-MD model is an environmental impact assessment model (Antle 2011) but is able to simulate these economic impacts of climate change on farmers using impact indicators such adoption rates, mean net farm returns which is a function of yields, and poverty rates. This model is designed to simulate and compare two systems at a time, a base system and a system that is operated under altered climate conditions such that it provides different economic outcomes for farms. As described by Antle (2011), it is assumed that farmers are initially operating a base technology with a base climate, in specified socio-economic conditions (held constant in this analysis). Thus a system is defined as a pair $j\ k$, where $j = B, A$ indexes the base and adapted technology and $k = B, P$ indexes the base and perturbed climates; hence BB is a system of base technology operated with base climate; system BP is the base technology in perturbed climate, AB as adapted technology etc. The TOA-MD

model can simulate the economic, environmental and social outcomes associated with each system to quantify the impacts of climate change.

The modeling of climate change impacts was applied as described in Antle (2011) under the following alternative scenarios of technology adoption:

- The impact of climate change without adaptation, i.e., assuming all farmers use the base technology (in TOA-MD model terminology, system 1=BB and system 2=BP).
- the impact of climate change with complete adaptation, i.e., assuming all farmers use the adapted technology in this case, early planting or use of drought tolerant (system 1 = AB and system 2 = AP)

In the TOA-MD model, each production activity (an individual crop species) generates an output that can be measured on a per-unit basis (e.g., kg grain/ha/time) or a per-farm basis (e.g., kg/farm/time). The model can represent the time units as a single production period, or over a user-specified number of production periods. In this analysis, each agricultural/production system comprised of a set of crops (cassava, groundnuts, sweet potatoes) in a single season, defined as crop yields per hectare, i.e., as kg/ha/season. Although farmers had other crops, they were not considered for lack of sufficient data on their farms such as for sorghum, vegetables, millet, cowpeas and green gram.

TOA-MD carries out simulations for a population of farms in specified strata, which in this case is male and female headed farms defined as a region. The production from a crop is represented in terms of the mean yield of each crop from the farms in each stratum, and a variance of output among the farms in the stratum. The variations due to whatever factors – physical, biological, economic, social, etc. – vary across farms.

Since system 2 involves the same crops as system 1, the productivity of system 2 is defined as a change in the yield of system 1; thus it is assumed that there is a correlation (ρ_{12})

between systems. Thus, suppose that crop yield of system h is y_h , $h = 1, 2$, with mean μ_h and variance σ_h , then the yield of system 2 is $y_2 = \beta y_1$, where $\beta > 0$, so β represents the yield of system 2 relative to system 1. However, this relative yield will not be the same for all farms, and thus it is assumed to vary randomly in the population, with mean μ_β and variance σ_β , so we can write $\beta = \mu_\beta + \sigma_\beta \varepsilon$, where ε is an independent standard normal variate. Thus $y_2 = (\mu_\beta + \sigma_\beta \varepsilon)y_1$, and applying the definitions of mean, variance and correlation we have

$$\mu_2 = \mu_\beta \mu_1, \sigma_2 = \mu_\beta \sigma_1 + \sigma_\beta (\sigma_1 + \mu_1), \rho_{12} = \mu_\beta \sigma_1 / \sigma_2.$$

This model has a natural linkage to crop model simulations carried out in the stratum at a statistically representative sample of locations. Again noting that $\beta = y_2/y_1$ is the relative yield at each site, μ_β and σ_β are the mean and standard deviation of the relative yields. The above equations show that with these parameters and the mean and variance of the yields for system 1, we can characterize the distribution of yields for system 2 that we need to run the TOA-MD model.

Specific impacts for male and female headed households were derived in form of trade off curves, comparing mean net farm returns and adoption rates of the two adaptation options. Mean net returns from production systems for male and female headed households could then be compared.

TOA-MD (development, strengths and weaknesses)

The Tradeoff Analysis Minimum data (TOA-MD) model was developed by Antle and Valdivia for *ex ante* assessment of adoption of new technologies (Antle and Valdivia, 2006; Claessens et al., 2009). A new version of the model TOA-MD5 has been developed to address adoption as well as climate impact assessment (Antle and Valdivia, 2006; Antle, 2011; Antle and Valdivia, 2011a; Antle and Valdivia, 2011b). The TOA-MD model simulates the economic, environmental and social outcomes associated with each system to

quantify the impacts of climate change. Impacts that can be simulated include changes in farm income or poverty rates, as well as other environmental or social outcomes of interest such as changes in greenhouse gas emissions or human health. More technical details of the model are provided on the TOA-MD website (<http://tradeoffs.oregonstate.edu/minimum-data-info>).

For analysis of climate change impact assessment, farmers are initially operating a *base technology* with a *base climate*, in specified *socio-economic conditions*.

The economic behavior of farmers is such that they make decisions based on maximizing expected value, and can continue to operate under a production system (1), or switch to an alternative system(2) depending on the opportunity cost; a production system being a particular technology used in a particular climate regime (Antle *et al.*, 1999;Claessens et al.,2010).Thus a farmer facing expected product and input prices p at a site s using a production system h (a combination of technology and climate) earns per hectare returns equal to $v_t = v_t(p,s,h)$.

The profit function is defined as, $v(p, s, z)$ (shs/ha), where p = output and input prices, s = location, h = production system such that the farmer earns $v_1(p, s, 1)$ from system 1. Expected prices are assumed constant over time. Farmers choose to remain in system 1 or switch to system 2 under altered climate conditions based on the opportunity cost (or the gain or loss from switching) given by $\omega = v_1 - v_2$, where v_1 = net returns from system 1 and v_2 = net returns from system 2. Farms adopt system 2 if $\omega < 0$ (i.e. net returns from system 2 are greater than net returns from system 1) and remain in system 1 (non adopters) if $\omega > 0$ (i.e. net returns from system 2 are lower than net returns from system 1). In system 1 farmers are operating a base technology with a base climate, and system 2 is defined as the case where farmers continue using the base technology under a perturbed climate. In this analysis, the

base system was without, and with adaptation such that the adaptation options were also assessed.

The opportunity cost ω follows a distribution $\varphi(\omega)$ as shown (Fig. 7).

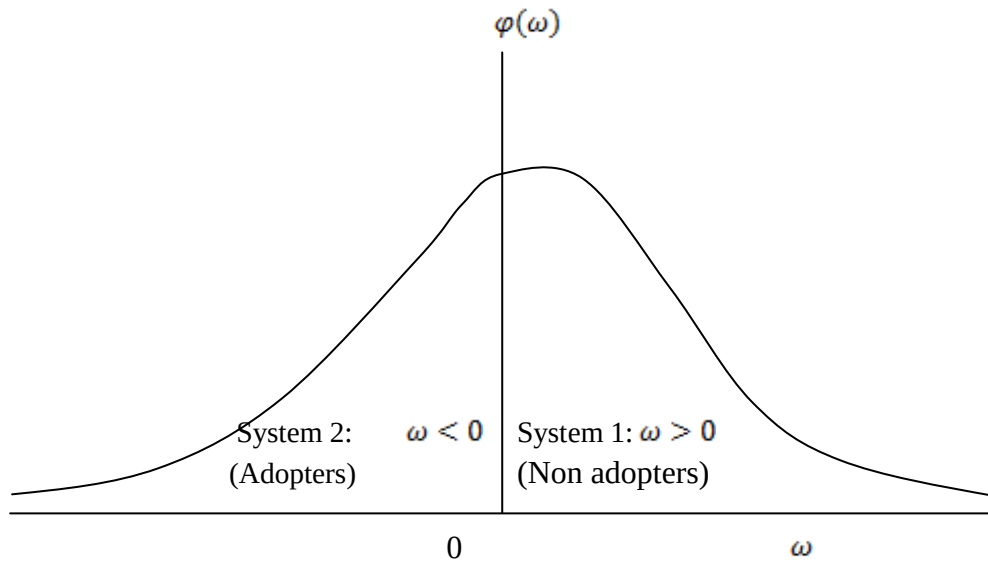


Fig. 1: Switching from system 1 to system 2

Thus the percentage of adopters (without compensation) is given by

$$A = 100 \int_{-\infty}^0 \varphi(\omega) d\omega$$

The percentage of non adopters (remain in system 1) is

$$\tilde{A} = 100 - 100 \int_{-\infty}^0 \varphi(\omega) d\omega = 100 \int_0^{\infty} \varphi(\omega) d\omega$$

where A = percentage of adopters and $\tilde{A}$ = percentage of non adopters.

Therefore the indicators of impact are the adoption rates of farmers of the adaptation practices given yield losses, the mean net returns on the farm and the changes in poverty rates. Opportunity cost of adaptation, which varies from site to site, is aggregated at field level to generate trade off curves. Overall vulnerability is measured by the proportion of

farmers made worse off, (Antle *et al.*, 2004; Claissens *et al.*, 2010) and can also be defined relative to thresholds such as poverty line to assess how many more households are put into poverty by climate change. Vulnerability assessments provide the understanding of adaptive capacity (IPCC 2007).

3.3 Data and sources

3.3.1 Sampling design

The overall approach to the study involved a two stage process:1) a stakeholder consultative workshop and 2) a household questionnaire interview.

The stakeholder consultative workshop was organized in Gweri sub-county, Soroti district. Gweri Sub-County was selected in consultation with technical staff in the region including Agricultural Officers and National Agricultural Advisory Services coordinators, on the basis of representativeness of the characteristics of the region, among other things. Notably also was the fact that other subcounties of interest were engaged in other climate change projects of the same nature so the findings would be duplicated and of no additional value to research.

The stakeholder workshop was undertaken to

- identify the perceived changes in climatic conditions of the area and their causes
- identify the effects of climate change and how the farmers are responding to them
- Understand how widespread and effective these strategies are according to the farmer
- Identify the gender dimensions of these response strategies and suitable study sites.

The workshop brought together local government (LG) officials, Community Based Facilitators (CBFs), and key farmers amongst other stakeholders. Based on the issues identified, stakeholders provided information on the climate change situation in the district

over the past 15 years. The information obtained included impacts of climate change, awareness amongst farmers and factors that they linked to this awareness. The workshop also provided a platform for in-depth consultation on key adaptation strategies.

A household survey then followed and was conducted in the three parishes *Aukot*, *Awoja* and *Dokolo* of Gweri sub-county to achieve an in-depth understanding of the drivers of climate change response/ adaptation and their gender dimensions, and profitability of adaptation. The survey was conducted in January 2011. The three parishes were selected based on prevalence of specific climate change adaptation practices as revealed by the stakeholder workshop. The focus of the study was on decision making at household level.

In each parish, a community based facilitator, identified by the sub-county National Agricultural Advisory Services (NAADS) coordinator, helped to construct a sampling frame that included all male and female-headed households from which 50 farmers were selected. All female headed households in the sampling frame were considered for the survey because they were fewer compared to males; while the male-headed households were randomly selected using random numbers. A total of 150 households for the three parishes grrttttwere obtained.

A semi-structured questionnaire was designed, informed by the stakeholder consultative workshop. Review of the questionnaire by experts ensured content validity; while pre-testing in a neighboring parish that was excluded from the main study, addressed issues of clarity.

3.3.2 Data collection

Data were collected on a number of household variables including demographics, socio-economic variables, land use and ownership, climate change impacts and adaptation practices. Quantitative data collected included, crop yield data on three key crops namely,

cassava, groundnuts and sweetpotato while using the adaptation practices, prices, land allocation and associated production costs and prices. Only 136 households were used in the analysis; 14 households having been dropped on account of inconsistent data. Ninety households were male headed with the balance of 46 households being headed by females.

3.4 Data analysis

The data from the questionnaire were entered into Statistical Package for Social Scientists (SPSS), cleaned and exported to STATA and EXCEL for analysis. Analyses were performed for both aggregate and disaggregated (male headed and female headed) samples. The logit regression model was run in STATA for both aggregate and gender disaggregated samples of the data to determine the influences of adaptation to climate change. Gross margins arising from the use of adaptation practices for cassava and groundnuts were determined for male and female headed households. The disaggregated sample was also used to run the MD-TOA in EXCEL to assess the potential impacts of climate change adaptation on male and female headed households using mean net returns of the production system.

Although data for the sweet potato enterprise were not utilized for the computation of gross margins, they were sufficient for the running of MD-TOA since it is a minimum data model because the farmers were considered as a system rather than individuals. Input variables for the model are summarized in the tables 1, 2, and 3 (see Appendix), disaggregated into male and female headed households. These data were available for technologies- no adaptation, timely planting alone and timely planting together with the use of drought tolerant crop varieties.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction

This Chapter presents findings of the stakeholder workshop and descriptive characteristics of male and female farmers surveyed. The factors influencing adaptation to climate change are analysed and gross margins arising from the use of two key adaptation strategies are described. Finally, simulation curves are used to study the impacts of climate change adaptation among male and female headed households. Results and their implications are discussed.

4.1 Stakeholder Consultative Workshop on The Climate Change Situation

Major climate events have occurred in the region as revealed by the stakeholder workshop. The region experienced severe flooding in 1976, 1996 and 2007 with 2007 being the most intense of the three. Incidents of strong winds and storms occur frequently in the region. The main farm level adaptation practices to the droughts and floods in the past include those practiced by both male and female heads such as adjusting planting time (early planting and change of planting dates) and use of drought tolerant, early maturing and disease resistant crop varieties. The more resource intensive practices including irrigation, tree planting, and adoption of flood tolerant crops such as paddy rice and use of improved animal breeds were reported to be mainly used by male headed households. Women heads prefer vegetable growing in swamps and shifting cultivated fields to uplands or lowlands during floods and droughts respectively (Table 4.0). Notably, also is that land in the region is owned and controlled mainly by the clan, and by men within the clan. Women especially widows do not have full rights to land and seek permission on major decisions and any major changes to be made on the farmland. The practices in the table below (table 4.0) are those that farmers believe are effective in countering the changing weather patterns.

Table 4.0 Table showing incidence of extreme weather events, adaptations and their usage in male and female headed households

Extreme weather events	Adaptation strategies	Usage by households
Floods • 1976 • 1996 • 2007 (most severe so far)- water flowed from neighboring districts causing flooding even with no rain in the area Note: Intensity of the floods has increased over time	1. Shifting from lowland to upland areas, and or having scattered farms	Men and women
	2. Early harvesting, processing and storage e.g. cassava and sweet potatoes	Men and women
	3. Growing fast maturing crops to offset food shortage after floods (e.g. cowpeas and sorghum), and dropping late maturing varieties e.g migyera for cassava	Men and women
	5. Adoption of flood tolerant crops particularly paddy rice and eucalyptus trees	Mostly men
	6. Keeping smaller number of animals of improved breed e.g. Friesian cows and Boer goats	Men and women
2. Prolonged droughts • 1944 • 1992-1994: Extended widespread IDP camps & cattle rustling • 2008 and 2009: November-May instead of November-January, rains came in August. Note: higher frequency of droughts with higher temperatures were reported	1. Growing crops in swampy areas	Mostly women
	2. Early maturing crops (sorghum(sekedo), cowpeas, green gram)	Mostly women
	3. Drought tolerant crops (oranges, mangoes, cassava, Serenut II)	Mostly men
	4. Irrigation oranges, cowpeas, tomatoes, vegetables	Mostly men
	5. Enterprise mix (e.g. goat, apiculture, poultry)	Mostly men
	6. Early planting (groundnuts, cowpeas, cassava)	Mostly men

Although many adaptation practices were reported during the stakeholder workshop, only a few were widespread; notably early planting and the use of drought tolerant plant varieties. The effectiveness of these adaptations will be ascertained through their impacts on the households in terms of household production and income.

4.2 Climate Change Adaptation Practices and Constraints

The main farm level adaptation methods included timely planting, use of improved crop varieties (including drought tolerant and disease resistant varieties), changing planting dates, crop diversification to flood tolerant crops such as paddy rice and irrigation.

Majority (86%) of the farmers that adapted to climate change practiced timely planting and in many instances, this practice was used together with drought tolerant and early maturing crop varieties. Cross tabulation results showed that a majority of the male headed households (72%) reported taking action to adapt by adopting climate change related adaptation technologies compared to 59% of female headed households. Additionally, they showed no significant difference in the choice of adaptation practices between male and female headed households.

However, farmers who did not adopt any practices cited resource related constraints such as lack of money/ credit, limited land, lack of knowledge of climate change adaptation options and lack of inputs including planting material in that order. Others noted lack of adequate and reliable weather forecast. The lack of sufficient time to implement the adaptation practices was highlighted by almost 18% of female headed households compared to 5% of male headed households.

Tables 4.1 and 4.2 show descriptive statistics of the variables hypothesized to influence the adaptation to climate change. The households (hh) generally had low access to credit (Table 4.2). On average, male headed hh in the sample had better education experience, bigger households and land sizes (Table 4.1); majority employed adaptation practices on their farms (72%) compared to the female hh who were just over half. Similarly, the male hh in the sample had better access to information through radio, better means of transportation and possessed more animals.

Table 4 1. Characteristics of farmers

Variable	Group	Min	max	Mean	Sd
Years of education	Female	0	11	3.2	3.218
	Male	0	15	6.7	3.435
Household size	Female	1	16	7	3.31
	Male	1	30	10	5.19
Farming exp (years)	Female	7	58	26.5	12.668
	Male	1	57	23.3	13.668
Land size (acres)	Female	0.5	7	3.045	1.509
	Male	0.25	30	5.323	5.409

Source: Computed from Field Survey Data

Table 4.2. Characteristics of farmers

Categorical Variables	Female(%)	Male(%)
Using cc adaptation practices		
Yes	58.58	71.91
No	41.42	28.09
Land ownership		
Head	42.22	52.81
Both man +wife		10.11
Clan family	55.56	37.08
Children	2.22	
If household uses modern inputs		
yes	84.44	85.39
no	15.56	14.61
Access to credit		
yes	22.22	36.67
no	77.78	63.33
Possession of radio		
yes	38.64	73.33
no	61.36	26.67
Possession of animals		
yes	70.00	82.22
no	30.00	17.78
Possession of bicycle		
Yes	60.00	85.56
No	40.00	14.44

Source: Computed from Field Survey Data

Cross tabulations showed ownership of land ($p=0.07$, Fisher's exact test $=0.02$), land size ($p=0.004$), and access to credit ($p=0.0907$) were significantly different between male and female heads. Males had more ownership of land, higher land averages in acres and more access to credit. Over half of farmers that had access to credit reported to borrow from informal village banks, and used animals and land as security. There was also a significant

difference in both possession and type of animals kept ($p=0.061$, $p<0.1$). While females mainly kept the smaller animals such as goats and chickens, the male heads kept cattle and pigs. The degree to which these factors influenced the decision to adapt to climate change varied as shown in further analysis in the subsequent sections.

4.3 Factors Influencing the Decision for Farmers to Adapt to Climate Change

The results from the logit regression analysis for all farming households in the sample ($n=139$) are presented in Table 4.3. The results show that land ownership ($p=0.006$, $p<0.01$), use of purchased inputs ($p=0.050$), gender of the household head ($p=0.055$, $p<0.1$), total land size ($p=0.08$, $p<0.1$), access to credit ($p=0.039$, $p<0.05$) and possession of a bicycle ($p=0.060$, $p<0.1$) significantly influenced the decision for farmers to adapt to climate change. As hypothesized, results show that gender of the household head was a significant factor in adaptation to climate change, negatively influencing the process. The negative sign means that female headship was associated with reduced the likelihood of adaptation to climate change.

Table 4.3: Determinants of adaptation to climate change (dependent variable is adaptation to climate change) in Eastern Uganda

Explanatory variable	Odds ratio	Estimated coefficient	SE of coefficient	p> z
Gender of h/h head(GEN)	0.340986	-1.075914	0.5596936	0.055*
Household size	1.002315	0.0023121	0.0570206	0.968
Land size(LAND)	1.153329	0.1426522	0.0815557	0.080*
Purchase inputs(PINP)	3.12888	1.140675	0.5812253	0.050**
Education	0.9047109	-0.1001399	0.0719682	0.164
Access to credit(ACRED)	2.905061	1.066454	0.5170207	0.039**
Land ownership (LO)	0.2562874	-1.361456	0.4947219	0.006***
Possession of bicycle(BI)	2.192927	0.7450301	0.3961371	0.060*
Radio (RAD)	0.5517722	-0.5946199	0.3751707	0.113
Possession of animals	0.9888483	-0.0112144	0.1107662	0.919
constant		0.414683	0.9433912	0.395
Log likelihood	-66.009485(5 iterations)			
Number of observations	125			
LR chi2(11)	24.70			
Prob > chi2				0.0059***
Pseudo R2	0.1576			

*** p<0.01, ** p<0.05, *p<0.1

In the analysis, the household head being female and owning land reduces the likelihood of employing climate change adaptation practices. On the other hand, having bicycles, credit and purchased inputs, and large pieces of land increases the likelihood of adaptation. From literature, climate change adaptation has been reported to be largely revolving around adoption of technologies or improvement in existing ones. The findings in the analysis are consistent with other studies (Hill and Vigneri 2009;Koru and Houlden 2008; Tenge *et al.*,2004) that associated gender of the household head being female with lower adoption of technologies.

Land ownership was cited as a major factor besides limited access to social services such as credits, and low possession of animals for vulnerability to poverty while assessing gender dimensions of poverty (MFPED 2002). Instead ownership of animals and land ownership negatively influenced all farmers in this study (Table 4.3). However, it may also be due to the

fact that only 6.4% of farmers reported livestock as their main source of income. It is possible land owners were hiring out their land to the land less in order to generate more income for the household or had off-farm income sources as a way of adapting to climate change. This result could also be due to the limited number of adaptation strategies investigated in this study.

Positive determinants of the probability to adapt to climate change included land size, use of purchased inputs, access to credit, and possession of bicycles among others. Household size, level of education of the household head and possession of animals were nearly insignificant (with odds ratios of very close to 1). The positive influence of land size on the entire sample were consistent with those by Advancing Capacity to Support Climate Change, ACCCA (2010) study in Northern Ethiopia which reported that large farms positively influenced adoption of soil and water conservation, tree planting and use of improved varieties. Daressa *et al.*, (2008) also reported that land size represents wealth, an argument also emphasized by Knowler and Bradshaw, 2007 and Bashaasha *et al.* (2010) that adoption of agricultural technologies requires monetary input. Similarly, access to credit increases financial resources of farmers, reduces cash constraints and allows farmers to purchase inputs such as drought tolerant crop varieties (Gbetibou *et al.*, 2009; Behnin 2009; Daressa *et al.*, 2009). The ability to use these purchased inputs enhanced adaptation particularly for female headed households (Table 4.4).

The possession of radios ($p=0.05$), possession of a bicycle ($p=0.020$, $p<0.05$), and use of purchased inputs ($p=0.022$, $p<0.05$) specifically significantly influenced the adaptation in the female-headed household (Table 4.4) with stronger coefficients and odds ratios. Possession of animals ($p=0.081$, $p<0.1$) also became significant although it less clear why it negatively influenced the climate change adaptation decision of female headed households. It is likely

that those households with animals used them as an adaptation to climate change itself and were reluctant on employing other crop production related adaptation practices considered in the scope of this study.

Table 4.4. Determinants of adaptation to climate change among female headed households

Explanatory variable	Odds ratio	Estimated coefficient	SE of coefficient	p> z
household size	0.8157321	-0.2036692	0.1713915	0.235
Land size(LAND)	1.076824	0.0740162	0.322621	0.819
Purchase inputs(PINP)	23.84587	3.171611	1.38516	0.022**
Education	1.02113	0.02091	0.1807595	0.908
Access to credit (ACRED)	10.42749	2.344446	1.483389	0.114
Land ownership (LO)	0.3801092	-0.9672967	1.092365	0.376
Possession of bicycle (BI)	19.11549	2.950499	1.268602	0.020**
Radio (RAD)	0.0874773	-2.436376	1.240582	0.050**
Possession of animals	0.6562676	-0.4211867	0.2414371	0.081*
constant		-0.9476864	2.256896	0.675
Log likelihood	-18.338681			
Number of observations	39			
LR Chi Square	16.12			
Prob > Chi Square	0.0643*			
Pseudo R ²	0.3054			

*** p<0.01, ** p<0.05, *p<0.1

Meanwhile, only land ownership (p=0.003, p<0.001) was found to negatively and significantly influence adaptation to climate change among male headed hh (Table 4.5). Land owners are not keen on employing the adaptation practices. It is likely that land ownership is used as a safety net for these households; or possibly, the households put it to non agricultural uses such as obtaining credit or uses that are not consistent with the climate change adaptation strategies under investigation.

Table 4.5: Determinants of adaptation to climate change among male headed households in Eastern Uganda

Explanatory variable	Odds ratio	Estimated coefficient	SE of coefficient	p> z
h/h size	1.03609	0.0354537	0.0670126	0.597
Land size(LAND)	1.131967	0.1239571	0.0832019	0.136
Purchase inputs(PINP)	2.770402	1.018992	0.7857697	0.195
Education	0.8665459	-0.1432402	0.0915734	0.118
Access to credit(ACRED)	2.634963	0.9688691	0.6215418	0.119
Land ownership (LO)	0.1116958	-2.191977	0.7464539	0.003***
Possession of bicycle(BI)	1.07304	0.0704953	0.4722129	0.881
Radio (RAD)	0.7831291	-0.2444577	0.4266639	0.567
Possession of animals	1.094864	0.0906301	0.1488075	0.542
constant		1.265501	1.199354	0.291
Log likelihood	-40.177942			
Number of observations	86			
LR Chi Square (11)	21.48			
Prob > Chi Square				0.0107**
Pseudo R ²	0.2109			

*** p<0.01, ** p<0.05, *p<0.1

Radios were reported as the major source of climate information although farmers questioned the reliability of this information. The ease of mobility in the home due to presence of bicycles and purchased farm inputs positively influenced the decision for female headed households to employ climate change adaptation practices. Access to means of transport facilitates female heads access to purchased inputs and also access to credit from informal village banks and other institutions, reducing the burden compounded by household responsibilities.

Although male headed households in the study area were more inclined to borrow and purchase inputs possibly because of the ability to secure credit using collateral such as land and animals, this increased credit access did not increase their probability to use adaptation practices. The borrowing could indeed be for other household needs such as children's education. The IPCC (2001) report posits that vulnerability to climate change is inversely

related to household resource endowments, a position reiterated by Dankelman (2008) that livelihood assets are important factors for gender differences in adaptation to climate change.

4.4 Profitability of Climate Change Adaptation Practices.

Although a number of crops were grown by the farmers, including millet, sorghum, maize, vegetables, sweet potatoes, rice and citrus fruits, profitability of adaptation practices was only determined by measuring gross margins arising out of the most commonly grown crops, cassava and groundnuts. Both crops were reported to be drought resistant. Eighty seven percent of the respondents reported crop farming as their main source of livelihood and income. And all the respondents that grew cassava and groundnuts as their main crop also reported using timely planting together with the drought tolerant crop varieties. These gross margins were compared for both male and female headed households.

Other crops although also commonly grown, were excluded from profitability calculations for lack of sufficient and reliable data on yield and costs respectively.

4.4.1 Gross Margins Arising Out of Adaptation to Climate Change.

Cassava

Migyera, a cassava variety developed by the International Institute for Tropical Agriculture (IITA) was introduced by NARO to the region (IITA, 2001). It was the most popular variety grown by majority of the farmers. Cassava itself being drought hardy crop, and disease resistant (disease pressure can be exacerbated by climate change) has replaced the once more popular sweet potatoes as the main food crop due to frequent occurrence of droughts.

The mean gross margins for cassava farms were Ug. Shs 975,183.3 per hectare and ranged from losses of -368,174 to gains of 9,483,568 (see Appendix Table 4). The average land area under production was 0.4834ha. Analysis revealed that up to 25% of the farmers sampled

made losses; however; the positive gross margins show that using drought tolerant crop varieties as an adaptation to climate change is a profitable venture.

It is likely that the entire production of cassava was not captured from records due to the practice of piecemeal harvesting done by the farmers thus the negative gross margins from some farms. Studies have also reported a consistent loss in yield once the roots have reached the optimum harvest stage (IITA, 2002). Analysis of variance between gross margins arising from cassava farms of male and female headed households showed that they were not only positive but also not significantly different (Table 4.6). Drought tolerant varieties are a profitable option for all farmers in the area. The labour costs included land opening, ploughing, planting, weeding, spraying and harvesting.

Table 4.6: Analysis of variance/t-test of mean for using cassava varieties

Variable	frequency	Mean(ug.shs)/ha	F-test (df=35)	t-test
Gross margins/ha			0.00	0.61
Female	13	966532.14		
Male	22	983834.38		
Total Revenue/ha			0.00	0.62
Female	13	1449194.2		
male	22	1482283.2		
Total cost/ha			0.05	0.05
Female	13	482662.05		
male	22	498448.78		
Labour costs			0.04	-3.67
Female	13	125444.44		
male	22	121444.44		
Area under crop			3.29*	1.81*
Female	12	0.3457		
Male	24	0.5775		

*=10% significance

Groundnuts

The average land area under groundnut production was 0.442 ha (see appendix :Table 5). The main variety grown by majority of the farmers was serenut2 which is drought tolerant, has

shorter maturity period (110 days) compared to Igola 1(125-130 days) previously popular with these farmers, and more resistant to groundnut rosette disease than the local varieties (Okello *et al.*, 2010). The mean gross margins were about Ugshs.2, 277,000 per hectare and ranged from Ug.shs 1.5million to about 8 million (See appendix Table 5). Although there seems to be great variability in gross margins among the farms, the use of drought tolerant ground nut varieties as an adaptation to climate change is a profitable venture.

Comparison of means of gross margins, total revenue, and total costs between the male and female headed households did not yield any significant difference between the two groups (Table 4.7). Only area under production was significantly lower for female headed households.

Table 4.7: ANOVA/t-test on gross margins from farms that use drought tolerant groundnut varieties.

Variable)	group	Mean	F(df=34)	t-test
Gross margins(n=35)	Female(13) Male(22)	2,234635.1 2,348130.7	0.04	0.29
Total Revenue/ha	Female(13) Male(22)	2860618.6 2700653.7	0.08	0.26
Total cost/ha	Female(13) Male(22)	512487.88 466018.6	0.26	-0.26
Labour costs	Female(13) Male(22)	176538.46 138009.09	1.55	-1.42
Acreage under crop	Female(13) Male(22)	0.84 1.25	3.47 *	1.88*

*=10% significance

Overall, it is more profitable to grow groundnuts using drought tolerant crop varieties as an adaptation to climate change than cassava because the former is regarded as a high value crop and mainly grown for cash, and because of piecemeal harvesting for the latter. Groundnuts also fetched higher prices per kg (Ushs.1600) compared to cassava (Ushs.200). It is also likely that farmers invest more time and resources in groundnut production which may explain the higher output.

This result is inconsistent with findings of MFPED (2002) report where poor yields were consistent with the female headed households in Soroti district. However, it could be argued that with adaptation to climate change since then, a balance has been attained. In support for this, FAO (2010-11) report posits that female headed household farms are believed to be just as efficient as their male counterparts in productivity if provided with the same resources; in this case, drought resistant crop varieties. The report further argues the yields could in fact surpass the male headed hh farms by 20-30% on their farms by 20-30% in such a situation. Contrary to this however, is Peterman *et al.* (2009) cited by Meinzen-dick *et al.* (2010) who found lower productivity to be persistent on female-owned plots and in female-headed households in Nigeria and Uganda when accounting for a range of socioeconomic variables, agricultural inputs, and crop choices. Notably though is the fact that other factors of productivity such as capital, labour e.t.c, being outside the scope of this study, were not considered.

Women headed households had almost half as small land holdings as males. This may be attributed to the disadvantage women have in statutory and customary land tenure systems; the presence of patrilineal inheritance imposed by cultural barriers in the rural African communities.

4.5 Assessing the Possible Impacts of Climate Change Adaptation Practices

As earlier highlighted, there was no significant difference between adaptation practices practiced by male or female farmers. The two most popular climate change adaptation practices were assessed using the TOA-MD model for their impacts on the farming system. The impacts of timely planting used alone, and used together with drought tolerant crop varieties were compared with those that would be experienced if farmers were not employing any practices at all (no adaptation). Timely planting was popular because farmers sought to

maximize potential from the earliest rains, whenever they came, and the use of drought tolerant varieties was specifically in response to the frequent droughts in the region as reported in the stakeholder workshop.

The impacts were simulated for predicted yield declines of up to 50% due to climate change as predicted by climate change models (IPCC 2007). Two impact indicators are used in this analysis: 1) adoption rates i.e. the proportion of farms made worse off or percentage of farms not affected by climate change at the predicted yield losses as a result of climate change while using the climate change adaptation, and 2) the mean net farm income of the production system as stipulated by Antle (2011). It is assumed that farmers being rational will adopt or not adopt/ drop a practice at a level that is beneficial to them.

The adoption rates and mean net returns to production are presented by trade off curves in Figs. 2, 3 and 4 below. The farmers were considered as a system (Antle 2011) rather than individuals. The interpretation of the curves is as follows: The point where a curve crosses the x-axis tells the proportion of farmers that would not make losses by using the adaptation practice, hence adoption rate. To the left of this point are farmers that experience net gains greater or equal to the amount on the vertical axis. These farms would definitely continue with the practice because it is profitable. Conversely, to the right of this point, farmers experience losses less than or equal to the amount on the vertical axis. The farmers are unlikely to continue with the practice.

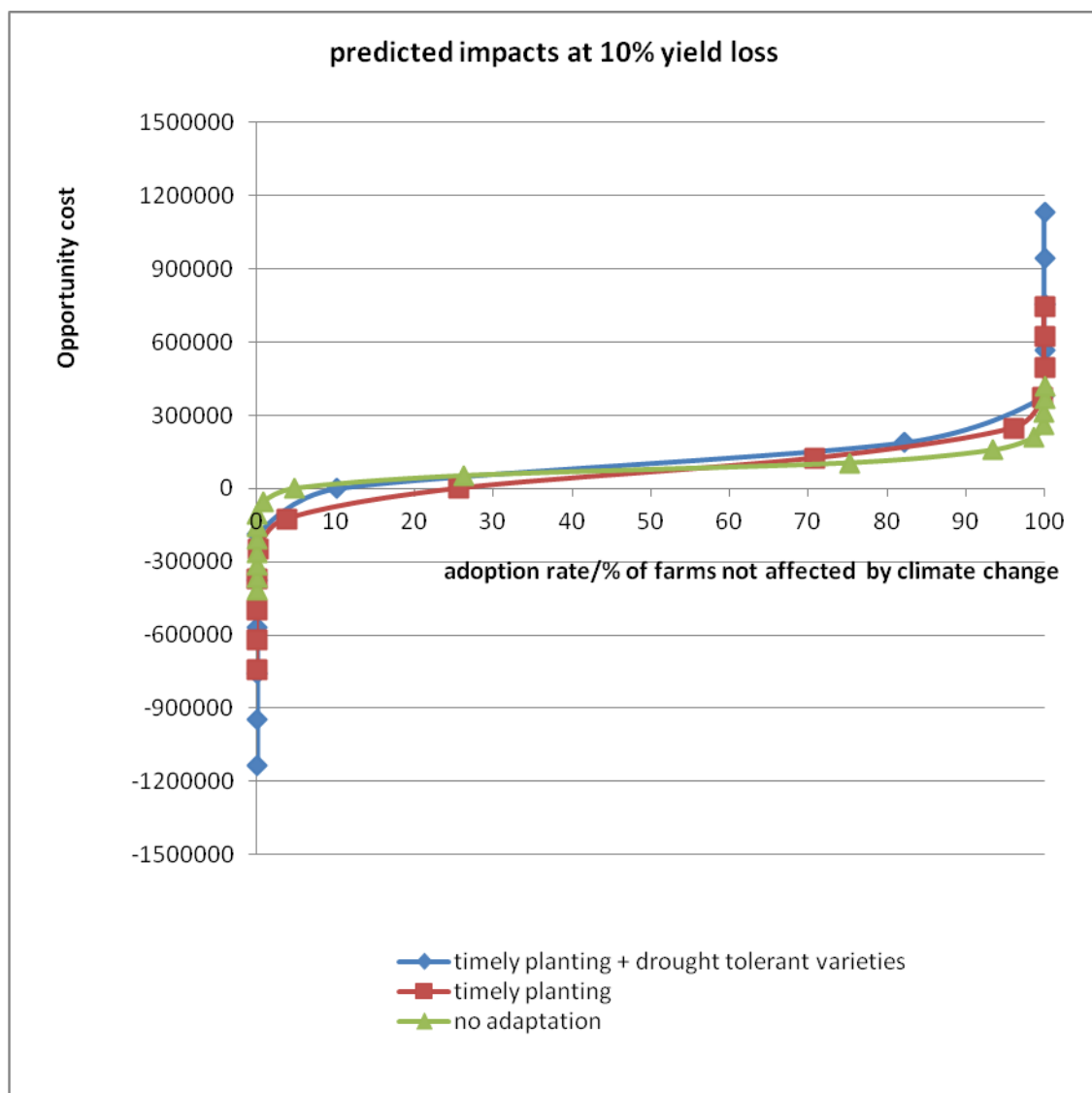


Fig. 2. Predicted impact at 10% decline in yields due to climate change

As Fig. 2 shows, a yield decline of 10% due to climate change, 10%, 26% and 10% of farmers using no adaptation, timely planting and timely planting with drought tolerant varieties respectively will continue with the practice assuming rationality. The rest will be experiencing losses. The use of drought tolerant varieties with timely planting appears to have a limited effect/ shield against the impacts for farmers compared to timely planting alone. It is likely that the farmers investigated are recycling their seed from previous season, or buy recycled seed from fellow farmers at cheaper prices. Recycled seed has reduces

potency which leads to lower yields. Alternatively, the cost of inputs may be an impediment in light of the expected yields.

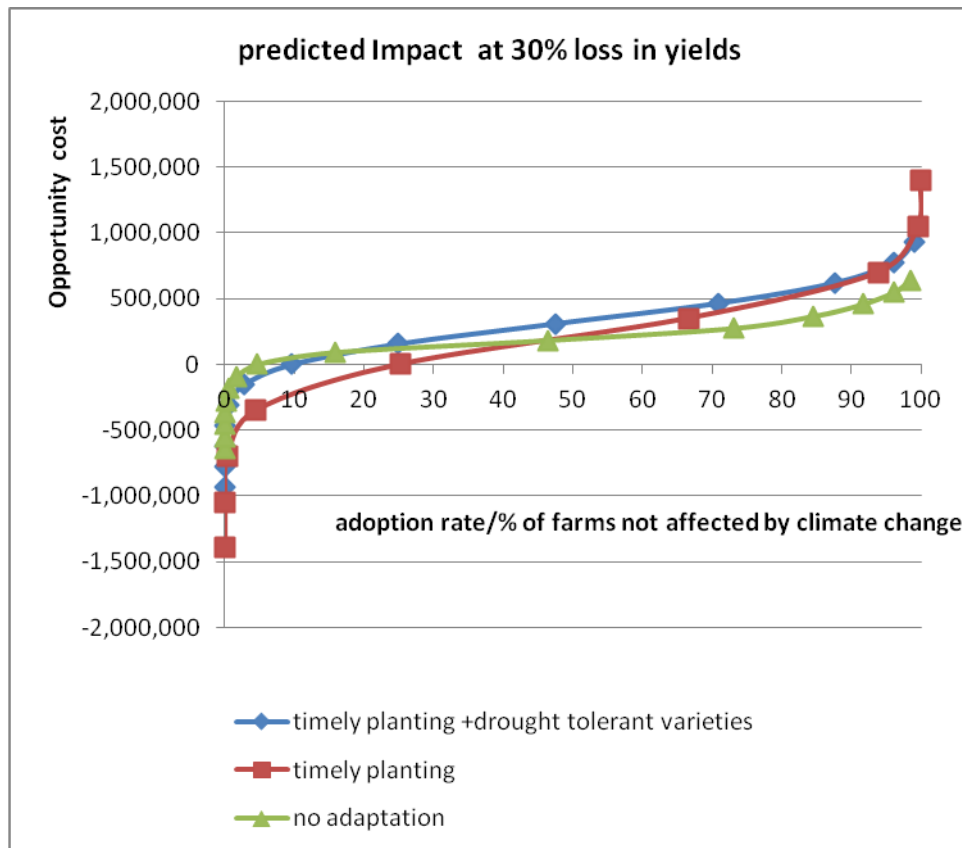


Fig. 3. Predicted impact of climate change at 30% decline in yields

In a similar trend as before, with yield losses of up to 30% due to climate change will cause up to 94.27% of farmers with no adaptation worse off, and 74.7% and 91.4% (Fig.3) of those using timely planting and drought tolerant varieties respectively. That is adoption rates of only 5.73%, 25.3% and 8.6% respectively.

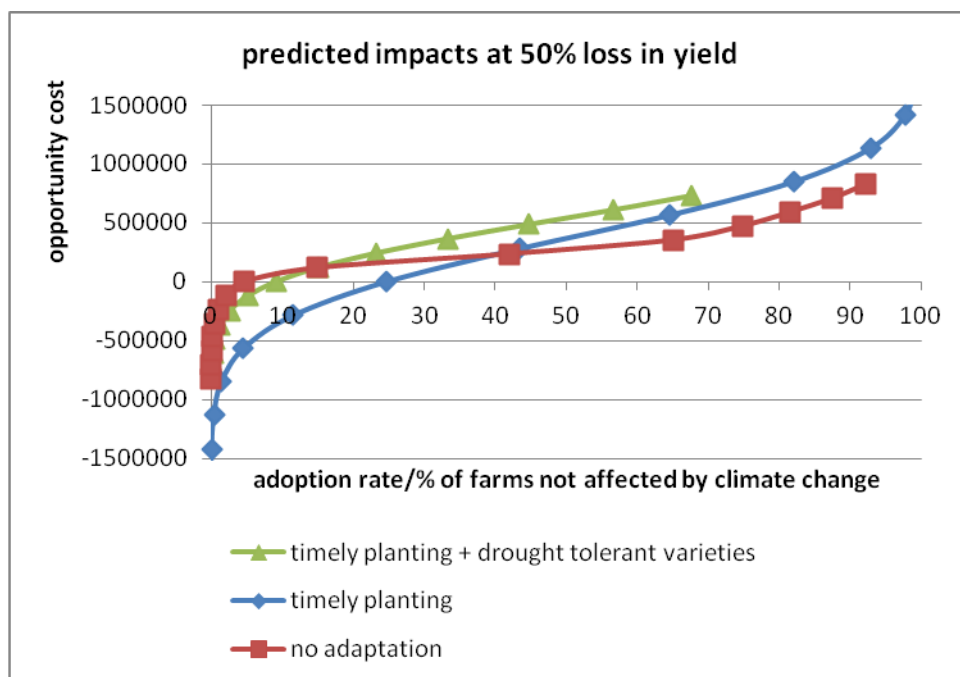


Fig. 4. Predicted impact of climate change at 50% decline in yields

A similar trend again would occur at 50% yield declines (Fig. 4); The adoption rates would increase very slightly for no adaptation and timely planting, 5.8% and 26.4% respectively. More farmers will drop drought tolerant crop varieties (8.14%) in favour of timely planting alone or no adaptation at all.

In the present analysis, timely planting seems to be the most sustainable practice for these set of farmers, even across male and female headed households (Table 4.8). However, as climate continues to change for the worse, more female households will discontinue adaptation practices while more males that were not adapting before, will start using adaptation practices. This is advantageous in that small holder farmers who are generally poor and may not readily have resources to facilitate adaptation in form of purchased inputs for their farms have a fall back practice.

Table 4.8 Impacts of adaptation in male and female headed households

Yield loss	10%		30%		50%	
Category/adoption rate	Female hh	Male hh	Female hh	Male hh	Female hh	Male hh
Timely planting	17.07	30.98	16.50	30.96	14.71	30.93
Timely+ drought tolerant	6.84	10.94	6.27	10.61	5.27	10.21
No adaptation	0.31	9.26	0.63	8.88	1.01	8.44

Contrary to what would have been expected, the use of drought tolerant crop varieties will not be a preferred practice in the long run for both male and female headed households. It seems that the farmers will be more concerned with issues of survival (food security), rather than income in case climate continues to change for the worse. However, in general farmers not employing adaptation practices will suffer the most losses. (Table 4.9).

In spite of the above findings, farmers using drought tolerant crop varieties in the study area though having less likelihood to thrive economically, would still experience the least percentage losses in mean net returns on the farm compared farmers practicing to timely planting and no adaptation practice at all (Table 4.9). In fact under the worst scenario presented, the use of drought tolerant varieties would provide the best shield against losses in mean net farm returns; much better than timely planting. This highlights the increasing role of climate change adaptation in agricultural production.

Table 4.9: Predicted impacts of climate change on net farm returns

Adaptation practice	Yield declines (%)	Net loss as % of mean net farm returns
No adaptation		
	10	22.7
	30	63.6
	50	82.3
Timely planting		
	10	14.1
	30	43.2
	50	69.9
Timely planting+Drought tolerant varieties		
	10	15.7
	30	46
	50	33

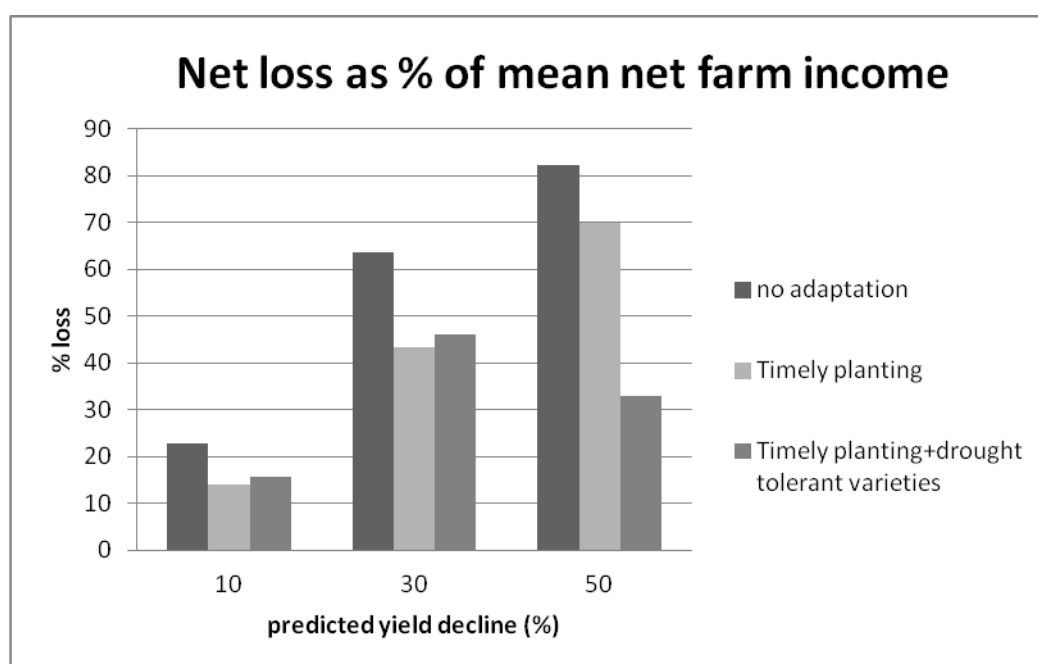


Fig. 5 Simulation of net losses using different responses at predicted yield losses

Farms with no adaptation would experience the highest percentage losses. Timely planting alone and also used together with drought tolerant crop varieties are similar in the 10% and 30% (Fig.5). In severe impacts of climate change (50%), drought tolerant varieties seem to register the least losses compared to timely planting alone.

When disaggregated into male and female headed households to observe simulated impacts on farmers practicing use of drought resistant varieties, female headed households would experience greater losses in net farm returns (Table 4.10). Similarly, the percentage of farmers that would be better off is much less for the female headed households as seen from farmers benefitting (Fig.6). A household being male headed would experience less economic impacts by 5% (Table 4.10) than the female headed households. Surprisingly though, net losses at 30% yield declines are more than at 50%.

Table 4.10 : The impacts of climate change on male and female headed households using drought tolerant crop varieties.

Parameter	Female hh			Male hh		
Predicted crop yield loss (%)	10	30	50	10	30	50
% farms impacted negatively	93.2	93.7	94.7	89.9	89.4	89.8
Net losses as % of mean net returns	18.8	53	23.9	15.1	44.7	35.0

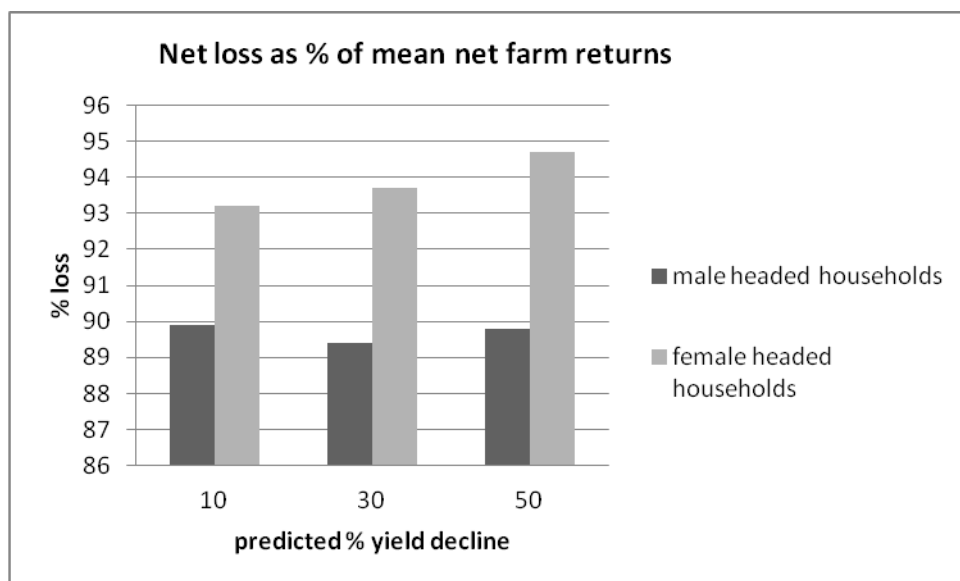


Fig. 6. Distribution of percentage net losses among male and female headed households at the predicted yield losses

These findings are consistent with other earlier researches (Meinzen-Dick *et al.*;2010; IFPRI, 2001) emphasize that different people in different areas will be impacted differently depending among others on their livelihood options, natural resource base and farming systems but female headed households will be hardest hit. The above findings show that impacts of climate change on farm incomes even when farmers are adapting differs between male and female headed households at all levels of climate change (slight to severe). Female headed households are predicted to suffer more losses in the mean net farm income than the male counterparts. Given that nobody knows for sure how the climate is going to change for the next many years (Rao 2013), the findings highlight the need to empower farmers to develop their adaptive capacities whilst addressing the different challenges farmer categories face. The fourth assessment report of the IPCC (2007) further asserts that ‘an economy will be as vulnerable as the weakest link in its resources’ and that adaptive capacity even though uneven, is a prerequisite for effective adaptation for all social groups. If the more vulnerable farmers are neglected, the impact on food security may be grave. And for farmers who are already very poor as the findings suggest, this is of greater interest for poverty and inequality

are major determinants of who is adversely hit the hardest because of inadequate assets and human capacities to adapt (Nhemachena and Hassan, 2007). The DSIP for Uganda which aims to improve food and income security for the poor also suggests that agriculture's ability to generate income for the poor particularly women is more important for food security than its ability to increase local food supplies (MAAIF, 2010).

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusions

Dankleman (2008) argues that there are causes for concern in integrating gender in climate change adaptation; the inequalities in women's status such as poverty, lack of assets, lack of education, unequal access to information and their livelihood systems of multi-tasking. The lack of gender specific data to facilitate designing of gender-specific adaptation policies is an impediment to this process and strategies: lack of information and not enough attention for women's priorities

The rationale, as argued by many, for considering gender in agricultural research and particularly climate change relates to agricultural productivity, food security, nutrition, poverty reduction, and empowerment. This study sought to investigate the gender dimensions of climate change impacts and adaptation. The survey targeted farmers that were also heads of households because climate change adaptation involved decision making, on choice of crop and allocation of resources for production, and heads of households highly influence this process.

In response to the effects of climate change, smallholder farmers in Soroti took up climate change adaptation practices which included shifting gardens from lowland to highland during the droughts, use of drought tolerant and early maturing crop varieties, changing planting dates or early planting in expectation of the rains, tree planting and diversifying the enterprises on their farms. Most important among these was the use of drought tolerant crop varieties on the most commonly grown crops, cassava, sweet potato and groundnuts a major cash crop.

Factors influencing the decision to adapt to climate change were examined using logistic regression. The analysis showed gender of the household head, amount of land owned by the household, land ownership status, access to credit, membership to farmer organization, possession of a radio, use of purchased inputs on the farm as significant. Gender of household head being female, land ownership and possession of a radio negatively influenced climate change adaptation. Women headed households were less likely to adapt to climate change.

The study highlights the gender differences in climate change adaptation decisions in households. The study has shown that the number and type of factors that influence the climate change adaptation decisions of female heads are different from those that influence the adaptation decisions of male heads. The results suggest that the climate change adaptation decision of female heads is more sensitive (to influences/factors) than that of male heads. The climate change adaptation decision of female heads appear to be influenced more by household assets such as farm implements, radios, transportation means compared to the male heads whose decision appears to be influenced by real estate, especially land. Other demographic factors appear to play no significant role in influencing climate change adaptation decisions of both female and male heads.

These results underscore the need for gender differentiated interventions to promote/incentivise climate change adaptation at the household level. The results further suggest that the interventions centered around enhancing the household asset base may have a higher propensity to encourage or foster climate change adaptation among female heads than male heads.

Gross margins per hectare arising from use of drought tolerant varieties for cassava and groundnuts were similar between the male and female headed households. This implies that

once provided with adequate resources, both men and women are able to overcome barriers to productivity presented by climate change through adaptation.

Climate change adaptation is costly (Bashaasha 2009, Mendelson 2004). Without money or assets, farmers cannot access the resources and technologies necessary to enhance adaptive capacities. However, although results show that these resources (land, access to credit, livestock type) are unevenly distributed between the males and female heads at the decision making level.

Simulation results also suggest that women headed households would be worse off if climate continued to change in that they would have greater negative economic impacts, more percentage losses in net returns from their farms, and would be left poorer than their male counterparts. Further investigation is necessary on how all farmers can be assisted to move forward together for sustainable economic development.

This study particularly highlights the fact that climate change adaptation has a cost implication even for small holder farmers. Without sufficient resources, services or government intervention, particularly credit, farmers may not effectively utilize the resources and climate change related technologies particularly inputs necessary to effectively adapt to climate change and bring them out of poverty. This issue is a constraint for both male and female headed households but is more critical for female headed households that had a lower capacity to access inputs.

The present study has also demonstrated the presence of gender inequity at the decision making level with respect to climate change adaptation. Their vulnerabilities as related to resources have gender differences with female headed households particularly worse off compared to their male counterparts. Adaptation is fostered or constrained by specific factors for each gender category requiring specific interventions for different household categories.

These important findings if not noted will undermine the ability of agriculture as a tool to transform lives, alleviate hunger and fight poverty among farmers.

5.2 Recommendations

We recommend for further study investigation to better understand the negative relationship of factors such as land ownership, and access to climate information which were otherwise hypothesized to positively influence adaptation to climate change among small holder farmers. Land owners need to be sensitized to make use of the relevant adaptation options available to them in order to promote food security in the area even as they pursue income security.

This study also recommends that timely planting being a less costly practice and yet easier to implement compared to use of purchased crop varieties should be promoted for all farmers; female headed households need to be specifically and selectively reinforced. In order to facilitate adoption of the practice, early warning systems should be improved so that farmers can be prepared adequately.

Specifically, complementary interventions such as drought tolerance used together with timely planting, that maximize the relevance of technologies and bring change in more than one aspect of farmers' livelihoods for example, ease of implementation, reduced costs, higher returns etc. would be preferred considering that farmer problems are multifaceted, and climate change is an ongoing challenge.

These analyses will provide some insight on how best promote gender differentiated interventions which help both male and farmers to become less vulnerable to severe impacts of climate change and variability.

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APPENDIX

Table1: Summary means for land allocation and yields from no adaptation (standard deviations in parentheses)

No adaptation				
Activity	Area (land allocation, ha)		Crop yield(kg/ha)	
	Male	Female	Male	Female
cassava	0.74 (0.39)	0.41(0.28)	4387 (3378)	1625 (649.8)
Gnuts	0	0.33(0.15)	0	1235 (178)
Sweet potato	0.26(0.12)	0.26 (0.05)	15200 (22011)	3493 (3164)

Source: Computed from Field Survey Data; currency is Uganda shillings

Table 2: Summary means for timely planting alone

Group	Male			Female		
Crop	cassava	gnuts	sweetpotato	cassava	gnuts	sweetpotato
Yields/ha	2667.6(419)	1037.4	10982.8(8389)	12350	1729	9384.8(8680)
Costs	148200	297635(8783)	311220(20958)	780520	276640	197600
Price/kg	220(113)	1650(212)	61.25(48.4)	130	1500	54.3(25)
revenue	586872	1711710	672695.9	1605500	2593500	509595.4
Profit	438672	1414075	361475.9	824980	2316860	311995.4

Source: Computed from Field Survey Data

Table 3: Summary means for farms that used timely planting together with drought tolerant crop varieties

Male hh				Female hh		
Crop	cassava	gnuts	Sweet potato	cassava	gnuts	sweetpotato
Yieldskg/ha	5213.7(7063.3)	1043(758.3)	4438.4(1984)	2467.2(1515.8)	1064.6(659.3)	7411.067
Costs	394376.7((208472)	503639.5(20698)	158080(1379)	519758.6(210429)	535557.8(323647)	148200
Price/kg	203.5714(21.2)	1527.9(467.9)	97.4(33.4)	195(35)	1610(716.4)	50
Revenue	1061367	1593627	432300.7	481099.5	1713958	370553.4
Profit	666990.8	1089988	274220.7	-38659	1178400	222353.4

Source: Computed from Field Survey Data

Table 4: Summary statistics of gross margins from using improved cassava varieties

Variable	Mean	Std. Dev.	Min	Max
Total revenue/ha (Ug.shs)	1,465,739	1,751,494	189,770.2	9,883,865
Total variable cost/ha (Ug.shs)	490,555.4	200,475.7	148,258	882,134.9
Gross margins(Ug.shs)	975,183.3	1,742,479	-368,174	9,483,568
Land area under crop(ha)	0.4834	0.3771	0.101175	1.2141

Table 5: Summary statistics of gross margins from using improved groundnut varieties

Variable	Mean	Std. Dev.	Min	Max
Total revenue/ha(Ug.shs)	2760069	1604721	648628.6	8,648,382
Total cost/ha(Ug.shs)	483278.6	256311.1	49419.32	1229306
Gross margins(Ug.shs)	2,276,791	1664228	1,59377.3	8,344,453
Land area under crop(ha)	0.442279	0.27224	0.101175	1.2141