The Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT

CLIMATE CHANGE DEPARTMENT

Economic Assessment of the Impacts of Climate Change in Uganda

Arabica Coffee Production in the Mount Elgon Region (Bududa District)

October 2015

This document has been prepared by the Baastel consortium, composed of:

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LIST OF ACRONYMS

Acronym	Definition
BAU	Business As Usual
BCU	Bugisu Co-operative Union
CGCMs	Coupled Global Climate Models
CSA	Climate Smart Agriculture
DDP	District Development Plan
DFID	United Kingdom Department for International Development
DLG	District Local Government
EBA	Ecosystem Based Adaptation
ECMWF	European Centre for Medium-range Weather Forecasts
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environmental Facility
GDP	Gross Domestic Product
ICO	International Coffee Organization
IITA	International Institute on Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ITCP	Integrate Territorial Climate Plan
IUCN	International Union for the Conservation of Nature
masl	Meters above sea level
MFPED	Ministry of Finance, Planning and Economic Development
NAPA	National Adaptation Plan of Action
NARO	National Agricultural Research Organization
NPV	Net Present Value
RCP	Representative Concentration Pathway
SWC	Soil and Water Conservation
TACC	Territorial Approach to Climate Change
UBOS	Uganda Bureau of Statistics
UCDA	Uganda Coffee Development Authority
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
VIA	Vulnerability Impact Assessment

EXECUTIVE SUMMARY

The Mount Elgon region is very vulnerable to climate change and variability, with a heavy dependence on coffee production. Yields and quality of coffee crops have been declining over the last 30 years, in part owing to poor management practices and in part because of an increase in the frequency of droughts, landslides and floods. This study has reviewed the evolving situation for Arabica coffee cultivation in the Bududa district and looked at how climate variability is affecting coffee yields and livelihoods, based on the data collected in the field through interviews with key stakeholders and a literature review.

It identified seven potential adaptation approaches, and focused on the two that stakeholders considered to be most important: Climate Smart Agriculture (CSA) and institutional support measures (or extension services). According to literature and the stakeholders interviewed, CSA practices are not currently adopted, in part because farmers lack the resources and technical capacities to make the necessary investments.

In this study we use a restrictive definition of CSA, including those few activities that farmers in Bududa consider critical in order to adapt coffee cultivation to climate change in their geographical location. In particular, on the basis of the consultations conducted, we consider planting of shade trees, mulching and trench construction. Institutional support measures include activities such as monitoring field activities, training, setting standards, and supporting activities for scaling up sustainable land management (e.g. technology demonstrations, promotion of appropriate farm equipment and enhancing public–private partnerships for agricultural mechanisation).

The study has estimated the financial returns for coffee growing under 'Business as Usual' (BAU) and under a CSA programme scenario, with current climate variability and future climate change. It found that the internal rate of return (IRR) of coffee cultivation would increase from the current 16% to 25% if CSA were adopted under current climate variability, and from 9% to 22% under future climate conditions. So, even though coffee cultivation will become increasingly less profitable under both BAU and CSA scenarios (from 16% to 9% for BAU and from 25% to 22% CSA), **the rate of return of coffee cultivation under CSA, even with future climate conditions, is greater than that for BAU with current climate variability** (22% vs 16%). It should be stressed that **these are preliminary estimates based on limited data** and evidence on the effectiveness and impacts of CSA, and in particular a number of assumptions regarding the take up of CSA practices by farmers and the actual improvements in yields that could be achieved. Further work is needed to improve the evidence base on these issues.

For institutional support measures, the costs are based on an existing government support package. It should be noted however that there is also insufficient evidence around the effectiveness of such institutional support programmes, and there is an assumption (again based on anecdotal evidence) that such programmes lead to more effective uptake of CSA measures, which are then successful in improving yields.

The study found that although quite costly, investments in CSA are likely to be justified, as probable **benefits outweigh the costs, both under current conditions, and even more so when expected climate impacts are considered**. The study indicates that likely investment costs are in the range of US$2.4 million in 2016, rising to US$4.9 million by 2019, over and above the current institutional support programme of Bududa's District Local Government, which has a budget of only around US$ 214,329. The analysis shows that investment in these two complementary programmes – CSA and institutional support - would have an internal rate of return of around 36%. **If combined with other adaptation approaches, such as complementary policies or providing better climate information, there is, in the view of the study team, potential to sustain coffee cultivation in Bududa, both now and under future predicted climatic conditions.**

The study provides an illustration of the potential economic case for investment in CSA for coffee cultivation in the Bududa district. However, there needs to be further consensus before undertaking any major investment programme. In this context, the study recommends that further research and analysis is conducted in order to identify:

(i) The impact of climate variability on coffee yields in the Mt Elgon region, and other coffee growing regions in Uganda.

(ii) The cost and benefits of different approaches to CSA in the coffee sector, in particular to identify 'low regret' options and options where there are co-benefits.

(iii) The economic viability of coffee growing under BAU and CSA in different regions in Uganda, in order to focus investment on regions where there is a stronger economic case for coffee cultivation in the long term.

(iv) Barriers and enablers that effect the adoption of CSA practices by farmers, in order to identify what wrap-around support might be needed, and subsequent to this an analysis of how support may be best delivered.

(v) The costs and benefits of alternative livelihoods in Bududa, including cultivation of other crops and non-farming activities, versus coffee cultivation.

The above actions would help to inform the design of a CSA programme for coffee, including practical measures as well as institutional support, and help to identify what additional complementary strategies might be needed. Critically, the development of such a programme should also involve the private sector, and an analysis of the market and value chain for coffee, to enable improved commercialisation.

Further, given the high level of investment that is potentially required, it is recommended that any CSA programme is first piloted in order to establish whether expectations around costs, benefits, and yields, etc, are borne out in reality in Uganda.

SUMMARY

An Economic Assessment of the Impacts of Climate Change has been completed at the national level in Uganda. This study constitutes one of its five case studies. It has reviewed the evolving situation for Arabica coffee cultivation in the Bududa district. It has looked at how climate variability is affecting coffee yields and livelihoods based on the data collected in the field and literature review. It has then provided downscaled climate change scenarios for the district. Based on (i) these climate change scenarios and estimated impacts, and (ii) an estimated programme for the adoption of climate smart agriculture (CSA) for Arabica coffee (which includes planting of trees, mulching and trench construction), the study has estimated the financial returns for coffee growing under 'Business as Usual' (BAU) and under a CSA programme scenario, current climate variability and future climate change. It has then gone on to consider appropriate adaptation policies and measures with a direct impact on communities and the region's economy, carrying out a cost benefit assessment of such a programme. It must be noted that although it has identified seven potential adaptation approaches, the study has focused on the two that stakeholders considered to be most important: CSA and institutional support measures (or extension services). Finally, it makes policy recommendations for action to adapt Arabica coffee growing to climate change and variability. Coffee is important in terms of rural livelihoods, but it is not yet fully understood in relation to climate variability and change in Uganda. There are significant data, and evidence limitations on the specific impacts of climate variability on coffee production in the district. Findings must therefore be treated with a degree of caution, although estimates and the recommendations provide valuable information on the impacts of climate variability and change that can inform decisions for taking action. The study notes that there is a strong case for climate smart agriculture in coffee production, even in the absence of climate change.

In 2010-12 coffee represented around 3% of Uganda's Gross Domestic Product (GDP) and 20-30% of the country's foreign exchange earnings. The coffee sector employed over 3.5 million households in 2011. Arabica coffee production, the focus of this study, contributes 43% of Uganda's total direct coffee export earnings.

The case study has focused on the Bududa district of Mount Elgon, which is typical of agro ecological zones in the region and well covered by coffee cooperatives and private companies. The study found that most households in the district are subsistence farmers and there is little income derived from non-farming sources. Around half of all household income comes from coffee, with the rest derived from bananas, a range of vegetables, some livestock, bees and fishponds. The population of the region has been growing fast: it is more than 80% larger now than it was at the start of the 1990s. At the same time poverty is widespread: in 2007 around one-third of households were judged to be poor.

As far as coffee is concerned, key informant interviews conducted as part of this study state that the yields and quality of the crop have been declining, in part owing to poor management practices and in part because of an increase in climate variability and extreme events such as landslides and floods. Arabica coffee is very sensitive to weather conditions: optimum mean temperature range is 18-21°C and excessive moisture, heat, or dry conditions directly affect yields. Changing weather patterns have been observed in the district and the region more generally. Particularly long dry spells and excessive heat were recorded in Bududa in 1997, 2009 and 2014. Data collected in the field shows that these caused production losses in the range of 10 to 75% in the lower elevations and around 50% at higher elevations. There has also been an increase in the frequency of excessive rainfall and landslides, both of which have resulted in significant losses of crops. This has had an impact on local livelihoods and national income.

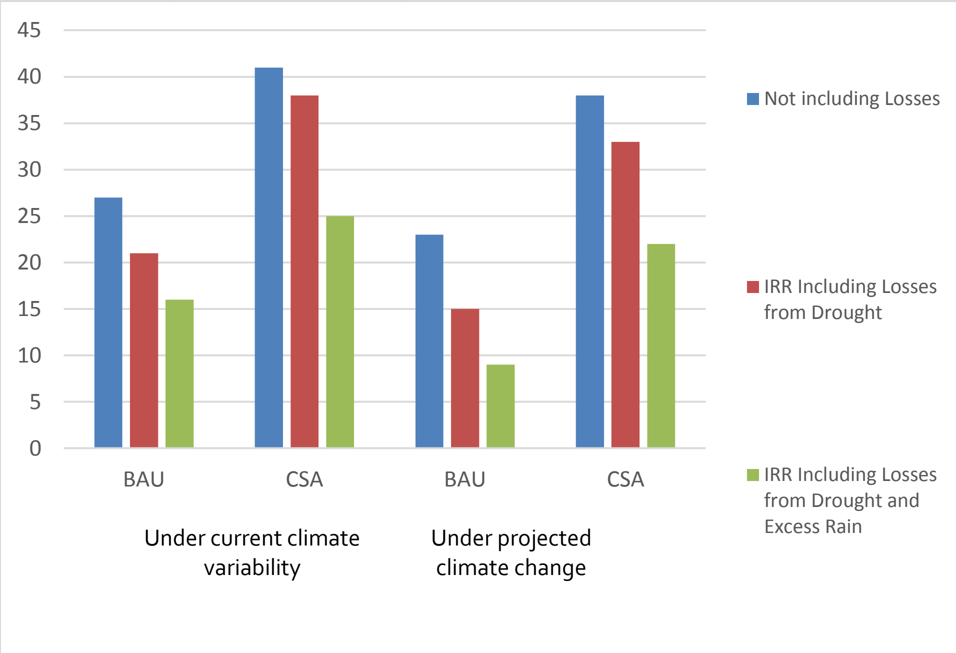
Climate change projections indicate an increase of temperatures in Mount Elgon, which might negatively affect Arabica coffee production, in particular at lower altitude ranges, and a slight decrease in total annual rainfall. The number of days with moderate to average rain might increase in future, which can have an effect

on pests and affect crop growth. Extreme events (excess of rainfall and droughts) are also likely to increase in frequency and intensity.

Climate projections suggest that the impacts of climate change could further affect coffee production in the area. The adoption of CSA practices, which includes planting of trees, mulching and trench construction, could help farmers deal with current climate variability and adapt to climate change. Based on the data collected in the field through interviews with key stakeholders, the internal rate of return (IRR[1]) of coffee cultivation would increase from 16% to 25% under current climate variability, and from 9% to 22% under future climate conditions. So, even though coffee cultivation will become increasingly less profitable under both BAU and CSA scenarios (from 16 to 9% for BAU and from 25% to 22% CSA), the rate of return of coffee cultivation under CSA, even with future climate conditions, is greater than that for BAU with current climate variability (22% vs 16%). It should be stressed that these are preliminary estimates based on limited data and evidence on the effectiveness and impacts of CSA, and in particular a number of assumptions regarding the take up of CSA practices by farmers and the actual improvements in yields that could be achieved. Further work is needed to improve the evidence base on these issues.

For institutional support measures, the costs are based on an existing government support package. It should be noted however that there is also insufficient evidence around the effectiveness of such institutional support programmes, and there is an assumption (again based on anecdotal evidence) that such programmes lead to more effective uptake of CSA measures, which are then successful in improving yields.

Figure ES1. Calculated returns to coffee growing in the Bududa District (IRR %) under current climate variability and projected climate change to 2050 over a 15 year period CSA relative to BAU



Source: Own Calculations based on data collected in the field

The study found that although quite costly, investments in CSA are likely to be justified, as probable benefits outweigh the costs, both under current conditions, and even more so when expected climate impacts are considered. The study indicates that likely investment costs are in the range of US$2.4 million in 2016, rising to US$4.9 million by 2019, over and above the current institutional support programme of Bududa's District Local Government, which has a budget of only around US$ 214,329. The analysis shows investment in these two complementary programmes – CSA and institutional support - would have an internal rate of return of

[1] The IRR is a way of measuring the return an investor can expect from a project of this kind: a value of 36% indicates benefits equal to 36 cents per dollar invested.

around 36%. If combined with other adaptation approaches, such as complementary policies or providing better climate information, there is, in the view of the study team, potential to sustain coffee cultivation in Bududa, both now and under future predicted climatic conditions. Coffee represents around 3% of Uganda's Gross Domestic Product (GDP) and around 20-30% of the country's foreign exchange earnings (Uganda Coffee Federation, 2012). Development of Uganda and its future income depend, to a considerable extent, on how resilient sectors such as coffee cultivation are to the impacts of climate change.

The study provides an illustration of the potential economic case for investment in CSA for coffee cultivation in the Bududa district. However, there needs to be further consensus before undertaking any major investment programme. In this context, the study recommends that further research and analysis is conducted in order to identify:

(i) The impact of climate variability on coffee yields in the Mt Elgon region, and other coffee growing regions in Uganda.

(ii) The cost and benefits of different approaches to CSA in the coffee sector, in particular to identify 'low regret' options and options where there are co-benefits.

(iii) The economic viability of coffee growing under BAU and CSA in different regions in Uganda, in order to focus investment on regions where there is a stronger economic case for coffee cultivation in the long term.

(iv) Barriers and enablers that affect the adoption of CSA practices by farmers, in order to identify what wrap-around support might be needed, and subsequent to this an analysis of how support may be best delivered.

(v) The costs and benefits of alternative livelihoods in Bududa, including cultivation of other crops and non-farming activities, versus coffee cultivation.

The above actions would help to inform the design of a CSA programme for coffee, including practical measures as well as institutional support, and help to identify what additional complementary strategies might be needed. Critically, the development of such a programme should also involve the private sector, and an analysis of the market and value chain for coffee, to enable improved commercialisation.

Further, given the high level of investment that is potentially required, it is recommended that any CSA programme is first piloted in order to establish whether expectations around costs, benefits, and yields, etc, are borne out in reality in Uganda.

1. INTRODUCTION

1.1. Rationale of the study

In Uganda, climate variability including unpredictable, intense and at times extreme weather events such as droughts, floods and landslides, is already threatening its ecosystems and livelihoods. The Ugandan National Adaptation Plan of Action (NAPA) estimates that up to 90% of Uganda's natural disasters are weather and climate related, in contrast with other sources, such as earthquakes. The magnitude, frequency and severity of these hazards have increased over the past decades.

According to a recent study (Baastel consortium, 2015 a), the impacts of climate change in Uganda are likely to intensify on a temporal scale during the 21st century, and the country is predicted to continue to experience rising temperatures. According to the same source, whereas total annual rainfall amounts are expected to differ little from what is presently experienced, less rainfall is expected to occur over many areas of Uganda, with slightly wetter conditions over the west and north-west. The study also projects that seasonal rainfall for the usually dry December-January-February season will increase significantly (up to 100% from present).

Given the country's high dependency on resources that are vulnerable to climate variability (71.9% of the population was employed in agriculture, forestry and fishing in 2013 (UBOS, 2014: 20)), the impacts of climate change on the Ugandan economy and wellbeing of its population has been and is expected to be significant. Uganda's capacity to adapt to these impacts remains low, throughout the country, at both national and local level.

In this context, an Economic Assessment of the Impacts of Climate Change is currently being completed at the national level in the country. The study includes five case studies. These provide an opportunity to assess the impacts of climate change at the local level, through consultation with various stakeholders, including local authorities, development partners, private sector operators and local communities. This bottom-up approach feeds into the national level assessment, providing concrete examples of the cost of climate change at the local level and possible benefits of a range of adaptation strategies implemented locally.

This study constitutes one of five case studies of the national study[2]. It seeks to assess the impacts of climate change and their costs on Arabica coffee production in Bududa District, in the Mount Elgon region, drawing on national projections of climate change. It hopes to contribute to the evidence base on the impact of climate change on Arabica coffee production in Uganda and Eastern Africa, more generally. In particular, the objectives of this case study are to:

- Downscale climate change scenarios to the Bududa district, in order to provide updated evidence of temperature and rainfall patterns over the next 50 to 80 years;
- Estimate the likely impacts of climate change on coffee production;
- Assess the economic cost of climate change on the local economy in terms of revenue losses for farmers and other actors in the value chain;

[2] The other four being economic assessments of the impacts of climate change: in the Kampala urban area, in close collaboration with the Kampala City Council Authority (KCCA) (infrastructures and flooding); on malaria prevalence in the districts of Tororo and Kabale; in three villages of the Karamoja region (agricultural sector) chosen from three different agro-ecological zones; and in the Mpanga river catchment (water and hydropower sectors).

- Communicate results and elaborate recommendations.

The Mount Elgon region is significantly vulnerable to climate change (UNDP, 2010). Excessive heat, droughts, excessive rain leading to flooding, landslides and hailstones have affected it severely over recent years. The impacts of these events on peoples' lives and livelihoods significantly affect income (UNDP, 2010). Bududa is one the most affected districts of the Mount Elgon region, especially in terms of landslides.

In response to this high vulnerability to climate change, a number of studies and projects have already been conducted in the area in recent years. These include the Territorial Approach to Climate Change (TACC) Project that was implemented in the districts of Mbale, Manafwa and Bududa until 2013[3]. Implemented by UNDP and funded by the Danish Embassy, the Department for International Development (DFID), the Global Environment Facility (GEF) and UNDP, as well as from technical and development support provided by the Welsh Assembly Government, the project aimed to introduce integrated and coordinated mitigation and adaptation planning to mitigate the impacts of climate change.

The project conducted an economic analysis of opportunities for mitigation and adaptation to climate change, covering a range of interventions, and formulated the Integrated Territorial Climate Plan (ITCP) for the Mbale region. A multi-sectoral strategic framework that lays out actions intended to guide future resource allocation to climate change activities, the ITCP was the first climate change plan to be developed at a sub-national level in Uganda, cutting across district local governments.

The plan includes an analysis of investment options for sustainable, climate friendly and resilient development; recommendations on the policy and institutional framework for plan implementation; as well as an investment package with a detailed costing (based on data collected in the field and literature review) of the implementation of the different adaptation options proposed, enabling proper prioritization and planning.

In addition, an Ecosystem Based Adaptation (EBA) Programme is being implemented in the Mount Elgon region, in particular in the districts of Kapchorwa, Kween, Bulambuli and Sironko. The programme is a joint initiative from the UNDP, the United Nations Environment Programme (UNEP) and the International Union for the Conservation of Nature (IUCN)[4]. The objective of the project is to strengthen ecosystem resilience by promoting EBA options and to reduce the vulnerability of communities, with particular emphasis on mountain ecosystems. The activities involve testing and piloting appropriate tools and methodologies, as well as learning lessons, and capturing experiences and practices in EBA that can be replicated in other parts of Uganda, particularly in the hilly and mountainous areas and the flood plains that are often affected by flooding or landslides. One of the key outputs of the EBA Project is a Climate Change Vulnerability Impact Assessment (VIA) of the Mt. Elgon ecosystem. This assessment is intended to articulate past and forecast future climate variability in the Mt. Elgon ecosystem and thereafter, recommend strategic priorities for monitoring and management of adaptation options (Republic of Uganda, 2013).

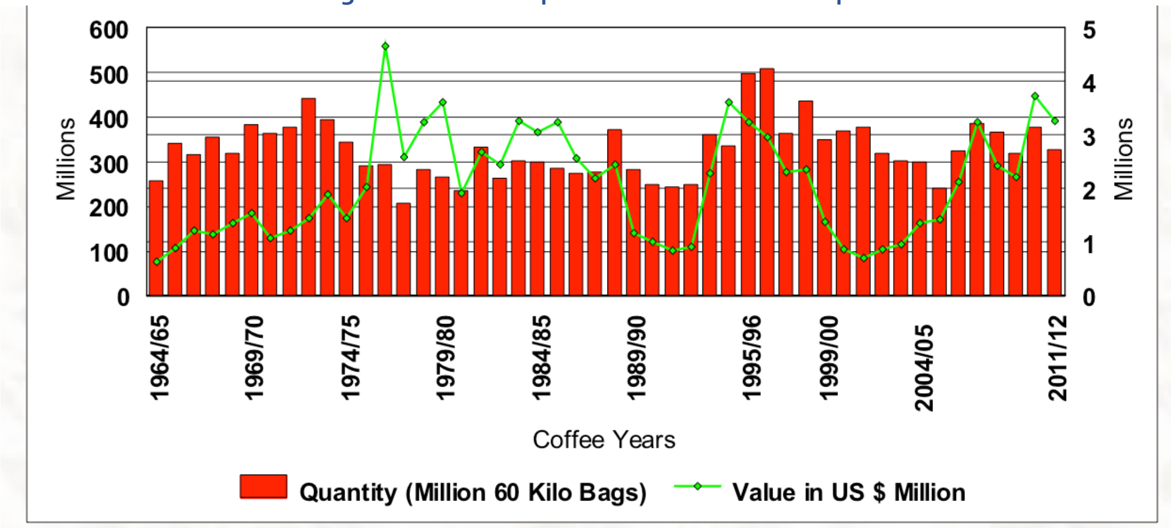
Given all these studies, and in particular the ITCP that provides a clear plan for the implementation of prioritized adaptation options in three districts of the region, there is little to be gained in implementing a second general assessment of the cost of different adaption options in the region. Instead, it makes more sense to concentrate on a specific aspect of climate change adaptation in the region, with a direct impact on communities and the region's economy and on a problem not so well understood in the region. Taking into account these factors, this study focuses on the production of Arabica coffee.

[3] http://www.undp-alm.org/projects/dc-uganda-tacc
[4] www.ebaflagship.org/about

1.2. Coffee in Uganda

More than 95% of the coffee produced in Uganda is exported (Uganda Coffee Federation, 2012). The country exports around 3 million (60 kg) bags of coffee per year (3.1 million in 2010/2011, 2.7 million in 2011/2012), according to the International Coffee Organisation (ICO) and the Uganda Coffee Federation. Coffee represents around 3% of Uganda's Gross Domestic Product (GDP) and around 20-30% of the country's foreign exchange earnings. In 2010/2011, exports represented around $449 million and $393 million in 2011/2012 (Uganda Coffee Federation, 2012).

Chart 1. Uganda's coffee exports and value since independence



Source: UCDA Database

The coffee sector employed over 3.5 million households in 2011 (Uganda Coffee Federation, 2012), around 48% of total households in the country. There are officially 500,000 smallholder coffee farmers (UCDA, 2012), accounting for 1.4% of the total population of the country. This commodity is the most important poverty alleviation crop in the country and one to which poverty levels are very sensitive. According to Okidi et al. (2005), had coffee prices been 10% higher during the 1990s there would have been an additional 6% decline in poverty in Uganda by 1999/2000. The national government envisages that by 2015 coffee exports will have increased to 4.5 million bags from the current annual average of 3 million bags (Uganda Coffee Yearbook 2011/2012).

Two types of coffee are grown in Uganda. Robusta coffee is indigenous to the central parts of the country and comprises the majority of its coffee exports (70% of the total volume in 2011, according to the Uganda Coffee Federation). Arabica coffee (also called 'mountain coffee'), was introduced by the British colonial authorities at the turn of the twentieth century and represents a small, but increasing proportion of Uganda's coffee exports (30% of the total volume in 2011 according to the Uganda Coffee Federation; up from around 10% in 2006, according to Masiga and Ruhweza, 2007). Arabica is grown in different highlands of the country, most notable on the slopes of Mount Elgon, at the border with Kenya, and the slopes of Mount Rwenzori, at the border with the Democratic Republic of Congo. Some Arabica coffee is also grown in the West Nile region in the North-Western part of the country. Bududa, situated in the fertile Mountain Elgon region, is the leading Arabica coffee-growing area in Uganda. While Robusta coffee has higher yields than Arabica (2,300-4,000 kg/ha vs. 1,500-3,000 kg/ha, according to Masiga and Ruhweza, 2007), Robusta typically fetches little more than half the price of Arabica per kg. According to the Uganda Coffee Federation, even with prices of Arabica coffee historically low, it contributed to 43% of total direct coffee export earnings in 2011/12, although it represented only 30% by volume (Uganda Coffee Federation, 2012).

Globally (Lane and Jarvis, 2007), and nationally, for Uganda as a country, the literature agrees on a negative impact of climate change on Arabica coffee production. For Uganda, MFPED (2004), Haggar and Schepp (2012), Nandozi (2012) and International Institute on Tropical Agriculture (IIAT) (2013) all predict a great reduction of areas most suitable for coffee production by 2030 and a great loss of area suitable for coffee growing at all by 2050. The exact reduction is unclear, and available studies indicate variations on the extent of loss of suitable growing area. We present some ranges in section 5.

1.3. Methodology

To achieve the objectives set out in 1.1, the methodology of this case study, and the structure of this report, follows several steps. More detail on each of these steps can be found in the respective sections.

1. The first step profiles households farming in the Bududa district and in particular the issues arising with the growing of coffee. Desk-based evidence was used and data was collected through interviews in Bududa. The people met are presented in Annex 1. It has to be noted that most farmers do not keep record of the economics of coffee growing and that the number of people met was not representative, so the information is rather anecdotal.
2. The next step provides downscaled climate change scenarios for Bududa following IPCC's best practices. The method and data are presented in section 3.1.
3. We then estimate the likely impacts of climate variability on coffee production, based on a literature review, and complemented with the selected interviews in the region and with other experts, as for step 1 (a list of these people is provided in Annex 1).
4. Based on these climate change scenarios and estimated impacts, and an estimated programme for the adoption of climate smart agriculture (CSA – see box 1) ,for Arabica coffee, the study estimates the financial returns for coffee growing under 'Business as Usual' (BAU) and under a CSA programme scenario, current climate variability and future climate change .
5. We go on to look at the prospects of adapting to climate change through CSA and carry out a cost benefit assessment of a programme to do that for the entire coffee plantations of the district of Bududa. We also consider an institutional support programme to complement CSA measures, given that there was a local agreement that this was a strategic adaptation measure that is necessary to underpin practical activities.
6. Finally, we make policy recommendations for action to adapt Arabica coffee growing to climate change.

Box 1: Climate Smart Agriculture (CSA)

The Food and Agriculture Organization of the United Nations (FAO) defines climate smart agriculture as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gas (mitigation), and enhances achievement of national food security and development goals" (FAO, 2010: ii).

In this study we use a restrictive definition of CSA, including those few activities that farmers in Bududa consider critical in order to adapt coffee cultivation to climate change in their geographical location. In particular, on the basis of the consultations conducted, we consider planting of shade trees, mulching and trench construction.

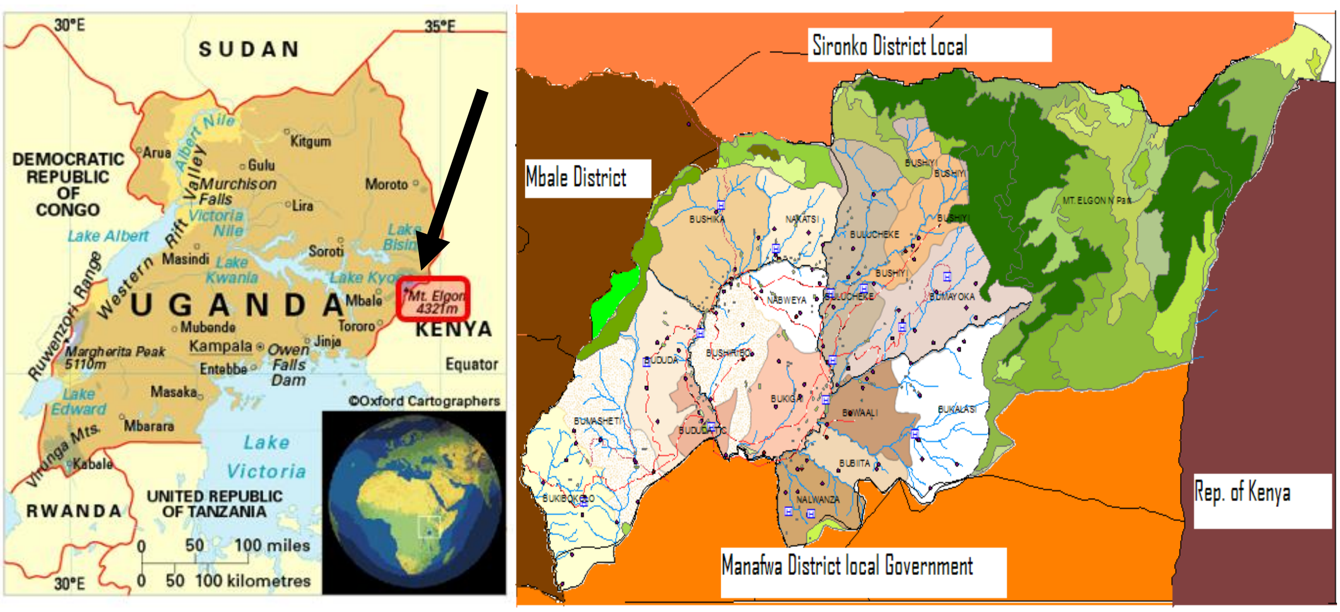
2. COFFEE PRODUCTION IN BUDUDA

2.1. Bududa district

2.1.1. Geography

Bududa district is located in Eastern Uganda, in the Mount Elgon region. It borders the Republic of Kenya in the east, the district of Sironko in the north, the district of Mbale in the west, the district of Bukwo in the north-east and the district of Manafwa in the south. It lies between the longitudes of 34° 16′ 18″ and 34° 32′ 6.69″ east, and latitudes 00° 58′ 45.63″ to 1° 7′ 22.07″. The administrative offices are around 40 km from Mbale town, the main city in the region. Map 1 shows the geographical location of Bududa district.

Map 1. Location of Bududa District in Mount Elgon region (left) and detailed map of Bududa district (right)



Source: Bududa District Development Plan (DDP) 2010/2011 – 2014/2015

The district of Bududa has a land area of approximately 274 square kilometres (0.11% of Uganda's land area). Of this total area 40% is part of Mount Elgon National Park. Bududa is composed of 15 sub counties, one town council, 94 parishes, 5 wards and 951 villages. The district is relatively new. It was carved out of Manafwa district and began operating on July 1st 2006.

2.1.2. Topography and climate

Bududa district lies at an average of 1,800 metres above sea level (altitude ranges from 1300 to 2850 masl) on the slopes of Mount Elgon, which is an extinct shield volcano with its highest point reaching 4,321 m. The towering Mount Elgon national park is located on the extreme east of the district.

The average rainfall is 1,800mm per annum. The district experiences two rainy seasons, with the highest rainfall coming in the first season of March to June and the second, which is normally light, in September to

November. A short dry spell occurs between June/July, while the December to March dry spell is longer. In general there are no extreme temperature ranges. Average maximum temperature ranges from 27 to 32°C, the minimum temperature from 15°C to 17°C.

2.1.3. Demography

According to the last census, carried out in 2014, Bududa has 37,028 households and a total population of 211,683 inhabitants, with an average of 5.7 persons per household (0.5% of Uganda's total households, and 0.6% of the country's total population) (UBOS, 2014). There is an equal split between men and women. Only 3% of the population of Bududa is urban.

The fertile soils and relatively reliable rainfall of Bududa have attracted a growing population. Together with high human fertility, this has resulted in a significant population increase over the last decades, by 83% from 1991 to 2014. Moreover, the rate of growth is increasing: on average, the population of Bududa district increased by 3.5% per year between 1991 and 2002, and by 3.8% per year between 2002 and 2014 (UBOS, 2014). In 2002, 56% of the population was under the age of 18. This creates pressure on the economically active age group to provide. The population density of Bududa is very high (774 per square km), as in all districts of the Mount Elgon region. Over the years, Bududa has been transformed into a heavily settled, intensively cultivated district, leading to a reduction in farm size, over-cultivation, expansion of cultivation to unsuitable areas and increased conflicts (GoU, UNDP, UNEP, 2008).

2.1.4. Livelihoods

Intensive agriculture forms the backbone of the economy of Bududa District. Around 86% of the district's working population were subsistence farmers in 2002 (UBOS, 2012). Agriculture includes the cultivation of coffee, bananas and some other crops, such as beans, maize, onions, tomatoes and cabbages. The production of coffee will be discussed below. In general, however, according to our observations in the field, coffee represents around half of the household income in the district. After coffee usually come bananas, beans and horticulture. It is important to note that according to observations in the field coffee and bananas are often cultivated together and typically make up around 70% of household income. Beans and maize are mainly grown for household food[5]. According to Bududa's proposed District Development Plan (DDP) 2015-2019, 91% of households own cattle and 80% own dairy exotic crosses. Along with the human population the number of animals has increased significantly since 2002.

Non-agricultural economic activities are in general uncommon in the district. Only 14% of Bududa's population was not employed in subsistence farming in 2002. Other sources of livelihood included family support (7%), formal employment incomes (3%) and business enterprises (2%) (UBOS, 2012). According to the DDP (2010-2014), in spite of these productive activities, 33% of the population of the district was poor in 2007 in the sense that they lived in households with real private consumption per adult equivalent below the poverty line.

2.2. Coffee production in Bududa district

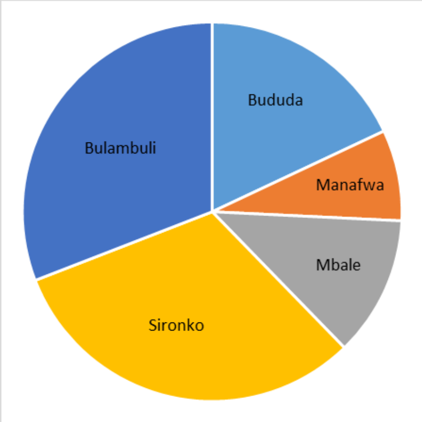
Arabica coffee was first introduced in the Mount Elgon region in 1912. In 1954, the government created the Bugisu Co-operative Union (BCU) in order to help farmers process and market coffee. BCU bought and processed the coffee, looked for markets and brought the money back to farmers.

[5] IIAT (2013) found the following income distribution for the Mt Elgon region: coffee 57%; banana 9%, off-farm income 7%, bean 5%, salary 5%, livestock 4%, vegetable 4%, maize 2%, trees 3%, other crops 3%.

Following the national pattern (Masiga and Ruhweza, 2007), BCU was the only coffee company in the Mount Elgon region until 1996: it collected and processed all the coffee produced in the area. In 1996 the economy was liberalized and a significant number of new players entered the market, bringing great competition.

Arabica is cultivated in the Mount Elgon region at altitudes of between 996 and 2022 m above sea level (IIAT, 2013). The Uganda Coffee Development Agency (UCDA) has made an estimation of coffee production in five districts of the Mount Elgon region in 2014 (Bududa, Bulambuli, Manafwa, Mbale and Sironko). UCDA estimates that the five districts have over 37 million coffee trees, covering an area of almost 23,000 ha. The yield per tree per year (parchment) differs among districts, with an average of 0.73 kg/year. The total estimated production in the five districts in 2014 was 27,000 tonnes.

Figure 1. Projections of coffee production for Bududa and other four districts in the Mount Elgon region, 2014



Source: UCDA (2014)

UCDA estimates that Bududa has around 7 million coffee trees, covering 4,340 ha (19% of the total number of coffee trees and ha in the five districts). It estimates that each tree produces an average of 0.7 kg per year. According to UCDA, the total production for Bududa in 2014 was around 5,000 tonnes, which means around 18% of the total production of the five districts of Mount Elgon, as illustrated in Figure 1. There are no clear figures on the evolution of coffee production in the district of Bududa or Mount Elgon region as a whole. Apart from the 2014 estimate, UCDA has not conducted field surveys since 1991, so there is no official information between 1991 and 2014. According to UCDA, the area that now is part of Bududa (the district was officially created in 2006) produced 12,000 tonnes in 1991. It seems clear, therefore, that there has been a significant reduction, of around 66%, in the production of coffee in the area in the last 20 years.

In order to fill the gap on the evolution of the coffee in Bududa, this project interviewed UCDA officials, the managers of several companies in the area and farmers. According to different stakeholders, the decrease in production is explained to a great extent by the reduction in the production per tree: in the 1960s, under the monopoly of BCU, with generalized good production systems, an average tree produced 2 kg per year. However, as we will discuss below, under best practices the yield can be higher. The station of Uganda's National Agricultural Research Organization (NARO) in the area is able to obtain 3 kg per tree per year. According to our interviews, the maximum that Bududa could produce under current practices is between 5,000 and 6,000 tonnes –only marginally higher than in 2014. The manager of a coffee co-operative also highlighted that the land under coffee is currently being reduced given the expansion of horticulture.

Primary data from three co-operatives (Bumayoka, Nabushi and Nalwaba), representing 1,950 coffee farmers, compiled in Table 1, illustrates the decline in production in Bududa.

Table 1. Production of three co-operatives

Co-operative	Current No. of farmers	Production (kg/year)		
		1960-2000	2012/2013	2013/2014
Bumayoka	800	200,000	40,000 – 50,000	55,000
Nabushi	600	180,000	20,000	18,000
Nalwab	550	150,000	5,000	11,000

It is important to note that, according to the primary data collected in the field, on average farmers have 1 acre of land (0.4 ha) under coffee trees, although some have up to 15 acres. On average, farmers have 600 coffee trees per acre, but it is relatively common to plant more, up to 800 trees per acre, in some areas. The land is often fragmented, with some trees close to the farmer's house and some significantly further away, at around 30 minutes walking distance. Trees that are further away from the farmer's house typically have up to a 50% lower yield than those close by.

Interviews conducted in the field provided the following information (as detailed in Annex 2):

- Coffee trees in Bududa are, on average, very old (between 45 and 70 years);
- The most common variety of coffee is Arabica SL14 (also called Nyasaland). It covers 90% of the coffee cultivated area and while it is relatively resistant to pest, it is not the most productive variety;
- The quality is decreasing. According to people interviewed, this is due to climate change, a tendency to pick coffee that is not ready when demand is high, and the way post-harvesting activities, such as pulping and storing, are often conducted;
- The price of coffee fluctuates significantly, ranging from 4000 to 8000 UGX/kg, and fluctuating between 5000 and 6500 UGX/kg most of the time;
- Farmers typically prefer to sell the coffee when they need to, instead of being attached to a particular society. Middlemen, private companies (Kawacom, Coffee a cup) and co-operative societies (BCU and Gumutindo) operate in Bududa.

3. CLIMATE CHANGE PROJECTIONS

3.1. Method and Data

As part of the study historical (1951 to 2005) climate model simulations, as well as future (2006 to 2095) climate model simulated projections for rainfall and near-surface temperatures were carried out for the Bududa District of Uganda. Future projections were made under conditions of a medium-to-low Carbon Dioxide (CO_2) Representative Concentration Pathway (RCP 4.5) [6] and a a high CO_2 Representative Concentration Pathway (RCP 8.5) (Meinhausen, et al., 2011 ; Riahi et al., 2011).

For rainfall, monthly total data from the Global Precipitation Climatology Centre (GPCC) were downloaded for the period 1951 to 2005. This data is based on quality-controlled data from 67,200 stations worldwide that feature record durations of 10-years or longer. The GPCC Full Data Reanalyses product used in this report, at a 0.5° x 0.5° degree resolution, is regarded as having a high accuracy and is regarded as suitable for use in the verification of models (Schneider et al., 2011; 2013).

For near-surface temperatures, monthly averaged data from the European Centre for Medium-range Weather Forecasts (ECMWF) Reanalysis (ERA-Interim) data products were downloaded for the period 1979 to 2005 (27 years) at a resolution of approximately 0.7° x 0.7°.

Systematic errors (also known as biases) often occur in model simulations and are attributed to various factors. These biases might create uncertainties and will have an influence on model simulated projections, which will make these projections less suitable for application in climate change impact studies. For this study a *bias correction* technique is applied to calibrate or to make model simulated output more representative of observations. For details see Rautenbach (2015). The bias corrected results are shown below.

3.2. Results

3.2.1. Average rainfall and temperature

The projections realised under RCP 4.5 and RCP 8.5 scenarios give the following results:

- Rainfall is predicted to decrease by 6-7% by the 2040s, and by 10-12% by the 2080s;
- Temperatures are expected to rise by between 1.7 and 2°C by the 2040s, and by between 2.7 and 4.6°C by the 2080s.

Chart 2 displays the observed and forecasted average monthly rainfall totals (mm) and Chart 3 displays the observed and forecasted average temperatures for Bududa domain, under the low-med (RCP 4.5) and high (RCP 8.5) CO_2 pathways.

[6] The Representative Concentration Pathways show the potential cumulative measure of anthropogenic emissions of greenhouse gases. In the Intergovernmental Panel on Climate Change's AR5 report four RCPs were used, two of which have been selected for this case-study.

Chart 2. Projected rainfall change, Bududa, 2009-2094

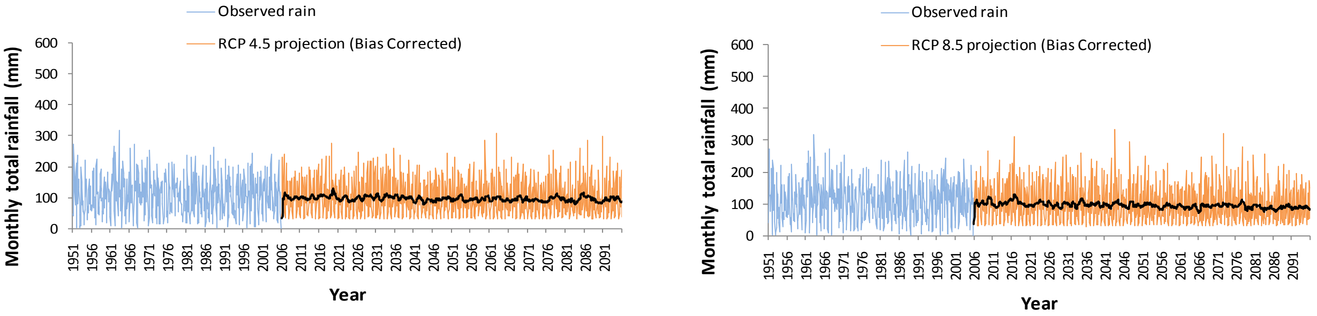
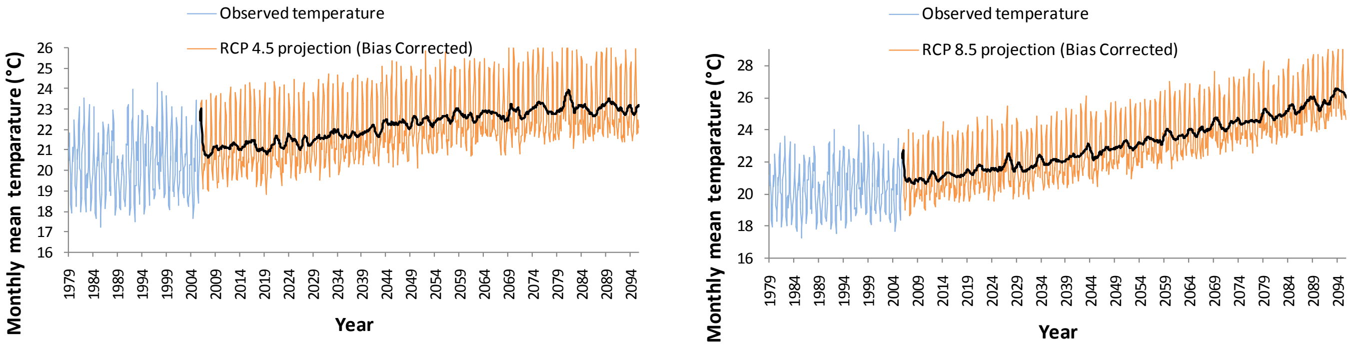


Chart 3. Projected temperature change, Bududa, 2009-2094



Note: The black lines represent a 12-month running average.

Table 2 below summarises 20-year averaged projections of annual rainfall totals and near-surface temperatures across the Bududa (Mount Elgon) District domain under RCP 4.5 and RCP 8.5 conditions.

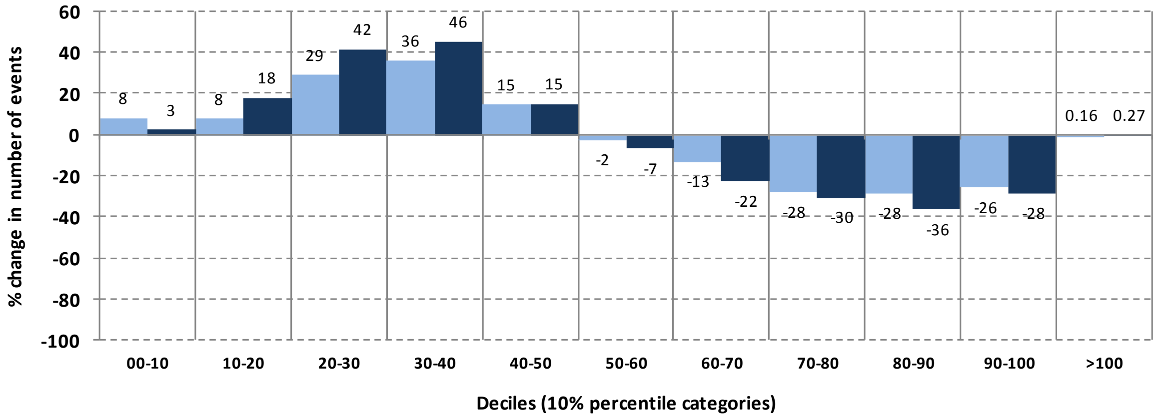
Table 2. 20-year averaged projections of annual rainfall totals and near-surface temperatures across the Bududa (Mount Elgon) District domain under RCP 4.5 and RCP 8.5 conditions

		≈1995 (1985-2005) current	≈2020 (2010-2030)	≈2040 (2030-2050)	≈2060 (2050-2070)	≈2080 (2070-2090)
RCP 4.5	**Rainfall (mm)**	1250	1209	1157	1143	1130
	Temperature (ºC)	20.3	21.3	22.0	22.6	23.0
RCP 8.5	**Rainfall (mm)**	1250	1214	1175	1110	1098
	Temperature (ºC)	20.3	21.4	22.3	23.6	24.9

3.2.2. Variability of rainfall and temperature

In this assessment daily rainfall and near-surface temperature data from the Bududa (Mount Elgon) District domain were used to calculate projected percentage changes in the number of daily rainfall events, over the 55-year period 2041-2095 (under conditions of both RCP 4.5 and RCP 8.5), relative to the number of daily rainfall events in historical deciles (each decile represents 10% of the days over the period) over the 55-year period 1951-2005. For example, the 0-10 decile is the 10% days over the period with the least rainfall, whereas 90-100 is the 10% with the most rainfall.

Chart 4. Projected % change in the number of daily rainfall events over the 55-year period 2041-2095 for RCP4.5 (light blue) and RCP8.5 (dark blue) concentration pathways, relative to the number of daily rainfall events in historical deciles over the 55-year period 1951-2005.

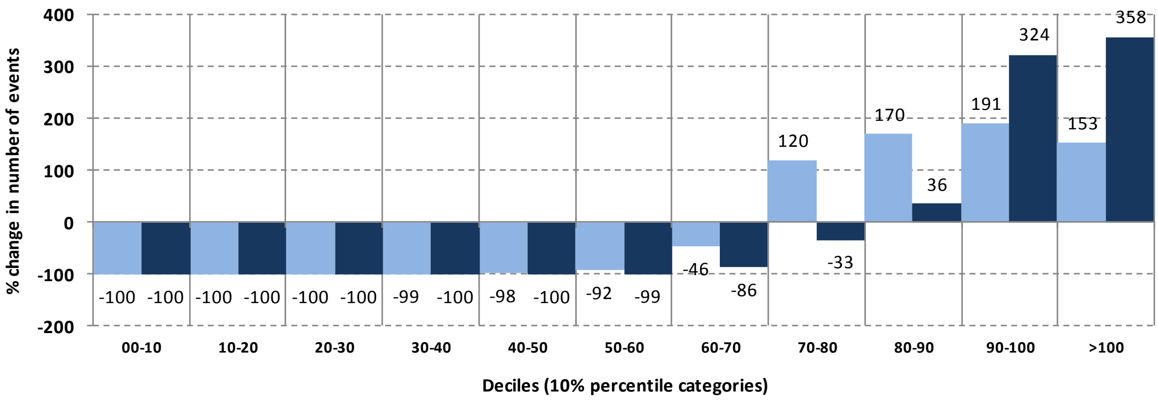


Under conditions of both the RCP 4.5 and RCP 8.5 pathways, the number of days with moderate to average rain might increase in future, while the number of days with more extreme rainfall might decrease.

Indeed, Chart 4 indicates that one might expect more days with rainfall in the lower rainfall categories (0%-40% deciles) and less days with rainfall in the higher rainfall categories (40%-100% deciles) to appear in future. A small, but increasing fraction of days might receive more daily rain than ever recorded before (>100% percentile). Only 0.16 and 0.27 of future rain days might experience rainfall totals that exceed the current maximum recorded rainfall under the RCP 4.5 and RCP 8.5 pathways, respectively.

Chart 5 provides similar information for temperature. It indicates that the number of low temperature events will not appear again in future, and that the number of high temperature events will increase tremendously (up to +358%).

Chart 5. Projected % change in the number of daily near-surface temperature events over the 55-year period 2041-2095 for RCP4.5 (light blue) and RCP8.5 (dark blue) concentration pathways, relative to the number of daily near-surface temperature events in historical deciles over the 55-year period 1951-2005.



These scenarios have been used in Section 6 to estimate future impacts of climate change on coffee production in the district.

4. IMPACTS OF CLIMATE VARIABILITY ON COFFEE YIELDS

The information on this section is based on a literature review and, given the limited evidence of the impacts of climate change in Bududa provided by the literature, mainly on the data collected in the field. The people met are listed in Annex 1. It is important to note that farmers in the region don't typically keep record of the economics of farming, so the information is rather anecdotal. The number of interviewees is also not representative. These limitations have to be noted and further research is strongly recommended to strengthen the evidence.

Uganda, and the Mount Elgon, is already experiencing climate variability, without the projections for future climate change. Increased climate variability has been affecting Bududa district, resulting in increased poverty due to a reduction in the production of coffee and other crops. According to local stakeholders, nowadays, the unpredictability of the weather does not allow them to anticipate it and plan properly.

It is worth noting that Arabica coffee is very sensitive to weather conditions. The plant can tolerate low temperatures, but not frost, and does best with an average temperature between 15°C and 24 °C, with an optimum mean temperature range of 18-21°C. The following lines study the impact on livelihoods of the change of the climate variables most relevant to coffee.

- *Excessive heat / Droughts*

Drought and excessive heat reduce the volume and/or quality of agricultural production. Typically the effect is short (6 months), as, if the weather improves, crops recover in the following season.

The people met during the field mission (Annex 1) agree that since around 2010 dry spells are often longer than 3 months (the "normal" duration). Particularly long dry spells and excessive heat have been recorded in Bududa in 1997, 2009 and 2014, according to local stakeholders. Although low-lands (1000-1200 m above sea level) are particularly hit, highlands (1500-2000 m above sea level) are also sometimes affected. According to anecdotal evidence, the loss on coffee production in the low-land ranges from 10 to 75%, depending on the farmers and the severity of the event. In the highlands farmers agree that drought/excessive heat can result in a loss of 50% of coffee production. According to a local private company of the sector, while it is possible to obtain 3kg per tree per year if the weather is good and the coffee tree is well maintained, the production will fall to 1.5 kg with bad weather even if the coffee tree is well maintained.

With heat the recently introduced KP variety breaks easily, and coffee beans become smaller and lighter[7]. Other crops are also affected: one of the farmers in the low land affirmed that the production decreased 40% for bananas, 50% for apiary, 50% for dairy, and 70% for beans and maize due to drought/excessive heat in 2014.

It is important to note that when they refer to the impacts of droughts / excessive heat, farmers typically refer as well to absence of shading trees and mulching. They recognize that with shading trees and mulching the impact of excessive heat would have been less significant.

[7] Mostly three varieties of coffee are used in the Bududa District. SL14 or Nyasaland is the traditional and most used one, covering probably around 90% of the coffee area. Nyasaland is relatively resistant to pests, but is not particularly productive and the beans are not especially big. KP423 is more recent, and although it can produce more per tree and the beans are bigger, it is very fragile and dependent on fertilizer. See Annex 2 for more information.

o *Excessive cold / excessive rainfall / landslides/mudslides / flooding*

The absence of a distinct dry season affects coffee flowering, as coffee trees produce too many leaves and not enough flowers/berries. Some farmers claim that they lost between 30 and 60% of their production in 2010 due to excessive rainfall (without extreme rainfall event). Coffee trees take at least one year to recover.

Excessive rainfall typically leads to flooding in the lowlands and to landslides and/or mudslides in the highlands. Flooding particularly affects those who have their house and/or garden close to a river in the lowlands. A farmer reported the loss of 35% of his coffee nursery in 2014.

Landslides have been very significant on the highlands of the Mount Elgon region, similarly to other areas in Uganda. Bududa District is a landslide hotspot within the country. Landslides and mudslides have been recurrent in Bududa since at least 1933 (NEMA, 2010; Wanasolo, 2012). In the 20th century, major landslide events occurred in 1933, 1964, 1970 and 1997. The most severe landslide occurred in Nametsi Parish on 1st March 2010. According to UCDA (Kagenda, 2010), 60,000 coffee trees were destroyed, with an estimated production loss of around 41 tonnes that year. The company "Coffee a cup" alone produced 5 tonnes of coffee in this area the previous year, which means the loss was very important when the event occurred. Landslides occurred also in 2011, 2012, 2013 and 2014. In 2012 and 2013, people were killed and coffee trees lost (Bumwalukani in June 2012). The most recent landslide took place in June 2014. Heavy rains led to landslides affecting the sub-counties of Bushika, Bushibiro and Nakatsi in particular. According to Bududa DLG, the following impacts on livelihoods were experienced:

- 28 ha (70 acres) of crops destroyed (disaggregated data is not available; it includes coffee, beans, cassava, sugarcane, bananas, maize and fruit trees)[8]
- Animals -mainly hens and goats- were lost.

Farmers provided some data on the impact of landslides on coffee production. In the mid-lands, farmers report to have lost between 10% and 20% of their coffee trees in 2014 due to landslides. In the highlands, 17% of the focus group discussion participants were affected by mini landslides on their farms in 2014, with a range between 5% and 45% of coffee trees lost. It is important to note that it takes up to 50 years to fully recover the landslide area for any crop to grow in. In addition, in order to protect soil, trees are typically planted, particularly albizia trees, a fast-growing tropical variety used to provide shade to protect coffee plantations. For instance, in 2010, UCDA planted around 160,000 albizia trees to protect the soil in the destroyed coffee farms.

o *Hail stones*

According to the anecdotal information gathered in the field, hail stones are now more frequent. A particularly strong and long hail stone event took place in August 2013, in the sub-counties of Bushiyi, Bumayoka and Bukalasi. As a result of such events coffee trees were destroyed: the production is lost for 3 years, as new coffee trees need to grow. According to UCDA (2013), 1,820 households (11,000 people) and 357 ha with 608,000 coffee trees were affected, causing an estimated crop yield loss of 304 tonnes of parchment. "Coffee a cup" alone lost 9 tonnes over 3 years. Of the three co-operatives analysed, Bumayoka lost 30 tonnes (16% of its annual production); Nabushi lost 15 tonnes (around 75% of its annual production) and Nalwaba lost 7 tons (around 39% of its annual production), all of them for 3 years.

o *Pests*

Local stakeholders have observed the existence of new pests of which they did not know earlier. Some pests and diseases, such as the coffee stem borer and black ants, that previously did not exist in higher lands, are

[8]Again the information provided is not very clear. A reference is made to another 40 acres, but it is not clear whether these are included or not in the 70 acres.

now more common. It is argued that pesticides are "a must" to produce coffee, which implies an additional cost and environmental impact. According to the information gathered in the field, even with pesticides, pests can result in a loss of 20-50% of production.

o *Social impacts*

According to local stakeholders, climate variability has had additional impacts on society.

First, climate variability has resulted in loss of lives. The 1933 landslide killed 25 people; the 1964 landslide, 18 people; the 1970 landslide, 70 people; and the 1997 landslide, 48 people (NEMA, 2010). The 2010 landslide alone killed 365 people in Nametsi parish. More than 8,000 people from surrounding villages were displaced temporarily (Gorokhovich et al., 2013). The 2014 landslide killed 1 person, but affected 313 households[9] (around 1,815 people[10]).

Second, changes in climate variables were reported to have also resulted in health problems. According to information gathered in the field, the reported number of cases of malaria increased by 70% in Bududa. According to UBOS (2012), malaria ranks highest among the diseases that affect the population in Bududa (38% of the total disease cases). In 2011, almost 90,000 cases of malaria were registered (UBOS, 2012). According to local stakeholders, malaria cases cause additional costs for treatment and a loss in productivity on farms. Furthermore, reduction in production leads to poor nutrition, directly, in the sense that less food is available, and indirectly, as with less income the diet becomes poorer. In particular, farmers cannot buy meat and rely exclusively on beans and posho (maize meals). Contamination of rivers during landslides also leads to outbreaks of communicable diseases such as cholera and diarrhoea. The contamination of rivers Bududa and Manafwa that followed the 2014 landslide resulted in an increase in patients in Bushika Health Centre III.

Third, climate variability has affected infrastructure, such as roads, bridges and public buildings. The 2014 landslide destroyed the Bududa Circular road, Bunamanda-Wanasofu community road, Nalufutu-Shazou road, the Kibitsi river bridge along the Bududa –Circular road, and the Tsutsu-Namubya bridge. Destruction of roads and bridges disrupts transport and imply that coffee has difficulties to reach markets. The same landslide resulted in the disruption of education in 6 schools of the district.

Finally, income loss is translated, according to local stakeholders, into psychological trauma, which results in disruption of family cohesion and domestic violence, and other unsocial behaviours, such as robbery. According to local stakeholders, reduction of income also compromises education, as many families are unable to pay school fees.

[9]The information provided is not very clear. A reference is made to another 117 household, but it is not clear whether these are included or not in the 313 households.

[10]UBOS (2014) provides the average household size. In the three sub-counties the average is around 5.8 persons per household.

5. Economic Assessment of the Impacts of Climate variability and Change in Coffee Production

5.1. Current economic impacts of climate variability in coffee production

This section explores coffee production under current weather variability. There are different ways of managing coffee production, with different costs and returns. Farmers in the field claim that output has decreased owing to bad management practices. Farmers applying good management techniques not only produce more, but have also shown positive production trends. There are many important ways to increase coffee production: the existence of shading trees, which have often been cut; the existence of physical structures for soil and water conservation (SWC), such as terraces and trenches; the appropriate use of fertilizers, including organic manure; or regular pruning, among others.

Tables A1 and A2 in Annex 3 illustrate the costs, return and cash flow of coffee production on one hectare in Bududa in a 15 year period under a business as usual (BAU) scenario and best practice or climate smart agriculture (CSA) scenario, which includes planting of trees, mulching and trench construction, according to data collected in the field[11]. They show an increase in yields in going from BAU to CSA of the order of 2 to 2.5 times, depending on the year. Based on the data in Annex 3, Table 3 summarizes the costs and returns of coffee production in Bududa over a 15 year period for both scenarios. It is clear that although the marginal costs of CSA are greater (by 13.1 US$/tree for the 15 years; an increase by a factor of 2.6 compared to BAU), the marginal return of CSA is also significantly greater (by 29 US$ /tree for the 15 years; an increase by a factor of 3.4 compared to BAU). The profit per tree per year goes up from US$0.2 to $1.3, while the internal rate of return (IRR) goes up from 27% to 41%. In terms of yield, it goes up from 1.3 to 3.6 kg of parchment.

[11] Note that according to local sources coffee trees do not produce in the first two years, and produce only 30% of their full capacity in the third year. Full capacity is reached in the fourth and fifth years. Annex 3 presents these and additional details.

Table 3. Summary of costs and returns of coffee production in 1 ha area in a 15 year period.

	CSA	BAU	MC	MB
Cost Per Tree (15 Years) US$	21.4	8.3	13.1	
Cost Per Tree Per Year US$	1.4	0.6	0.9	
Return/Tree (15 Years) %	41.1	12.0		29.0
Return/Tree/Year %	2.7	0.8		1.9
Profit Per Tree US$	19.7	3.7		
Profit Per Tree Per Year US$	1.3	0.2		
IRR %	41	27		
Kg of Parchment (15 Years) US$	1.3	3.6		8.7
Total Costs (15 Years) US$	32,144	12,495	19,648	
Total Revenue (15 Years) US$	61,628	18,068		43,560
Cash Flow $	29,484	5,572		23,922

Note: MC=Marginal Costs; MB=Marginal Benefits

Source: Own calculations based on information gathered in the field

These estimates consider only the benefits of CSA in terms of direct coffee production, and ignore the benefits that well maintained coffee gardens have on the environment and, indirectly, on income. For instance, planting shade trees not only may increase the productivity of coffee trees, which is accounted for above, but it also reduces the risk of floods and therefore what these events represent in terms of economic and social costs. We will discuss the cost and benefits of applying CSA when dealing with adaptation options.

The above analysis can be extended to take account of climate variability. From section 4 we can see that at least two kinds of climate events can reduce the returns to coffee growers: periods of excessive heat and periods of excessive rainfall, accompanied by landslides. In making a risk based assessment the following assumptions are made (Table 4). These are based on our review of the literature as well as discussions with local farmers.[12]

Table 4. Assumptions about current losses from climate variability

	Assumption*	Source
1	Trees are replanted every 15 years	Case Study[1]
3	Extreme Event losses from excessive heat occur with probability of 15% (3 in last 20 years). Losses from an event in highlands = 50% of production	Case Study[1]
5	Extreme Event losses from excessive rainfall and landslides occur with probability of 25% (4 in last 16 years). An event in highlands results in a loss of 15% of trees	Case Study[1]

* Note that these assumptions include the duration of the impacts discussed above. Reference is to BAU methods.

1. Community information based on the methodology as outlined in detail above

Source: As stated the assumptions are based on data and information collected during the fieldwork.

The economic model used to estimate the returns for a hectare of land (detailed in Annex 3) has been used to evaluate the impacts of the same areas but including these uncertainties. It looked at two planting cycles starting in 2015 (30 years period) and considers the two options discussed above – BAU and CSA. In each case

[12] The assumptions in Table 6 are taken from local interviews. Landslides and excess rainfall have been combined into one set of events. It is likely that losses also occur from period of sustained rainfall that is not intense and that does not cause landslides. No data were available for the frequency of such events or of their consequences in terms of output. Hence they have not been included, which probably biases the estimated returns upwards.

the model calculates the expected revenues, allowing for the losses due to excessive heat and excessive rainfall, accompanied in some cases by landslides. Based on the data collected, if these losses continue to occur with the frequency of the recent past the returns are as shown in Table 5.

Table 5. Returns to coffee growing in the Bududa District (IRR %) under current climate variability over a 15 year period (%)

	No Losses from drought and excess rain	Including Losses from Drought only	Including Losses from Drought and Excess Rain
BAU	27	21	16
CSA	41	38	25

Source: Own Calculations based on data and information collected during the fieldwork

The calculations are based on expected streams of revenues through two planting cycles. It is notable that under BAU and taking account of both kinds of climate-related losses, the IRR is 16%, whereas with CSA it is more profitable with an IRR of 25%. However, for both BAU and CSA one has to bear in mind the variation of income: every six years or so you can lose up to half your yield and every three years you can face a loss of around 15% of your trees[13]. So this profitability, which is an average over the 15 year period, includes important year to year variability.

5.2. Future economic impacts of climate change in coffee production

Based on the discussion in the previous section we attempt to include climate projections into the projections for coffee growing in this district. In addition to the assumptions made in Table 4 about current climate variability we now make the further assumptions regarding the additional changes as given in Table 6. The assumed increases in the frequency of droughts and excess of rainfall are based on existing literature as well as the climate projections reported in Section 4[14]. Some further evaluation of the sensitivity of the results is required.

Table 6. Assumed Changes in Climate Factors Beyond 2015

	Assumption*	Source
1	Trees are replanted every 15 years	Case Study
2	With climate change yields, under BAU, will decline 10-50% by 2050. Interim declines will be proportional. Mean loss is 30% by 2050	Agriculture Sector Report (Baastel consortium, 2015 b) and Section 4

[13] The analysis of the loss of trees is complex, as it has to account for a future drop in revenues. This has been done, assuming the trees are not replanted.

[14] The projections in Section 4 indicate a clear increase in temperature but little change in average rainfall. They also make no clear indications of increases in extreme events, although there is some suggestion that periods of low rainfall may be more dominant. Given this information we have retained the yield loss range of 10-50% by 2050, given by the literature and used in the Agriculture Sector Report.

3	Extreme Event losses from excessive heat occur with probability of 15% (3 in last 20 years). Losses from an event in highlands = 50% of production	Case Study
4	With climate change frequency of excessive heat may increase from 15% to 30% by 2050. Increase in interim years is proportional	Ag Sector Report
5	Extreme Event losses from excessive rainfall and landslides occur with probability of 25% (3 in last 20 years). An event in highlands results in a loss of 15% of trees	Case Study
6	With climate change frequency of such events (excessive rainfall and landslides) may increase from 25% to 50% by 2050. Increase in interim years is proportional	Ag Sector Report

* Note that these assumptions include the duration of the impacts discussed above. Reference is to BAU methods.

Based on the best available estimates we can rework the profitability calculations for coffee that were presented in Table 5. Recall that we are considering two cycles of coffee plantation, each of 15 years, from 2015 to 2045. The new IRR values are shown in Table 7.

Table 7. Returns to coffee growing in the Bududa District (IRR %) under projected climate change over a 15 year period for two growing cycles

	No Losses from drought and excess rain	Including Losses from Drought only	Including losses from Drought and Floods
BAU	22	15	9
CSA	38	33	22

Source: Own Calculations

Now we find that BAU is only marginally profitable over the two cycles when we consider both losses from drought and floods, and (not shown in the table) it is not profitable in the second cycle. The IRR for the first cycle is 10.4% and 5.7% for the second cycle. The average for the two cycles is 9% as shown in Table 7.

The first cycle (2015-2030), however, is still profitable under CSA (IRR is 22%) but its profitability drops to 12% in the second cycle[15]. In both cases farmers suffer from large fluctuations in incomes for years when droughts or floods occur, as before under 'normal' climate variability.

It is also important to note that under the climate change scenarios profitability will drop for both BAU and CSA – but under CSA it is much less of a drop; and that with CSA, profitability is still higher – even with climate change – than BAU now.

[15] These results are supported in part by other work looking at the prospects for Arabica in Africa. Davis et al. 2012 studied the survival of Arabica coffee in East Africa (focused on Ethiopia and South Sudan) up to 2080. Two main types of analysis were performed: a locality analysis and an area analysis. In the locality analysis the most favourable outcome is a circa 65% reduction in the number of pre-existing bio-climatically suitable localities, and at the worst, an almost 100% (99.7%) reduction, by 2080. In the area analysis the most favourable outcome is a 38% reduction, and the least favourable a circa 90% reduction, by 2080.

6. IDENTIFICATION AND EVALUATION OF ADAPTATION OPTIONS

6.1. Identification of adaptation options

There is a significant level of agreement among stakeholders interviewed on which adaptation strategies are needed. Seven types of adaptation strategy were identified:

1/ The most important type of adaptation strategy is the implementation of **climate smart agriculture (CSA)** practices, including the adoption of soil and water conservation (SWC) techniques (such as conservation tillage, erosion bunds or terracing) and agroforestry at the farm scale. These can be combined, for instance, by planting agroforestry forage shrubs on contour bunds to stabilize these. Among the coffee shade trees Cordia Africana stands out. The number of trees that would be required is difficult to estimate. In areas with particularly high population density, in the highlands, it is around 15-20 trees per acre; in areas with lower population density it goes up to more than 50. In addition, planting beans under coffee and banana for food and protection of crops should be promoted. Moreover, the construction and maintenance of physical structures, such as trenches, is critical for soil stability, especially in steep slopes. According to information collected in the field, currently only 32% of the communities have well developed and maintained SWC trenches, 28% are poorly done and not well maintained, and 40% of the households do not have trenches at all. At village and parish level, it would also be important to improve land use planning, managing the development of human settlements and restoring river banks and wetlands through demarcation and tree planting.

2/ The second type of adaptation strategy refers to support from public institutions at the central and district levels and in particular to the **strengthening of extension services** (the technical assistance that government officials provide to farmers), which are currently insufficient due to human and infrastructure constraints. This could include a range of activities, such as monitoring field activities, training, setting standards, and supporting activities for scaling up sustainable land management (e.g. technology demonstrations, promotion of appropriate farm equipment, enhancing public –private partnerships for agricultural mechanisation). The strengthening of extension services could improve farmer's technical knowledge and, consequently, their management of plantations. It is also important to approve and enforce appropriate bylaws regarding land use.

3/ The third type of adaptation strategy refers to **commercialization**, that is, the options available to farmers to sell their products. Farmers often feel exploited by coffee buyers, and suggest that a regulated system that ensures more fair and transparent transactions would encourage sustainable production.

4/ The fourth type of adaptation strategy refers to the **provision of climate data** that could assist farmers in planning better how to manage their fields, although this is less relevant for perennial crops, such as coffee, than for annual crops.

5/ The fifth type of adaptation strategy refers to the **engagement of the private sector**, so that private investment contributes to adaptation. Private companies could integrate adaptation practices in their procedures and standards, and encourage farmers to adopt adaptation practices. In this sense, it is important that the programme of institutional support links with the private sector and both are aligned towards adaptation. Specific public-private partnerships should be explored.

6/ The third and fifth points indicate the need to undertake a **market analysis** that examines the value chain of coffee. This is a critical step to promote adaptation to climate variability and change.

7/ Finally, there are **complementary strategies** that could help adaptation but are only indirectly related to coffee production. Family planning would reduce population pressure, and therefore pressure on the land under coffee cultivation. The promotion of energy saving cook stoves and alternative sources of energy, such as biogas or solar, would reduce the need to cut trees that provide shade to coffee and retain soil. Sensitization, education and awareness programmes would enhance adaptation strategies, particularly those referred to in point 1.

6.2. Costing of adaptation options

In the costing we consider only two of the possible adaptation options listed in 6.1: CSA and extension services. These have been prioritized as a result of the discussions undertaken with stakeholders in the field. The estimates are based on data collected in the field, which has significant limitations, so results must be treated with caution and more research done. Further research should also be conducted regarding the other possible CSA approaches and adaptation strategies.

For CSA, specifically SWC techniques, at farm level we have the data given in Annex 3 Table A2, which includes mulching, trench construction, manure purchase and application, non-coffee tree seedlings, pitting and planting trees. For planting shade trees, we can calculate the number of trees that is needed based on the number of hectares and the number of trees needed on average per ha; and we know that the cost per tree is around US$ 0,33. Table 3 (Section 5) constitutes the basis for estimating the cost of other CSA measures. This programme elaborated in Annex 3 is the most detailed estimate of what is needed to achieve the CSA objectives based on data collected in the field. Total additional costs for CSA versus BAU are about US$1,700 per ha over the 15 year cycle, but of course the CSA generated much higher revenues.

For institutional support, we have Bududa DLG's proposed budget for the period 2015/2016-2019/20. Details are provided in Annex 4, which includes items relevant to animals, bees and crops other than coffee.

Table 8 includes only those items that are relevant for coffee, but they also cover support for other crops. It was not possible to separate coffee from other crops. Total costs amount to US$ 214,329 over the 5 year period.

Table 8. Summary of costs of institutional adaptation support programme for farmers in Bududa district 2015/16-2019/20

	US$
Improve coordination of agricultural services in the district[16]	119,090
Build capacity to respond to climate change[17]	4,092
Lower the incidences of diseases, pests and weeds[18]	1,980
Enhanced productivity of land through sustainable use and management of soil and water resources[19]	71,914
Improved access to high quality inputs[20]	1,749
Accelerated development of selected strategic commodities through value addition[21]	15,174
Promotion of access to financial institutions[22]	330
Total	**214,329**

Source: Bududa District Local Government

In the subsequent analysis of adaptation options we use the cost information for adopting CSA practices as given in Annex 3 Table A2, plus the institutional costs as given in

[16] Among other activities, this strategy includes supervising and monitoring field activities, departmental meetings and sector report writing and dissemination. A full list of the activities included in this strategy is provided in Annex 4.
[17] Among other activities, this strategy includes advertising and public relations; staff training; and infrastructure. A full list of the activities included in this strategy is provided in Annex 4.
[18] This strategy includes setting and operationalizing standards for diagnostics, surveillance and control of pests and diseases including weeds; and establishing demonstrations on disease, pest and weeds control using agro chemicals. See Annex 4.
[19] This strategy includes supporting ongoing activities for scaling up sustainable land management; establishing demonstrations on small-scale irrigation technologies and rain water harvesting and management in districts; building capacity for development of appropriate farm structures as well as testing, adaptation, demonstration and promotion of appropriate farm equipment; and enhancing public –private partnerships for agricultural mechanisation. See Annex 4.
[20] This strategy includes building and strengthening institutions involved in input supply by strengthening input dealers capacity and network of professional dealers/stockists, and designing and implementing training courses for input dealers; raising awareness among farmers on the value of adopting high quality inputs through designing and implementing training courses for farmers; and establishing demonstration plots for promoting improved inputs, and disseminating materials on agricultural inputs. See Annex 4.
[21] Among other activities, this strategy includes undertaking value chain studies for Banana, Coffee commodities not yet studied to identify areas for intervention; facilitating financing and construction of appropriate storage structures for post-harvest handling; and enforcing crop laws, regulations, standards and guidelines along the entire value chain. A full list of the activities included in this strategy is provided in Annex 4.
[22] This strategy includes sensitizing/training farmers on group formation and farming as a business; training on record keeping and auditing of SACCOS, primary societies and ACES; and registering them. See Annex 4.

Table 8, to evaluate the cost effectiveness of adapting coffee production to climate change in the Bududa district from 2015 onwards.

6.3. Evaluation of benefits of adaptation – effectiveness of interventions

The adaptation option that is considered here is the conversion of all coffee growing areas in Bududa district to Climate Smart Agriculture (CSA). The following programme is evaluated in terms of costs and benefits:

1. The 4,340 hectares of land are converted to CSA gradually over a period of four years. This involves planting of trees, mulching and trench construction over a 15 years growing cycle. It is assumed that the additional costs are borne by the adaptation programme, although this cost could be shared with the owners. These costs are presented inTable 9.
2. The productivity of trees depends among other factors on their altitude. We were given an estimate from local stakeholders that 10% of the trees in Bududa district are at a low altitude, 70% at mid-altitude and 20% at high altitude. This has to be combined with an estimate of the productivity, which was built based on data collected in the field. The range is an average of 0.4 kg/tree/year in 2014 at low altitude and 0.8kg/tree/year at mid to high altitude, representing a considerable decline over the yields ten years earlier. Under CSA the range is 1.2-1.5kg/tree/year at low altitude and 2.0 to 3.0 kg/tree/year at mid to high altitude. We used these estimates to adjust the generic figures provided in Annex 3 as typical for coffee plantations in Uganda. The adjusting meant increasing the average productivity of a tree under BAU by a factor of 55% and under CSA by 44%.[23]
3. The analysis considers two cycles of coffee growing, each of 15 years. At the end of the first cycle a new set of trees is planted for the coffee as well as provision of shade.
4. The impacts of climate change on yields and extreme event frequency is as given in points 2-6 of Table 6.
5. The move to CSA results in higher yields but we do not assume any reduction in losses due to extreme events to avoid double counting. The loss rates due to such events are as given earlier in Table 6.
6. The programme is supported by the adaptation crop component of the Bududa District Local Government Development Plan as outlined in

[23] Since the adjustments are similar the relative comparison of BAU and CSA comes out rather similar to the one presented earlier in Section 5.

7. Table 8– requiring US$ 214,329 over 5 years. It is further assumed that similar support will be needed every five years to the end of the first cycle of planting.
8. The benefits of the higher yields have to be traded off against the upfront costs of tree planting and other adaptation costs. Costs per hectare of CSA in the district over the first cycle are given in Table 9. They start at US$ 2,162, and move between US$ 1,071 and US$ 646. The total costs for the district, assuming a four year phase in for the programme, are given for the first cycle in Table 10. They start at US$2.4 million per year, and go up to a maximum of US$ 4.9 million per year in 2019, after which point they continue at US$ 3.3 million per year for the remainder of the 15-year cycle. The total cost of all phases is US$ 64.2 million.

Table 9. Costs per Hectare of CSA in Bududa district (US$), 15 year cycle

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Manure Purchase	170	0	0	170	0	0	0	170	0	0	0	170	0	0	0	**680**
Manure Transport	153	0	0	153	0	0	0	153	0	0	0	153	0	0	0	**612**
Hole Filling with Manure	102	0	0	51	0	0	0	102	0	0	0	102	0	0	0	**357**
Tree Seedlings + Transport	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**51**
Pitting and Planting Trees	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Mulching	510	510	510	510	510	510	510	510	510	510	510	510	510	510	510	**7 650**
SWC Trench Construction	1 020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1 020**
SWC Trench Repairs	136	136	136	136	136	136	136	136	136	136	136	136	136	136	136	**2 040**
Total Additional Cost	**2 162**	**646**	**646**	**1020**	**646**	**646**	**646**	**1071**	**646**	**646**	**646**	**1071**	**646**	**646**	**646**	**12 430**

Source: District Programme for CSA.

Table 10. Total Costs of CSA in Bududa District (US$ Million)

	First 15yr cycle																Start of 2nd 15yr cycle					
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total	2031	2032	2033	2034	...	Total
Direct Farm Costs Phase 1	2.3	0.7	0.7	1.1	0.7	0.7	0.7	1.2	0.7	0.7	0.7	1.2	0.7	0.7	0.7	**13.5**	2.3	0.0	0.0	0.0	...	**15.8**
Direct Farm Costs Phase 2	0.0	2.3	0.7	0.7	1.1	0.7	0.7	0.7	1.2	0.7	0.7	0.7	1.2	0.7	0.7	**12.8**	0.7	2.3	0.0	0.0	...	**15.8**
Direct Farm Costs Phase 3	0.0	0.0	2.3	0.7	0.7	1.1	0.7	0.7	0.7	1.2	0.7	0.7	0.7	1.2	0.7	**12.1**	0.7	0.7	2.3	0.0	...	**15.8**
Direct Farm Costs Phase 4	0.0	0.0	0.0	2.3	0.7	0.7	1.1	0.7	0.7	0.7	1.2	0.7	0.7	0.7	1.2	**11.4**	0.7	0.7	0.7	2.3	...	**15.8**
Indirect Costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.6**	0.0	0.0	0.0	0.0	...	**0.8**
Total Costs	**2.4**	**3.1**	**3.8**	**4.9**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**50.4**	**4.5**	**3.8**	**3.1**	**2.4**	...	**64.2**

Source: Own Calculations. Total costs may differ from the apparent sum of the column on account of rounding errors.

The first cycle of the programme from 2016 to 2030 has a net present value (NPV[24]) of around US$28.7 million at a 10% discount rate and an IRR of 29%[25] - i.e. the benefits outweigh the costs by US$28.7 million, and there is a higher IRR than under BAU. The second cycle of the programme from 2031 to 2048 has an NPV of around US$19.8 million and an IRR of 23%. The lower IRR rate is the result of higher losses and low yields due to climate change. Nevertheless both cycles are justified on cost benefit grounds. The IRR figures here are slightly higher than those in Table 8. This can be explained as follows: in Table 8 we were looking at someone planting an area and practicing either BAU or CSA. The IRRs are for those alternatives. Here we are looking at the marginal gain in switching from BAU to CSA, with the support of the government programme. Also we have allowed for a range of coffee productivities in different zones of the district, which makes a difference.

The cost benefit analysis shows the programme to have positive net benefits but it is only a guide and is based on several assumptions that should be examined further. The most important is the increase in yields brought about by CSA. The information provided by local key informants estimated this to be, on average, around three times with no climate change. **Climatic factors reduce that gain but it still remains substantial and the result is this healthy rate of return.**

As a sensitivity test we looked at what increase would be needed for the adaptation programme to have an internal rate of return of at least 10%. Some slippage in performance is likely with CSA, as we observed there has been with current coffee growing practices. If CSA achieves only a doubling of yields instead of the factor of 3, the IRR is still around 18% for the first cycle and 14% for the second. With an increase in yields of around 90% from CSA the IRR declines to 11% for the first cycle and 6% for the second. Thus the performance of the programme is very sensitive to the improvements in yields from CSA, once these fall to less than 100%.

The other factor not included in the analysis is possible increases in extreme events. We have assumed the current frequency will continue to 2045, but this may underestimate losses and make the adoption of CSA less attractive (we are looking at the difference in performance in CSA versus BAU so such events will make a difference if they reduce gains in CSA more than they reduce output under BAU).

6.4. Barriers and enabling factors for adaptation

The above programme is costly and requires, in addition to the current programme summarised in

[24] The NPV of an investment is determined by calculating the present value (PV) of the total benefits and costs, which is achieved by discounting the future value of each cash flow. NPV is a useful tool to determine whether a project or investment will result in a net profit or a loss because of its simplicity. A positive NPV results in profit, while a negative NPV results in a loss.

[25] The benefit cost table is not included. It is complex and quite detailed and would normally be regarded as a working sheet. It can be provided on request.

Table 8, around US$2.4 million in 2016, rising to US$4.9 million by 2019. As yet such funds are not available locally. According to Bududa District Local Government, a barrier for adaptation is also the limited availability of funds from central and local government to facilitate implementation of planned conservation measures within the district as outlined in

Table 8. A first problem is the number of staff both at the district and sub-county levels. According to the DLG, only 15% of approved staff was actually hired in December 2014. As a result some issues are not covered, and many are not properly covered, as one official deals with too many issues. In addition, there are barriers related to the mountainous geography and the poor infrastructure, which results in the majority of the population of the district living in hard-to-reach areas where service delivery is complicated.

Moreover, ownership of small land areas and low productivity lead to unsustainable land use management with many crops fighting for the same nutrient. Coffee survives because it has a deep root system.

7. Conclusions and Policy Recommendations

7.1. Conclusions

This case study has reviewed the evolving situation for Arabica coffee cultivation in the Bududa district, which is typical of agro-ecological zones in the Mount Elgon region. It has looked at how climate variability is affecting coffee yields and livelihoods already, based on the data collected in the field and on a literature review. It has then provided downscaled climate change scenarios for the district. Based on these climate change scenarios and estimated impacts, the study has evaluated a programme for the adoption of climate smart agriculture (CSA), which includes planting of trees, mulching and trench construction, for Arabica coffee. The study has also estimated the financial returns for coffee growing under 'Business as Usual' (BAU) and under a CSA programme scenario, current climate variability and future climate change. It has then gone on to consider appropriate adaptation policies and measures with a direct impact on communities and the region's economy, carrying out a cost benefit assessment of such a programme. It must be noted that although it has identified seven potential adaptation approaches, the study has focused on the two that stakeholders considered to be most important: CSA and institutional support measures (or extension services). Finally, it proposes recommendations for action to adapt Arabica coffee growing practices to climate change and variability.

Although this study is beset by significant data limitations, for example on the specific impacts of climate variability on coffee production in the district, and must therefore be treated with a degree of caution, its estimates and the recommendations provide a valuable illustration of the potential impacts of climate variability and change on coffee production and the benefits of a package of CSA and institutional support. Coffee is important in terms of rural livelihoods and national income, and yet coffee production is not fully understood in relation to climate variability and change.

The study highlights that most households in the district are subsistence farmers and there is little income derived from non-farming sources. Around half of all household income comes from coffee, with the rest derived from bananas, a range of vegetables, some livestock, bees and fishponds. The population of the region has been growing fast: it is more than 80% larger now than it was at the start of the 1990s. At the same time poverty is widespread: in 2007 around one-third of households were judged to be poor.

As far as coffee is concerned, key informant interviews conducted as part of this study state that the yields and quality of the crop have been declining, in part owing to poor management practices and in part because of an increase in climate variability and extreme events such as droughts, landslides and floods. Changing weather patterns have been observed in the district and the region more generally. Particularly long dry spells and excessive heat were recorded in Bududa in 1997, 2009 and 2014. Data collected in the field shows that these caused losses in the range of 10 to 75% in the lower elevation areas and around 50% at higher elevations. There has also been an increase in the frequency of excessive rainfall and landslides both of which have resulted in significant losses of crops. This has had an impact on local livelihoods and national income.

Climate projections suggest that the impacts of climate change could further affect coffee production in the area. The adoption of CSA practices, which is defined in this study as the planting of trees, mulching and trench construction, could help farmers deal with current climate variability and adapt to climate change. Based on the data collected in the field through interviews with key stakeholders, the internal rate of return of coffee cultivation would increase from 16% to 25% under current climate variability, and from 9 to 22% under future climate conditions, if CSA were adopted. So, even though coffee cultivation will become increasingly less profitable under both BAU and CSA scenarios (from 16% to 9% for BAU and from 25% to 22% CSA), the rate of return of coffee cultivation under CSA, even with future climate conditions, is greater than that for BAU with current climate variability (22% vs 16%). It should be stressed that these are preliminary estimates based on limited data and evidence on the effectiveness and impacts of CSA, and in particular a number of assumptions regarding the take up of CSA practices by farmers and the actual improvements in yields that could be achieved. Further work is needed to improve the evidence base on these issues.

For institutional support measures, the costs are based on an existing government support package. It should be noted however that there is also insufficient evidence around the effectiveness of such institutional support programmes, and there is an assumption (again based on anecdotal evidence) that such programmes lead to more effective uptake of CSA measures, which are then successful in improving yields.

The study found that although quite costly, investments in CSA are likely to be justified, as probable benefits outweigh the costs, both under current conditions, and even more so when expected climate impacts are considered. The study indicates that likely investment costs are in the range of US$2.4 million in 2016, rising to US$4.9 million by 2019, over and above the current institutional support programme of Bududa's District Local Government, which has a budget of only around US$ 214,329. The analysis shows investment in these two complementary programmes – CSA and institutional support - would have an internal rate of return of around 36%. If combined with other adaptation approaches, such as complementary policies or providing better climate information, there is, in the view of the study team, potential to sustain coffee cultivation in Bududa, both now and under future predicted climatic conditions. Coffee represents around 3% of Uganda's Gross Domestic Product (GDP) and around 20-30% of the country's foreign exchange earnings (Uganda Coffee Federation, 2012). Development of Uganda and its future income depend, to a considerable extent, on how resilient sectors such as coffee cultivation are to the impacts of climate change.

7.2. Policy recommendations

The study provides an illustration of the potential economic case for investment in CSA for coffee cultivation in the Bududa district. However, there needs to be further consensus before undertaking any major investment programme. In this context, the study recommends that further research and analysis is conducted in order to identify:

1. The impact of climate variability on coffee yields in the Mt Elgon region, and other coffee growing regions in Uganda.
2. The cost and benefits of different approaches to CSA in the coffee sector, in particular to identify 'low regret' options and options where there are co-benefits.
3. The economic viability of coffee growing under BAU and CSA in different regions in Uganda, in order to focus investment on regions where there is a stronger economic case for coffee cultivation in the long term.
4. Barriers and enablers that effect the adoption of CSA practices by farmers, in order to identify what wrap-around support might be needed, and subsequent to this an analysis of how support may be best delivered.
5. The costs and benefits of alternative livelihoods in Bududa, including cultivation of other crops and non-farming activities, versus coffee cultivation.

The above actions would help to inform the design of a CSA programme for coffee, including practical measures as well as institutional support, and help to identify what additional complementary strategies might be needed. Critically, the development of such a programme should also involve the private sector, and an analysis of the market and value chain for coffee, to enable improved commercialisation.

Further, given the high level of investment that is potentially required, it is recommended that any CSA programme is first piloted in order to establish whether expectations around costs, benefits, and yields, etc, are borne out in reality in Uganda

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ANNEXES

Annex 1. List of people met during the field mission

Name		Organisation	Position	Type of stakeholder
Werishe	Joseph	Uganda Coffee Development Authority (UCDA)	Regional Coffee Extension Officer- Eastern Region	Government
Lubuuka	David	Bududa District Local Government (DLG)	Chief Administrative Officer	
Wadada	Simon		District Agricultural Officer	
Namono	Marrion		District Environmental Officer	
Maduduya	Evelyn		District Planner	
Musaba	Charles Michael		Secretary District Land Board	
Odongo	Felix		Distrrict Production Officer	
Wabulo	W.I.	Bugisu Cooperative Union (BCU)	Ag. General Manager	Private Sector
Mabonga	Nathan		Treasurer	
Watira	Wilson		Director of Production and Commercialization	
Kotachi	Moses	Coffee a Cup (Mbale)	Coordinator	
Waboire	Peter		Project Officer	
Nabwaya	Stephen		Chairman / Bududa Section Manager	
Wamayeye	Willington	Gumutindo Management Agency Ltd	Managing Director	
	Simon	Kawacom Bududa	Unit Manager	
Lule	Samuel	Farmers (Low land)		Farmers
Tumakooko	Emmanuel			
Kuloba	Patrick			
Mukhwana	Boniface			
Namboka	Petronia			
Wandukwa	Miles	Farmers (Middle land)		
Wanasolo	Joram			
Wanabiti	Kalista			
Waraba	Paul			
Natseba	Thimothy			
	Nicholas	Farmers (High land)		
	Charles			
Masolo	Richard			
Namono	Doreen			
Nandutu	Margaret			
Nasila	Mary			
Nabutuwa	Miliselina			
Namome	Ester			
Nakamolo	Betty			
Buruwa	James			
Kuloba	Geresom			
Shinyale	Partrick			
Wandukwa	John			
Wambi	Joseph			
Bukuwa	Charleset			
Khalotsi	Partrick			
Kutosi	Robert			
Wambalo	Peter			
Watulo	Roger			
Wakoko	Sam			
Kituno	Elisafan			
Namatati	John			
Watsila	Moses			
Natsami	Martin			
Kamana	Henry			
Wambuko	Fred			

Annex 2. Information on coffee production collected during interviews in Bududa

Age of trees

There is no overall assessment of the average age of coffee trees in Bududa or the Mount Elgon region. In many cases coffee trees are very old (between 45 and 70 years) in the region. A significant number of trees are around 20 years old. This is a symptom of poor management, as trees should normally be stumped every four years.

Varieties

Three varieties of coffee are used in the Bududa District. SL14 or Nyasaland is the traditional and most used one, covering probably around 90% of the coffee area. Nyasaland is relatively resistant to pests, but is not particularly productive (it can provide 2/3 kg per tree per year under good management) and the beans are not especially big. KP423 is more recent, and although it can produce more per tree (around 4kg/tree/year under good management) and the beans are bigger, it is very fragile and dependent on fertilizer, which implies additional costs and risk, so is not very common in the area (probably around 8%). Katimo was introduced in the district 3 or 4 years ago. It provides very good yields in the first years, but is said to degrade the land to a significant extent. It is the least used variety in the region (probably around 2%). In the selection of varieties the path dependency must be taken into account. Nyasaland is the most resistant variety, in part because farmers already know how to manage it. It is important to note that the size of the bean is not so relevant: although the biggest beans are paid the best price, the difference in price with other sizes is not too big.

Quality

According to different companies, the quality of coffee is decreasing in Bududa. The manager of Kawacom affirms that the 'outan' (a term used to measure the quality of the coffee) has decreased from 75% in 2012 to 62% in 2014. Different causes of this decrease are mentioned, including (i) climate conditions those years, as has been discussed above, (ii) tendency to pick coffee that is not ready when demand is high, and (iii) the way post-harvesting activities, such as pulping and storing, are often conducted.

Prices

The price of coffee fluctuates significantly. The range goes between 1.32 and 2.64 US$/kg, fluctuating between 1.65 and 2.15 US$/kg most of the time, according both to farmers and the coffee buyers.

Buyer

According to the information collected in the field, farmers typically prefer to sell the coffee when they need, instead of being attached to a particular society. Middlemen, private companies (Kawacom, Coffee a cup) and co-operative societies (BCU and Gumutindo) operate in Bududa. According to interviewed farmers, prices are usually very similar between them, although co-operatives offer typically a slightly higher price.

BCU and Gumutindo are made up of farmers. They organize themselves in primary groups, which create small-scale cooperatives and, in turn the union. Policies are developed in participatory meetings, where the body of directors (one per area) is also elected. People interviewed consider that these co-operatives are more interested in promoting people than in making business. BCU, for instance, gives farmers 80% of the price and keeps only 20%. Gumutindo offers second payments, that is, gives some more money if the profit is high. In addition, they reinvest profit, by offering bonuses, such as scholarships and farmer inputs. In any case, the benefits offered to farmers by these cooperatives have decreased significantly, given that with so many players in the market these cooperatives are reluctant to invest in farmers that sell then their good quality coffee to other people.

Some companies, such as Kawacom, are said to offer little or no advantages to farmers. According to Kawacom's Regional Branch Manager, they advance up to 80% of the money and sundry facilities at no cost. If it is rainy, farmers bring coffee to sun dry to Mbale in order to avoid bad drying. Farmers do not need to pay for the transport, which is subsidized (a truck with capacity for 8 tonnes of coffee costs 400,000 UGX per day). Some farmers complain that some of these companies do not provide receipts and sometimes they end up not being paid.

Regarding the markets of destination, 90% of the beans of Bududa are sold, without roasting them, to international markets. BCU sells mainly to China, Russia and South Sudan, while Kawacom sells exclusively to the Netherlands. At the national scale, the enlarged EU is the main destination (68% of exports in 2011/2012), followed by Sudan (20%) and USA (10%) (Uganda Coffee Federation, 2012). 10% is roasted and sold for the national market.

Annex 3. Economics of Arabica coffee production in Bududa District

Table A1. Cost of coffee production in 1 ha area in 15 years period. Business as usual scenario. UGX

	Costs																			
				FYO	FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	FY9	FY10	FY11	FY12	FY13	FY14	G/Total	
No.	Items	Qtty	Rates	Total																
1	Bush clearing	1	20 000	20 000	0	0	0	0	0	0	0	0	0						20 000	0,05%
2	Land rent	1	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	375 000	5 625 000	14,86%
3	1st & 2nd Ploughing	2	40 000	80 000	0	0	0	0	0	0	0	0	0						80 000	0,21%
4	Marking and pitting holes for coffee	1 500	600	900 000	0	0	0	0	0	0	0	0	0						900 000	2,38%
5	Cost of seedlings	1 500	300	450 000	0	0	0	0	0	0	0	0	0						450 000	1,19%
6	Transporting seedlings	1	35 000	35 000	0	0	0	0	0	0	0	0	0						35 000	0,09%
7	Planting coffee seedlings	1 500	200	300 000	0	0	0	0	0	0	0	0	0						300 000	0,79%
8	Labour weeding (X3)	3	30 000	90 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	60 000	930 000	2,46%
9	Prunning (yearly from year 3)	1 500	50	0	0	75 000	75 000	75 000	75 000	75 000	75 000	75 000	75 000	75 000	75 000	75 000	75 000	75 000	975 000	2,57%
10	Stumping (50% year 6 & 50% year 8)	1 500	500						375 000		375 000				375 000		375 000		1 500 000	3,96%
11	Fertilizer application (X2/Yr)	600	200	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	1 800 000	4,75%
12	Pesticides	1,0	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000						1 000 000	2,64%
13	Fungicides	1,0	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000						1 500 000	3,96%
14	Spray pump (CP15)	1	150 000	150 000	0	0	150 000	0	0	150 000	0	0	150 000			150 000			750 000	1,98%
15	Labour for spraying	2,5	70 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	175 000	2 625 000	6,93%
16	Training for planting and maintenance	4	50 000	200 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	1 600 000	4,23%
17	Tools (pruning desuckering)	4	20 000	80 000			80 000				80 000				80 000				320 000	0,85%
18	Harvesting	1 500	300	0	0	135 000	450 000	450 000	315 000	180 000	0	0	225 000	135 000	450 000	450 000	315 000	180 000	3 285 000	8,68%
19	Pulping, drying and sorting	1 500	600	0	0	270 000	900 000	900 000	630 000	360 000	0	0	450 000	270 000	900 000	900 000	630 000	360 000	6 570 000	17,35%
20	Supervision costs	15	15 000	225 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	200 000	3 025 000	7,99%
21	Overhead cost (5%)	1	374 700	374 700	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	4 574 700	12,08%
	Total investment cost.			**3 824 700**	**1 580 000**	**2 060 000**	**3 235 000**	**3 005 000**	**2 975 000**	**2 345 000**	**2 110 000**	**1 655 000**	**2 480 000**	**1 810 000**	**3 210 000**	**2 905 000**	**2 725 000**	**1 945 000**	37 864 700	100,00%

Table A1. Return of coffee production in 1 ha area in 15 years period. Business as usual scenario. UGX.

Returns (Revenue projection)																	
Production (Kg/tree/year) - Adap Opt			0,00	0,00	0,30	1,00	1,00	0,70	0,40	0,00	0,00	0,50	0,30	1,00	1,00	0,70	0,40	
No of trees per Ha			1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	
Sale at 5,000/= per Kg (parchment)			5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	
Revenue/Reurn			**0**	**0**	**2 250 000**	**7 500 000**	**7 500 000**	**5 250 000**	**3 000 000**	**0**	**0**	**3 750 000**	**2 250 000**	**7 500 000**	**7 500 000**	**5 250 000**	**3 000 000**	**54 750 000**

Table A1. Cash flow of coffee production in 1 ha area in 15 years period. Business as usual scenario. UGX

Cash flow		**Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
Revenue			0	0	2.250.000	7.500.000	7.500.000	5.250.000	3.000.000	0	0	3.750.000	2.250.000	7.500.000	7.500.000	5.250.000	3.000.000	54.750.000
Operation costs			3.824.700	1.580.000	2.060.000	3.235.000	3.005.000	2.975.000	2.345.000	2.110.000	1.655.000	2.480.000	1.810.000	3.210.000	2.905.000	2.725.000	1.945.000	37.864.700
Cash flow			(3.824.700)	(1.580.000)	190.000	4.265.000	4.495.000	2.275.000	655.000	(2.110.000)	(1.655.000)	1.270.000	440.000	4.290.000	4.595.000	2.525.000	1.055.000	16.885.300
PV			-3.824.700	-1.245.677	118.100	2.090.087	1.736.695	692.985	157.301	-399.504	-247.050	149.465	40.826	313.827	265.013	114.813	37.821	

Source: Own calculations based on data collected in the field.

Table A2. Cost of coffee production in 1 ha area in 15 years period. Climate smart agriculture scenario. UGX.

Costs

No.	Items	Qtty	Rates	FY0 Total	FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	FY9	FY10	FY11	FY12	FY13	FY14	G/Total	
1	Bush clearing	1	20.000	20.000	0	0	0	0	0	0	0	0	0						20.000	0,02%
2	Land rent	1	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	5.625.000	5,77%
3	Marking and pitting holes for coffee	1.500	600	900.000	0	0	0	0	0	0	0	0	0						900.000	0,92%
4	Manur purchase (tipper truck)	10	50.000	500.000	0	0	500.000	0	0	0	500.000	0	0	0	500.000	0	0	0	2.000.000	2,05%
5	Loading and transporting manure	10	45.000	450.000	0	0	450.000	0	0	0	450.000	0	0	0	450.000	0	0	0	1.800.000	1,85%
6	Mixing and hole filling with manure	1.500	200	300.000	0	0	150.000	0	0	0	300.000	0	0	0	300.000	0	0	0	1.050.000	1,08%
7	Cost of seedlings	1.500	300	450.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	450.000	0,46%
8	Transporting seedlings	1	35.000	35.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35.000	0,04%
9	Planting coffee seedlings	1.500	200	300.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300.000	0,31%
10	Agro-forestry seedlings & transport	150	1.000	150.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150.000	0,15%
11	Pitting and planting trees	150	400	60.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60.000	0,06%
12	Mulching (grass and labour)	1,0	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	22.500.000	23,10%
13	Labour weeding (X3)	3	30.000	90.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	930.000	0,95%
14	Prunning (yearly from year 3)	1.500	50	0	0	75.000	75.000	75.000	75.000	75.000	75.000	75.000	75.000	75.000	75.000	75.000	75.000	75.000	975.000	1,00%
15	Stumping (50% year 6 & 50% year 8)	1.500	500			0	0	0	375.000	0	375.000	0	0	0	375.000	0	375.000	0	1.500.000	1,54%
16	Pesticides	1,0	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	1.500.000	1,54%
17	Fungicides	1,0	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	2.250.000	2,31%
18	Spray pump (CP15)	1	150.000	150.000	0	0	150.000	0	0	150.000	0	0	0	0	0	150.000	0	0	600.000	0,62%
19	Labour for spraying	2,5	70.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	175.000	2.625.000	2,69%
20	Training for planting and maintenance	4	50.000	200.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	1.600.000	1,64%
21	Tools (pruning desuckering)	4	20.000	80.000			80.000				80.000				80.000				320.000	0,33%
22	SWC trench construction (ave slope)	2,5	1.200.000	3.000.000															3.000.000	3,08%
23	SWC trench repairs (average slope)	2,5	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000	6.000.000	6,16%
24	Harvesting	1.500	300	0	0	360.000	1.237.500	1.237.500	1.035.000	450.000	450.000	787.500	787.500	1.237.500	1.237.500	1.035.000	675.000	675.000	11.205.000	11,50%
25	Pulping, drying and sorting	1.500	600	0	0	720.000	2.475.000	2.475.000	2.070.000	900.000	900.000	1.575.000	1.575.000	2.475.000	2.475.000	2.070.000	1.350.000	1.350.000	22.410.000	23,01%
26	Supervision costs	15	15.000	225.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	3.025.000	3,11%
27	Overhead cost (5%)	1	374.700	374.700	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	4.574.700	4,70%
	Total investment cost.			**9.984.700**	**3.360.000**	**4.515.000**	**8.477.500**	**7.147.500**	**6.915.000**	**4.935.000**	**6.490.000**	**5.797.500**	**5.797.500**	**7.147.500**	**8.852.500**	**6.690.000**	**5.835.000**	**5.460.000**	**97.404.700**	**100,00%**

Table A2. Return of coffee production in 1 ha area in 15 years period. Climate smart agriculture scenario. UGX

Returns (Revenue projection)

Production (Kg/tree/year)+Adap Opt			0,00	0,00	0,80	2,75	2,75	2,30	1,00	1,00	1,75	1,75	2,75	2,75	2,30	1,50	1,50	
No of trees per Ha			1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	
Sale at 5,000/= per Kg (parchment)			5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	
Revenue/Reurn			**0**	**0**	**6.000.000**	**20.625.000**	**20.625.000**	**17.250.000**	**7.500.000**	**7.500.000**	**13.125.000**	**13.125.000**	**20.625.000**	**20.625.000**	**17.250.000**	**11.250.000**	**11.250.000**	**186.750.000**

Table A2. Cash flow of coffee production in 1 ha area in 15 years period. Climate smart agriculture scenario. UGX

Cash flow		**Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
Revenue			0	0	6.000.000	20.625.000	20.625.000	17.250.000	7.500.000	7.500.000	13.125.000	13.125.000	20.625.000	20.625.000	17.250.000	11.250.000	11.250.000	186.750.000
Operation costs			9.984.700	3.360.000	4.515.000	8.477.500	7.147.500	6.915.000	4.935.000	6.490.000	5.797.500	5.797.500	7.147.500	8.852.500	6.690.000	5.835.000	5.460.000	97.404.700
Cash flow			(9.984.700)	(3.360.000)	1.485.000	12.147.500	13.477.500	10.335.000	2.565.000	1.010.000	7.327.500	7.327.500	13.477.500	11.772.500	10.560.000	5.415.000	5.790.000	89.345.300
PV			-9.984.700	-2.375.171	742.057	4.290.950	3.365.359	1.824.266	320.052	89.086	456.878	322.965	419.918	259.286	164.411	59.596	45.046	

Source: Own calculations based on data collected in the field.

Annex 4. Bududa District Local Government Proposed Five Years (2015/2016 – 2019/2020) Development Plan

Table A3. Bududa District Local Government Proposed Five Years (2015/16 – 2019/2020) Development Plan

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
Sector objective: Enhancing agricultural production and productivity to Household Incomes and improves Food and Nutrition Security of Bududa.														
Improve coordination of agricultural services in the district	Supervision and monitoring of field activities	Number of monitoring reports compiled	20	16 LLGs	16 LLGs	16 LLGs	16 LLGs	16 LLGs	5,000	PMA			DPO	
	Renovation and fencing of production office	No of office block renovated	2	District head quarters	District head quarters		District head quarters		20,000	PRDP			DPO	
	Departmental meetings-sector report writing and dissemination.	Number of meetings conducted and reports in place	20	Hqters	Hqters	Hqters	Hqters	Hqters	10,000	PMA	LR		DPO	
	Payment of general staff salaries	% of staff receiving		Hqters	Hqters	Hqters	Hqters	Hqters	261,420				DPO	

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Collab
		salary	100%							MOF				
	Preparation of work plans, Report writing and accountability for funds received.	Number of reports and works plans compiled	20	Hqters	Hqters	Hqters	Hqters	Hqters	10,000	PMA	LR		DPO	
	Meeting, workshops, seminars, study tours and radio talk shows	No of workshop conducted	20	Hqters 16 LLGs	Hqters 16 LLGs	Hqters 16 LLGs	Hqters 16 LLGs	Hqters 16 LLGs	25,000	PMA	LR		DPO	
	Provision of adequate, decent and well equipped office	No of bookshelves procured Office painted	5	Hqters	Hqters	Hqters	Hqters	Hqters	20,000	PMA	LR		DPO	
Policy issues	Review and harmonize all obsolete laws, rules, and legislations in the crops, livestock and fisheries sub-sectors.	Copy of Harmonized Sector review report												
	Design and implement HIV/AIDS and gender responsive programmes in each sec	No of HIV/AIDS and gender responsive programmes implemented each epicenter	10	2	2	2	2	2	10,000	PMG PRDP	LR			

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
Build capacity to respond to Climate Change	Integrate climate risk management in agricultural business strategies	Evidence of integration of climate risk management in agricultural business strategies												
	Celebration of world food day	No of celebrations conducted	5	Hqters	Hqters	Hqters	Hqters	Hqters	17,500	PMA	LR		DPO	
	Advertising and public relations	No of adverts conducted	10	Hqters	Hqters	Hqters	Hqters	Hqters	5,000	PMA	LR		DPO	
	Staff training	No of staff trained	5	1work shop at District	1work shop at District	1work shop at District	1work shop at District	1work shop at District	12,500	PMA	LR			
	Computer supplies and IT services	Computer supplied and serviced	5 laptops	4 (quarterly servicing District	4 (quarterly servicing District	4 (quarterly servicing District	4 (quarterly servicing District	4 (quarterly servicing District	25,000	PMA	LR			
	Stationary	Quantity of stationary procured	20	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	2,500	PMA	LR			
	Electricity	Bill paid	60	Monthly at the District	Monthly at the District	Monthly at the District	Monthly at the District	Monthly at the District	6,000	PMA	LR			

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
	Water	Water bill paid	60	Monthly at the District	Monthly at the District	Monthly at the District	Monthly at the District	Monthly at the District	500	PMA	LR			
	Travel in land	No of travels conducted	25	Quarterly 5 District	Quarterly 5 District	Quarterly 5 District	Quarterly 5 District	Quarterly 5 District	10,000	PMA	LR			
	Fuel	Quantity of fuel procured	5000 Ltr	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	20,000	PMA	LR			
	Maintenance of the motor vehicles	No vehicles maintained	1	1at the District	1at the District	1at the District	1at the District	1at the District	25,000	PMA	LR			
Sub sector: Crop														
Lower the incidences of diseases, pests and weeds	Set and operationalize standards for diagnostics, surveillance and control of pests and diseases including weeds	No. of Plants clinics Established and operational standards	9	3	3	3			20,000	PMG	LR	Don	DAO	
	Establish demonstrations on disease, pest and weeds control using agro chemicals	No of demonstrations set (e.g. Demonstrate on control of pests and diseases by	20	4	4	4	4	4	40,000	PMG PRDP	LR			

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,ooo (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
		Spraying of old coffee trees from coffee rust)												
Enhanced productivity of land through sustainable use and management of soil and water resources	Support ongoing activities for scaling up Sustainable Land management (SLM).	No of terraces and contour bans constructed	5	1	1	1	1	1	150,000	PMG PRDP	LR	Don	DAO	
	Establish demonstrations on small-scale irrigation technologies and rain water harvesting and management in districts	No of demos established	5	1	1	1	1	1	5,000	PRDP	LR	Don		
	Build capacity for development of appropriate farm structures as well as testing, adaptation, demonstration and promotion of appropriate farm equipment	No of soil testing kits acquired	5	1	1	1	1		10,000	PMG PRDP	LR	Don		
	Enhance PPPs for Agricultural Mechanization	Number of PPPs for agricultural mechanizatio n undertaken.												
Improve access to high quality inputs, planting and stocking materials	Build and strengthen institutions involved in input supply by strengthening input dealers capacity and network of professional	No of stockists and input dealers sensitized	36	10	-	12	-	14	3,000	PMG				

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
	dealers/stockists, and designing and implementing training courses for input dealers													
	Raise awareness among farmers on the value of adopting high quality inputs through designing and implementing training courses for farmers.	Number of farmers trained on good Farming practices	1000	200	200	200	200	200	10,000	PMG	LR			
	Establishment of demonstration plots for promoting improved inputs, and disseminating materials on agricultural inputs	No of demos organized for improved seeds (Banana, coffee, Irish potatoes, carrot etc.	20	4	4	4	4	4	40,000	PMG PRDP				
Accelerated development of selected strategic Commodities through value addition	Undertake value chain studies for Banana, Coffee commodities not yet studied to identify areas for intervention	Value chain studies reports on crop items studied	8	2	2	2	2	2	16,000	PMG PRDP				
	Workshops and seminars (meeting field staff)	No of meetings held at the district	25	5workshops District	5workshop s District	5workshops District	5workshops District	5workshops District	5,000	PMA	LR			

Strategy	**Intervention/Activity**	**Indicator**	**5 year Target**	**Timeframe/Location**					**Indicative budget,000 (UGX)**	**Sof**			**Implem. agency**	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Collab
	Fuel	Quantity of fuel procured	2,500 Ltr	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	10,000	PMG	LR			
	Data collection and analysis	No of sets of data collected and analysed	10	2	2	2	2	2	5,000	PMA	LR			
	Facilitate financing and construction of appropriate storage structures for post-harvest handling	No and types of storage facilities constructed												
	Enforce crop laws, regulations, standards and guidelines along the entire value chain	No enforcement carried out	60	12	12	12	12	12	60	PMG	LR			
	Monitoring and surveillance of pests & diseases		60	12	12	12	12	12	10,000	PMA	LR		DAO	
Sub sector :Veterinary sector														
Lower the incidences of diseases and vectors	Training and sensitization of farmers on animal health and how to control and prevent diseases.	No on animal related issues	1000	200	200	200	200	200	10,000	PMG			DVO	

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
	Routine vaccination of domestic animals and poultry	No of livestock vaccinated against FMD or LSD or Rabies	125,000	25000	25000	25000	25,000	25,000	20,000	PMG PRDP	LR		DVO	
	Prophylactic treatment of cattle, sheep, goats and pigs against tsetse flies	No of livestock treated against Nagana	6,000 H/cattle	2000	-	2000	-	2000	10,000	PMG			DVO	
	Procurement of Vaccine carries and automatic syringes	No of the equipment procured	20 cool boxes and 10 automatic syringes	10 cool boxes 5automatic syringes	-	-	10 cool boxes 5automatic syringes	-	3,680	PRDP PMG	LR		DVO	
	Disease surveillance, animal movement, Public Health inspections and enforcement of Veterinary law	-No of surveillance carried out -No of animals inspected -moved	20 surveillance 7200 inspected 4,800 animals	4 1440 960animals moved	4 1440 960animal smoved	4 1440 960animals moved	4 1440 960animals moved	4 1440 960animals moved	30,000	PMG	LR			

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Collab
			moved	within and without	within and without	within and without	within and without	within and without						
Improvement of quality of animal products	Construction of slaughter Houses at Bushika, sub county and Bunamubi trading centre	No slaughter house constructed	2	1	-	1	-	-	60,000	PRDP			DVO	
Increase milk production	Improvement of the breeds through Artificial Insemination	No of litres of Liquid nitrogen and semen procured	1000 litres and 10,000 straws of semen	200 litres of liquid nitrogen 2000 straws of semen	200 litres of liquid nitrogen 2000 straws of semen	200 litres of liquid nitrogen 2000 straws of semen	200 litres of liquid nitrogen 2000 straws of semen	200 litres of liquid nitrogen 2000 straws of semen	5,000	PMG			DVO	
	Establishment of improved pasture and legumes	No of sacs of grasses planted	48 sacs	-	12	12	12	12	1,920	PMG			DVO	
	Procurement of improved in calf dairy heifers, goats, pigs, Poultry for restocking	No of animals procured	320	64	64	64	64	64	800,000	PRDP	LR	DON	DVO	
	Undertake value chain studies for Dairy production not yet studied to identify areas for intervention	Value chain studies reports on animal resources studied	8	2	2	2	2	2	15,000	PMG PRDP	LR	Don	DVO	

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
	Workshops and seminars (meeting field staff)	No of meetings held at the district	25	5workshops District	5workshop s District	5workshops District	5workshops District	5workshops District	5000	PMA	LR			
	Fuel	Quantity of fuel procured	2,500 Ltr	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	10,000	PMG	LR			
Sub sector :Fisheries														
Increasing production and productivity of fish	Establishment of fish fry centre at the district	No of fish fry centre constructed	1	-	1	-	-	-	100,000	PRDP	LR	DON	Fis O	
	Training, sensitization and Demonstrations on modern methods of fish farming	Number of farmers using modern methods in fish farming	300	4 Sub counties	4 Sub counties	4 Sub counties	4 Sub counties	4 Sub counties	5,000	PMA	LR			
	Procurement of harvesting and sampling nets	No of seine nets purchased	5	1	1	1	1	1	20,000	PMG				
	Procurement of fish fries for 5 sub counties of Bududa Town council, Bududa, Bushika, Nalwanza, Nabweya, Bushiyi and Nakatzi	No of fish fries procured	50,000	10,000	10,000	10,000	10,000	10,000	25,000	PMG				

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
	Monitoring and surveillance of pests & diseases in fish		60	12	12	12	12	12	10,000	PMA	LR			
	Data collection and analysis	No of sets of data collected and analysed	10	2	2	2	2	2	5,000	PMG				
	Fuel	No litres procured	2500 lt	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	10,000	PMG	LR			
	Workshops and seminars (meeting field staff)	No of meetings held at the district	25	5workshops District	5workshop s District	5workshops District	5workshops District	5workshops District	5000	PMA	LR			
	Stationary	Assorted procured	Assorte d	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	10,000	PMG				
Sub sector : Entomology														
To increase honey production and productivity	Sensitization of farmers on honey production	Number of farmers involved in honey production	2000	5 Sub counties	5 Sub counties	5 Sub counties	5 Sub counties	5 Sub counties	10,000	PMA	LR	JICA		
	Demonstrations on modern methods of Bee Keeping by procuring demonstration and bee	Number of farmers using modern methods in	500	5 Sub counties	5 Sub counties	5 Sub counties	5 Sub counties	5 Sub counties	70,000	PMA	LR	JICA		

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab
	forage planting materials.	bee keeping												
	Workshops and seminars (meeting field staff)	No of meetings held at the district	25	5workshops District	5workshop s District	5workshops District	5workshops District	5workshops District	5000	PMA	LR			
	To improve on the production and quality of honey by procuring Bee hives, harvesting and processing equipment	No of sets of harvesting gears procured	5	1 sub county	1 sub county	1 sub county	1 sub county	1 sub county	150,000	PMA	LR	JICA		
	Workshops and seminars (meeting field staff)	No of meetings held at the district	25	5workshops District	5workshop s District	5workshops District	5workshops District	5workshops District	5000	PMA	LR			
	Monitoring and surveillance of pests & diseases		60	12	12	12	12	12	10,000	PMA	LR			
	Data collection and analysis	No of sets of data collected and analysed	10	2	2	2	2	2	5,000	PMA	LR	JICA		
	Fuel	No litres procured	2500 lt	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	10,000	PMG	LR			
	Stationary	Assorted procured	Assorte d	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	Quarterly at the District	10,000	PMG				

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,000 (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Collab
Sub sector: Commerce														
Promotion of access to financial institution by farmers	Sensitize/training farmers on group formation and farming as a business in 16LLGS	No of farmers sensitized	1000	200	200	200	200	200	5,000	PMA	LR			
	Training on record keeping and Auditing of SACCOS, PRIMARY SOCITIES ACES	No of well managed SACCOS,PRIMARY SOCITIES ACES	80	16	16	16	16	16	2,500	PMG	LR			
	Registration of SACCOS, PRIMARY SOCITIES ACES	No of SACCOS,PRIMARY SOCITIES ACES registered	50	10	10	10	10	10	2,500	PMA	LR			
Enhancement of revenue collection	Mapping out of all business premises in the district	No of business registered	1000	200	200	200	200	200	5,000	PMG	LR			
	Workshops and seminars (meeting field staff)	No of meetings held at the district	25	5workshops District	5workshops District	5workshops District	5workshops District	5workshops District	5000	PMA				
	Data collection and analysis	No of sets of data collected and analysed	10	2	2	2	2	2	5,000	PMA				

Strategy	Intervention/Activity	Indicator	5 year Target	Timeframe/Location					Indicative budget,ooo (UGX)	Sof			Implem. agency	
				2015/16	2016/17	2017/18	2018/19	2019/20		CG	LR	Don	Lead	Coll ab

Source: Bududa DLG