Climatic trends, risk perceptions and coping strategies of smallholder farmers in rural Uganda

Working Paper No. 121

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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NARO MAKERERE UNIVERSITY CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security CCAFS

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Abstract

Smallholder farmers in Uganda face a wide range of agricultural production risks, with climate change and variability presenting new risks and vulnerabilities. Climate related risks such as prolonged dry seasons have become more frequent and intense with negative impacts on agricultural livelihoods and food security. This paper assesses farmers' perceptions of climate change and variability and analyses historical trends in temperature and rainfall in two rural districts of Uganda in order to determine the major climate-related risks affecting crop and livestock production and to identify existing innovative strategies for coping with and adapting to climate-related risks, with potential for up-scaling in rural districts. The traditional coping strategies that have been developed by these communities overtime provide a foundation for designing effective adaptation strategies.

Drought, disease and pest epidemics, decreasing water sources, lack of pasture, bush fires, hailstorms, changes in crop flowering and fruiting times were the major climate-related risks reported across the two districts. Farmers use a wide range of agricultural technologies and strategies to cope with climate change and climate variability. Mulching, intercropping and planting of food security crops were among the most common practices used. Other strategies included water harvesting for domestic consumption, other soil and water conservation technologies and on-farm diversification. Farmers often use a combination of these technologies and practices to enhance agricultural productivity. The average maximum temperatures increased across the two districts. Trends in average annual rainfall showed mixed results with a general decline in one district and a relatively stable trend in the other district. Perceived changes in climate included erratic rainfall onset and cessation, which were either early or late, poor seasonal distribution of rainfall and little rainfall. Farmers also reported variations in temperatures. Farmers' perception of changing rainfall characteristics and increasing temperatures were consistent with the observed historical climatic trends from meteorological data.

Keywords

Agriculture; climate risks; livelihoods; vulnerabilities; coping strategies.

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Contents

Acronyms

GOU	Government of Uganda
NEMA	National Environmental Management Authority
RCM	Regional Climate Models
UBOS	Uganda Bureau of Statistics
UNHS	Uganda National Household Survey
WFP	World Food Programme

1. Introduction

Farming communities in East Africa face a wide range of agricultural production risks. For smallholder farmers in Uganda, climate change and variability presents new risks and vulnerabilities, including extended droughts and floods. Temperatures for the region during the 1990s were higher than they were earlier in the century and are currently between 0.2 and 0.3°C warmer than the 1961–90 average. While the Regional Climate Models (RCMs) agree that the region will become warmer, the degree of warming predicted is quite variable. The projected increase in rainfall in the region, extending into the Horn of Africa, is robust across RCMs, with 18 of 21 models projecting an increase in the core of this region, east of the Great Lakes (Christensen et al. 2007).

The anticipated impacts of climate change in East Africa include an increase in frequency and severity of droughts leading to severe water shortages, floods in some areas, increased incidence of pests and diseases, and decline in crop yields. Other expected impacts are increased risks of food shortage and famine, and changes in planting dates of annual crops, and decline in biodiversity. The severe drought in 2010–2011 in the Greater Horn of Africa, for example, affected nearly nine million people mainly in Somalia, Kenya and Ethiopia (WFP 2011). The impacts of climate change and variability in East Africa are compounded by existing development challenges of high population growth rates, high and increasing poverty levels, low per capita incomes, high levels of inequality and declining GDP growth rates.

In Uganda, a large proportion of the population depends on agriculture for their livelihood, with agriculture contributing up to 22% of the GDP and supporting 66% of the working population (UBOS 2013, NEMA 2008, GOU 2007). Agricultural production in Uganda is almost entirely rain-fed (GOU 2007, Komutunga and Musiitwa 2001) and therefore marked by seasonality and negatively affected by extreme weather conditions. The farming systems are diverse, ranging from livestock based systems in semi-arid regions to crop-livestock mixed farming systems in temperate and humid regions. While the immediate impacts of climate change on overall agricultural production in Uganda are likely to be less severe than in other countries in East Africa, the local impacts are likely to vary by farming system (van de Steeg et al. 2009).

Farming communities in Uganda as elsewhere in East Africa are increasingly facing a wide range of agricultural production risks and these can sometimes differ from climate-related risks. For instance, low productivity can be attributed to non-climatic factors such as limited use of external inputs, nutrient mining and soil erosion, as well as climate-related droughts, and pests and disease factors. In recent years, weather patterns have become more erratic impacting negatively on soil moisture content leading to either reduced yields or total crop failure (Mubiru et al. 2012, Mubiru et al. 2009). These events are closely associated with climate change and variability. Rainfall patterns are highly variable, both within and between seasons. The erratic onset and cessation of rains makes it difficult for farmers to take advantage of timely planting of crops. Instances of frequent crop failures are increasingly becoming eminent (GOU 2007). Climate change and variability pose adverse impacts on food security and livelihoods, especially of the rural poor (GOU 2007).

Farming communities and households in rural Uganda have developed several adaptation options overtime to cope with current climate variability (DanChurchAid 2010, Anderson and Robinson 2009). For example, traditional methods of grain storage are widely used to cope with periods of hunger and to secure seed for successive crops following severe droughts. But such methods were less effective during periods of disease and pest attack and sometimes resulted in whole losses of food and seed. In Uganda, communities and households are continuously learning to adjust to changing conditions by adapting to new practices to control grain and seed borne pests and diseases. However, some of these changes to local practices are marginal rather than transformational in nature. Kristjanson et al. (2012) find little uptake of improved soil, water and land management practices, even when these were often cited to have great potential to contribute to improved food security (www.actionaid.org, Majaliwa et al. 2009). Moreover, these strategies may only be useful in the short term and not sufficient to address future changes in climate (Boko et al. 2007, Orindi and Murray 2005). The capacity of indigenous knowledge and traditional coping practices in adapting to climate variability is likely to be surpassed by the magnitude of changes expected from increased risk exposure.

In order to develop effective strategies for managing and coping with extreme weather and climate variability, there is need for farmers to differentiate climate-related risks from other agricultural production risks. We hypothesize that a better understanding of climate-related risks, as well as their impacts on crop and livestock production is the basis for continuous learning and selection of farmer innovations that are likely to enhance adaptive capacity of communities in the rural districts of Uganda. This paper assesses farmers' perceptions of climate change and variability, and analyses historical trends in temperature and rainfall in order to:

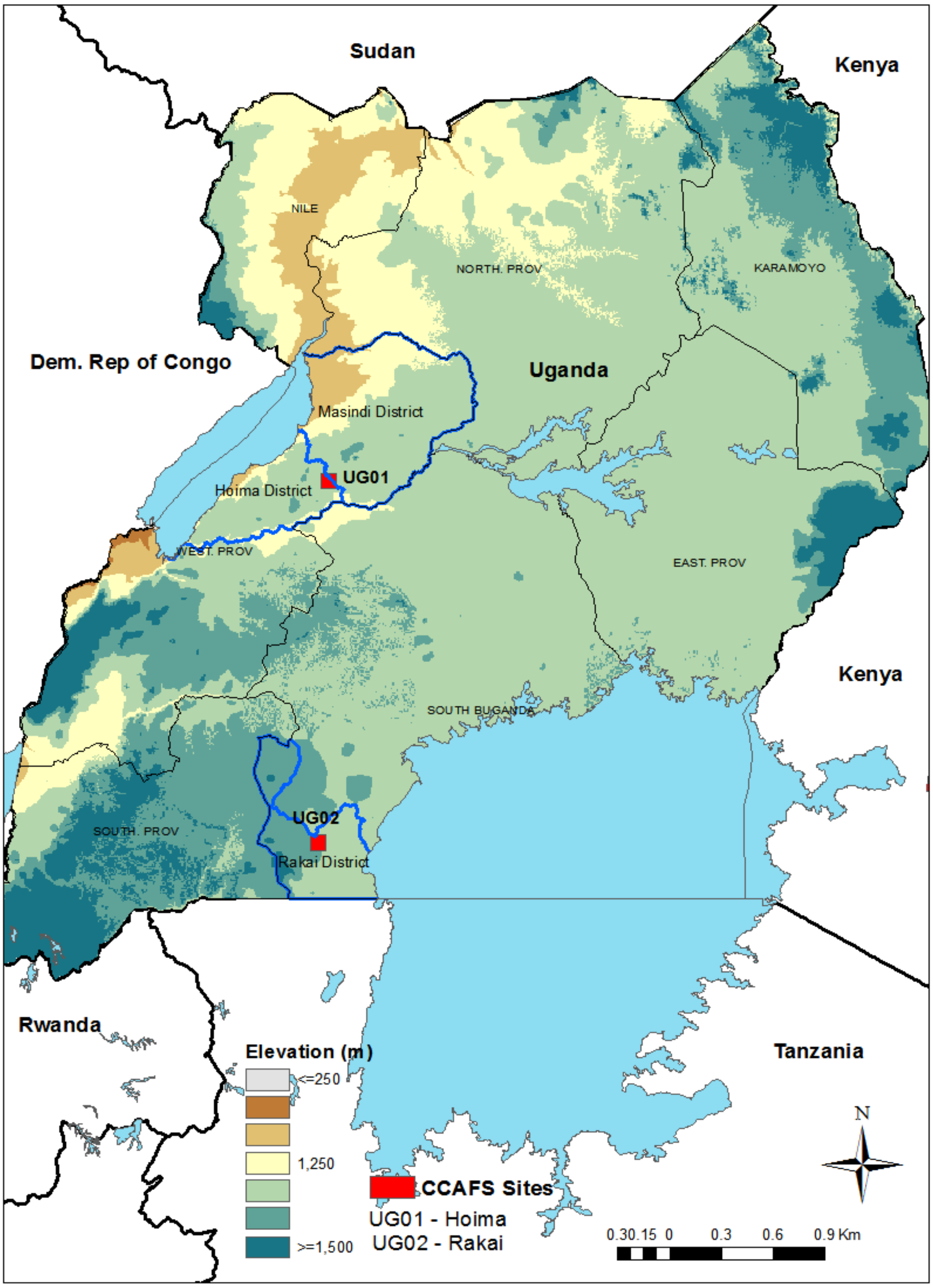
- Understand farmers perceptions of climate change at the local scale and whether this is consistent with historical or observed trends in rainfall and temperature patterns;
- Determine the major climate-related risks affecting crop and livestock production;
- Identify existing innovative strategies for coping with and adapting to climate-related risks, with potential for up-scaling in rural districts.

2. Methods

This study uses data collected from two rural districts of Rakai and Hoima in Uganda (Figure 1). These districts represent diverse agro-ecological, production, social and institutional settings and are representative of East African farming systems (perennial, annual and pastoral farming systems). Majority of the population across the two districts depend on rain-fed agriculture for their livelihoods, with over 85% of the people engaged in subsistence crop (maize, beans, banana) and livestock (cattle, goat, sheep, chicken) production. While the overall poverty levels, measured as the percentage of individuals estimated to be living below the poverty line, have significantly declined in Uganda over the last five years, poverty incidence in the rural areas remain high at 27.2% (UNHS 2010). In the two rural districts, poverty levels have declined over the years but still remain high ranging from 11.2% in Rakai to 25.3% in Hoima compared to the national average of 24.5% (UNHS 2010).

Rakai District is located in the south central region of Uganda, west of Lake Victoria. The district covers an area of 4,909 km^2 with an estimated population of 484,400 (UBOS 2013). The rainfall pattern is bimodal, spread over two growing seasons: March – May and September – December. Average annual rainfall ranges from 915 to 1,021 mm, while the temperature ranges from 12.5 to 30^{o}C (GOU 2004). The district also experiences severe dry spells in the periods June – August and January – February.

Figure 1. Map of Uganda showing Hoima and Rakai districts



Hoima District is located in western Uganda, east of Lake Albert. The district lies within an altitude range of 621 and 1,158 m above sea level, and is one of the lowest and hottest areas in the country. The district occupies an area of 5,933 km^2, with an estimated population of 548,800 (UBOS 2013). In contrast to Rakai, about 38% of the total area is occupied by water bodies (mostly Lake Albert) and 21% is forested. Average annual rainfall is about 1,270 mm with high spatial variability, ranging from about 800 to 1,400 mm (GOU 2004). Rainfall distribution is bimodal. The main rainy season is from August – November and the secondary season is from March – May (GOU 2004). Temperatures are usually high ranging from 15 to 30°C.

To better understand climate-related risks and their impacts on crop and livestock production in the two rural districts, we used household surveys and historical climate data, and information from focus group discussions. The household surveys build on initial baseline surveys conducted by CCAFS in 2010 (Mubiru and Kristjanson 2012, Kyazze and Kristjanson 2011). In each district, the household surveys were carried out in three villages, purposively selected to represent the CCAFS blocks. In each village, households were randomly selected from a complete list of all households in the village which had been generated earlier and used in the CCAFS baseline surveys. Data were collected from 120 households in total (60 from each district). The survey collected information on demographic characteristics, wealth indicators, livelihood, and land-use patterns.

The historical climatic data on rainfall and temperature from 1938 to 2012 were from weather stations close to the two sites (Kyotera and Kibanda in Rakai, and Bulindi in Hoima). The focus group discussions with mixed groups of men and women (42% men and 58% women) were used to triangulate the historical and survey data. Other secondary data sources used included Kristjanson et al (2012), Mubiru and Kristjanson (2012), Kyazze and Kristjanson (2011), Jost (2011) and UBOS (2009). Different statistical programs were used to analyse the annual and seasonal trends in rainfall and temperature and the household survey data.

3. Results and discussion

3.1 Demographic characteristics and wealth indicators

The demographic characteristics of the respondents and households in the study sites are summarized in Table 1. Households had varying demographic characteristics. Majority of the respondents across the two rural districts were male (56.7% in Hoima and 65% in Rakai). Similarly, more than three-quarters of the households across the two districts were headed by men. In Uganda, men are responsible for making decisions regarding livelihood activities, so a larger fraction of males indicates their dominance in farm-level decision making across the two districts. Nearly 80% of the household heads had attained primary level of education, with very few household heads having attained tertiary education. Most of the household heads were middle-aged with a mean age of 44 years for Rakai and 47 for Hoima. Average family size ranged from seven persons in Hoima to eight persons in Rakai.

Table 1. Demographic characteristics

Demographic characteristics	Hoima	Rakai
Sex of respondent (%)		
Male	56.7	65
Female	43.3	35
Household type (%)		
Male headed	76.7	81.7
Female headed	23.3	18.3
Education level (%)		
None	15.0	13.3
Primary	70.0	48.3
Secondary	10.0	31.7
Tertiary	5.0	6.7
Mean household size		
No. persons in household	6.82	8.20
No. of young dependents (<15 years)	1.93	3.04
No. of people of working age (15 to 64 years)	1.79	1.76
No. of old dependents (>64 years)	0.37	0.12
Age of household head (years)	47.0	44.0
Dependency ratio	1.3	1.8

The dependency ratio was relatively high, ranging from 1.3 in Hoima to 1.8 in Rakai. In 2009/2010, the national dependency ratio (young and old) in the population in rural areas was estimated to be 1.26 (UNHS 2010), constituting 126 dependents for every 100 persons in the working age group. High dependency ratio slows productivity and economic growth and also increases socioeconomic vulnerability. However, it can be argued that high dependency by old persons is more worrisome than dependency by young persons, because the old persons are expected never to get back into the workforce while the young ones are continuously graduating into the workforce.

Household wealth indicators are summarized in Table 2. Indicators used to assess the wealth status included type of housing (type of wall and roofing materials used), land ownership, mode of transportation to market and group membership. Across the two districts, more than three-quarters of the households had iron-roofed houses. However, the proportion of households (48.3%) with houses with walls made of mud and wattle was relatively high in Hoima compared to Rakai where at least 80% of the households had houses with walls made of bricks. Average land size ranged from 4.3 acres in Rakai to 5.4 acres in Hoima district, and is comparable to the national average land holdings of 5 acres (Kisamba-Mugerwa 2001). In both districts, the common mode of transport was bicycles. Nearly 7 out of 10 individuals in Hoima ride a bicycle while 5 out of 10 individuals in Rakai will walk to the market. In both districts, motorcycles—commonly referred to as *boda bodas* —are a significant means of transportation and are faster compared to bicycles. Membership to a group is perceived as a social investment, and individuals belonging to such groups retain more social capital compared to those not belonging to any group or association. More households in Rakai than Hoima belonged to a farming group.

Table 2. Wealth indicators

Wealth indicators	Hoima	Rakai
Type of wall for main house (%)		
Mud and wattle	48.3	16.7
Wood panel	5.0	3.3
Bricks	46.7	80.0
Type of roof for main house (%)		
Grass thatched	21.7	1.7
Iron roofed	78.3	98.3
Household mode of transportation to market (%)		
Own bicycle	70.2	53.3
Own motor cycle	10.5	11.7
Hired motorcycle (*Boda boda*)	24.6	40.0
Own truck	7.0	5.0
Walk/Pedestal	54.4	65.0
Group membership (%)		
Has membership	15.0	55.0
Has no membership	85.0	45.0
Average amount of land owned in acres	4.3	5.4

3.2 Livelihood and land use patterns

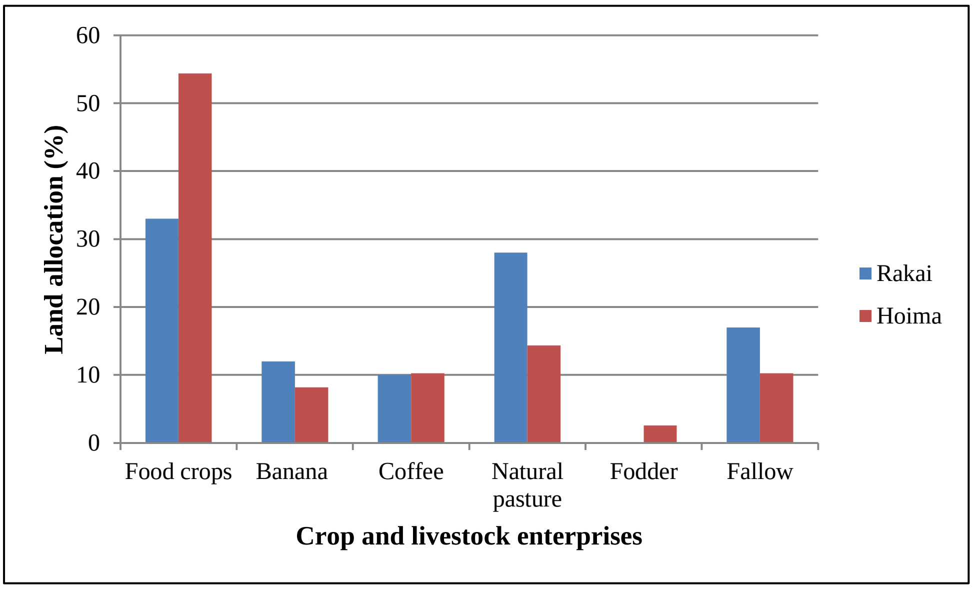
Understanding the effect of climate change on land use patterns and its implication for food security is important as a strategy to devise options to mitigate the impacts. Significant changes in land use are predicted among the farming communities in East and Central Africa (ECA) due to climate change and other drivers, including increasing populations (van de Steeg et al. 2009). Crop and livestock production are among the predominant livelihood activities across the two districts. Table 3 shows how farmers allocate land to different crop and livestock enterprises. There were similarities in the types of crops grown across the two districts. A large proportion of land, more than half, is allocated to crop production compared to livestock production (Figure 2).

Banana and coffee were the most important crops in Rakai, allocated the largest acreage of approximately one acre. These two crops are usually intercropped and farmers attach a lot of social and economic value to them. In contrast, maize; potatoes; and coffee were the most important crops in Hoima. The three crops were allocated the largest acreage, attributed to their economic and food security values in the district. There was increased allocation of land to seasonal crops such as beans, cassava and sweet potatoes in both districts. Beans and sweet potatoes are early maturing crops whereas cassava is more drought-tolerant and performs well in times of reduced rainfall as has been the case due to climate variability and change. This implies that farmers have adapted to climate change by spreading the risk through planting early maturing crops e.g. beans and sweet potatoes and drought-tolerant crops like cassava.

Table 3. Land allocation to crop and livestock enterprises

Agricultural enterprise	Mean acreage per household	
	Rakai (n=60)	Hoima (n=60)
Crops		
Bananas	1.2	0.8
Beans	0.7	0.7
Maize	0.7	1.1
Cassava	0.4	0.8
Sweet Potatoes	0.5	0.7
Potatoes	0.7	1.2
Coffee	1.0	1.0
Groundnuts	0.3	0.8
Livestock		
Natural pasture	2.8	1.4
Fodder	-	0.25
Fallow	1.7	1.0

Figure 2. Land allocation to different enterprises



Cassava, maize, sweet potatoes and sorghum are important crops in ECA, closely followed by rice, banana (or plantain), potatoes and beans (van de Steeg et al. 2009). Each of these crops is affected differently by climate variability and will be affected differently by climate change. In Uganda, maize, cassava and sweet potatoes are grown in areas that are projected to experience moderate losses due to climate change by 2050. In order to prevent these losses there will be need to introduce alternative crop varieties and crop substitution, as well as a change in livestock feeding practices.

Livestock production is also an important source of livelihood. Cattle, goats, pigs and poultry were among the livestock species kept by the household (Table 4), with no differences observed in average livestock holdings across the two sites.

Table 4. Average livestock holdings per household

Type of livestock	Average number of livestock per household	
	Rakai (n=60)	Hoima (n=60)
Cattle	3	5
Goats	4	3
Pigs	3	2
Chickens	10	10

3.3 Rainfall and temperature trends

This section looks at the rainfall and temperature trends, including variability in Rakai and Hoima districts over the period 1938–2012.

Rainfall trends and variability

Average monthly rainfall data shows that both districts experience a bi-modal distribution within the year (Figures 3 and 4). Peak rainfall seasons in Hoima are between March–May and August–November. Rainfall patterns for Rakai are similar to Hoima though with a slight difference, where peak rainfall seasons are between March–May and October–December. January, February and December are fairly dry months in Hoima, while in Rakai, February, June, July and August are also fairly dry months. The sharp peak in the March–May rainy season at both sites means that rains are more likely to come and disappear quickly while there is a more even distribution in the second season. The length of the growing period seems to be longer in the second season across the two sites.

Figure 3. Distribution of average monthly rainfall from 1938–2012 at Bulindi in Hoima district

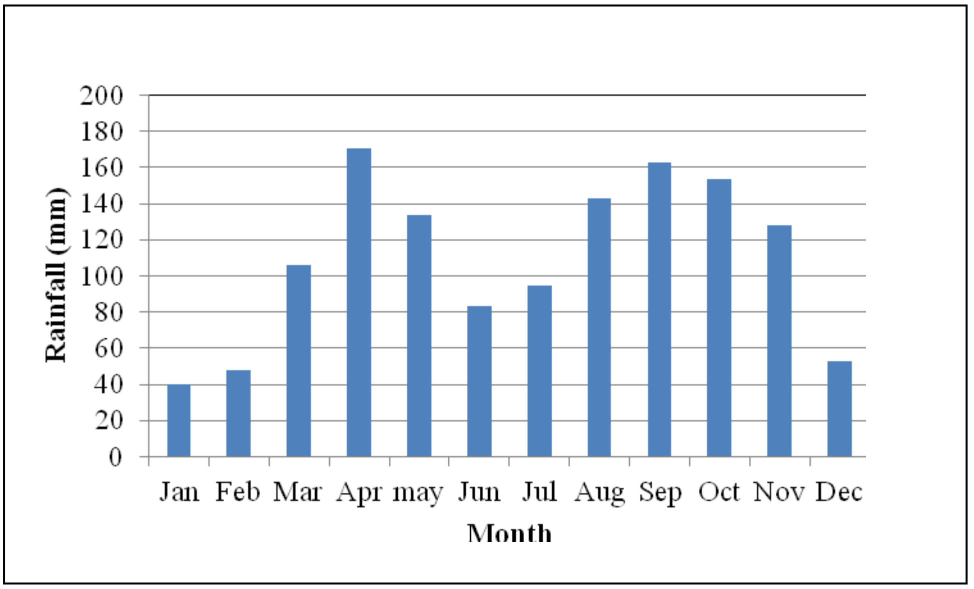
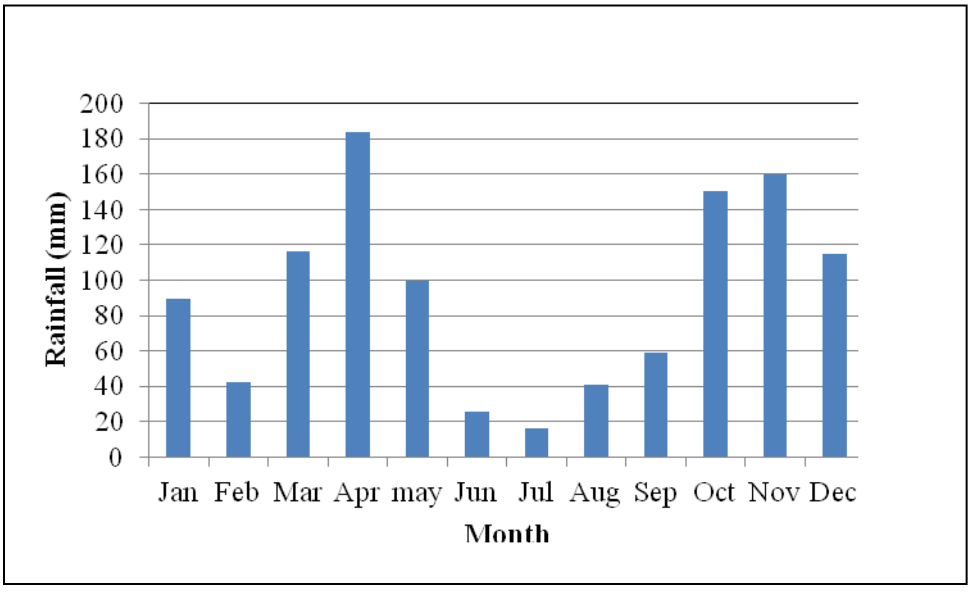


Figure 4. Distribution of average monthly rainfall from 1998–2007 at Kyotera in Rakai district



Trends in average annual rainfall are shown in Figures 5 and 6. Figure 5 shows a general declining trend in annual rainfall at Bulindi in Hoima district. The results for Kyotera in Rakai district show a relatively stable average annual rainfall trend (Figure 6). Total monthly rainfall over the years reveals a declining trend in monthly rainfall for all the months except January, March and August at Bulindi in Hoima district (Figure 7). At Kyotera in Rakai district, all the months with the exception of June, July, November and December reveal a declining trend in monthly rainfall (Figure 8).

Figure 5. Average total annual rainfall trend at Bulindi in Hoima district

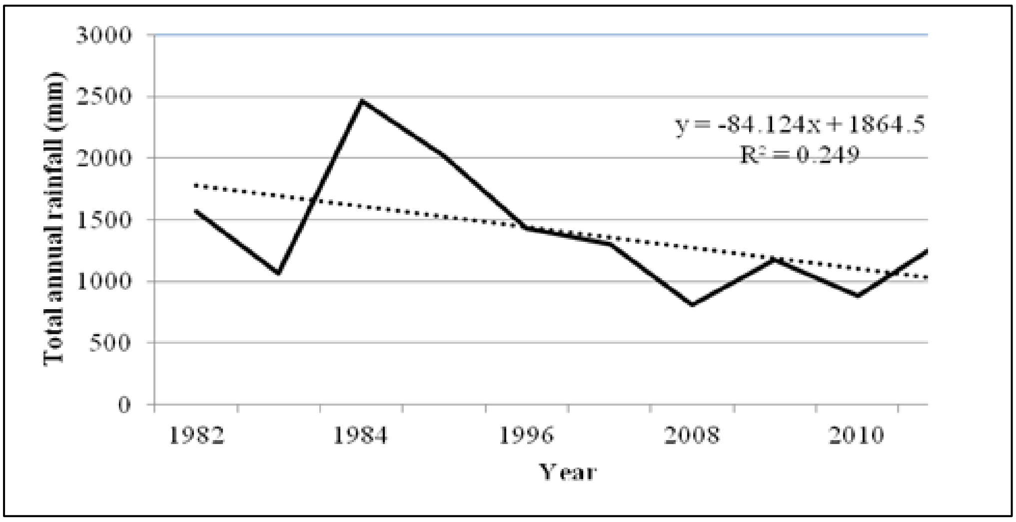
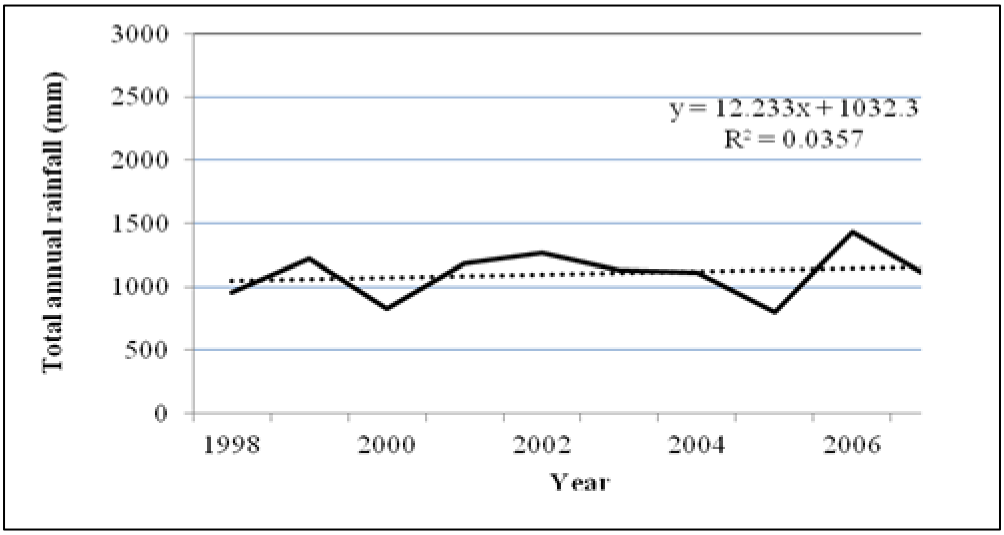


Figure 6. Average total annual rainfall trend at Kyotera in Rakai district



At Bulindi, the number of rainy days shows a decreasing trend for the months of February, May, June, August and October (Figure 9), while the others either have a stable trend (July) or an increasing trend. At Kyotera, (Figure 10), there was a decreasing trend in the number of rainy days for all months except June, July and November.

Figure 7. Trend in monthly rainfall amount from 1982-2011at Bulindi in Hoima district

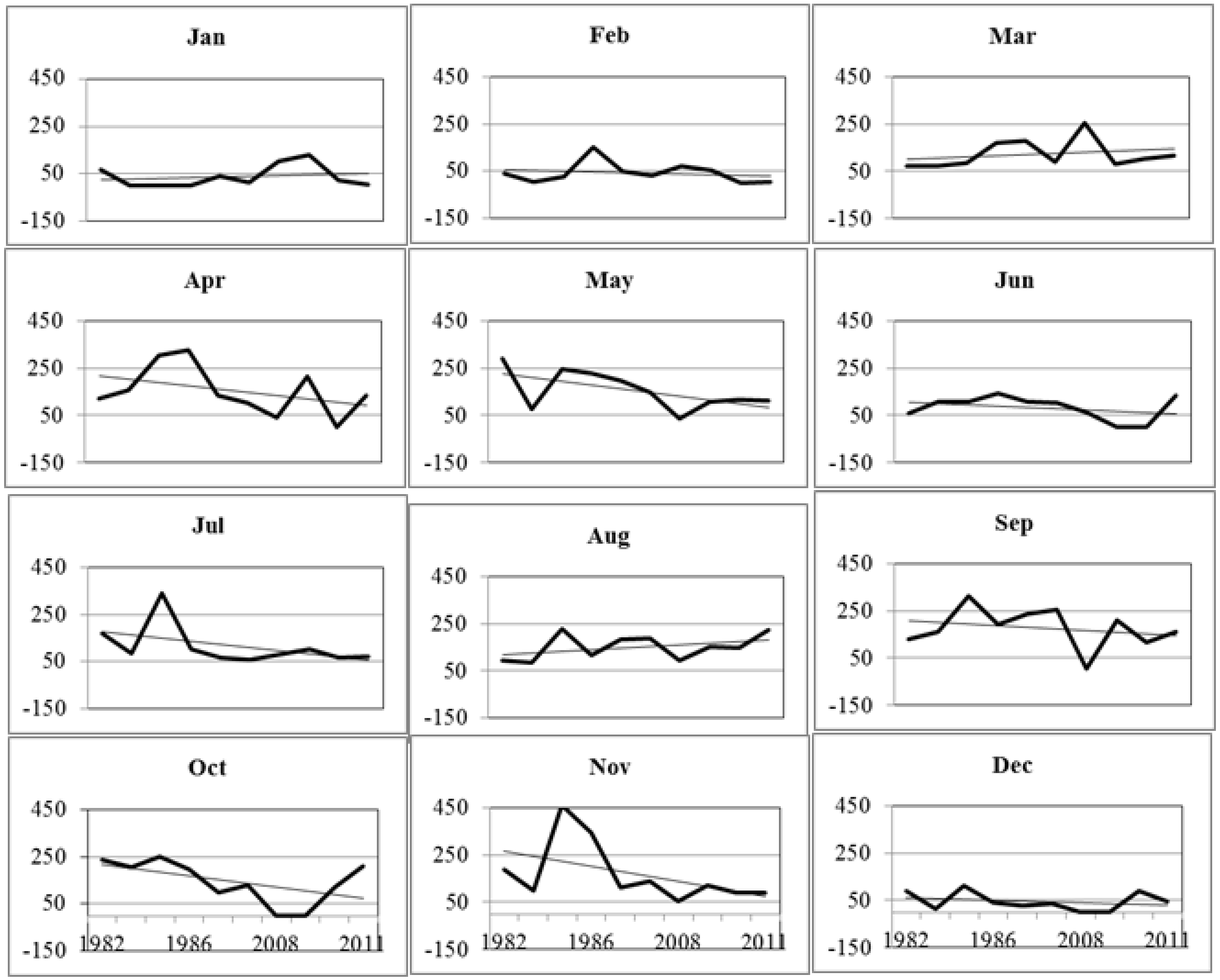


Figure 8. Trend in monthly rainfall amount from 1998-2007 at Kyotera, Rakai district

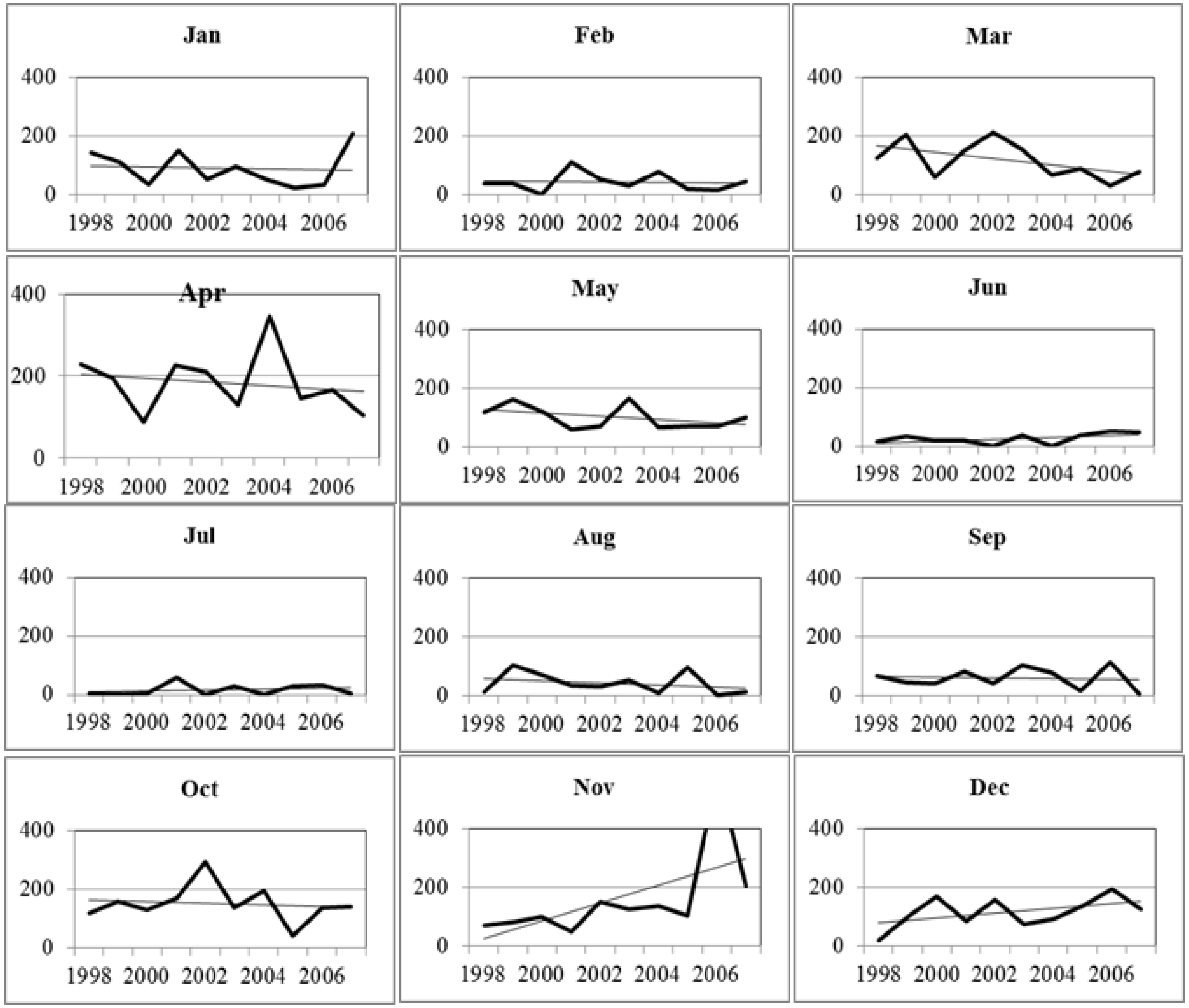


Figure 9. Trends in number of rainy days from 1977-2011 at Bulindi in Hoima district

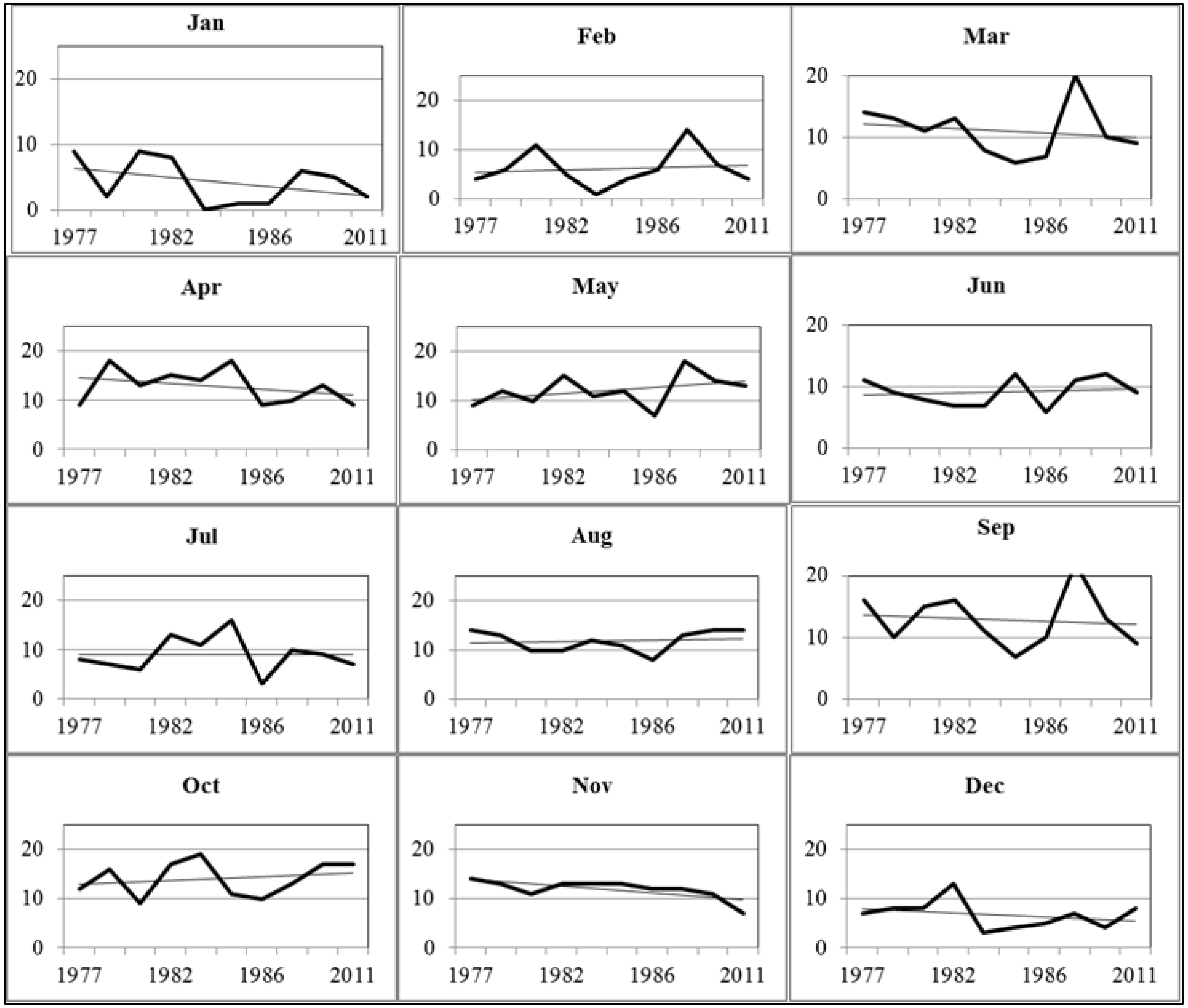
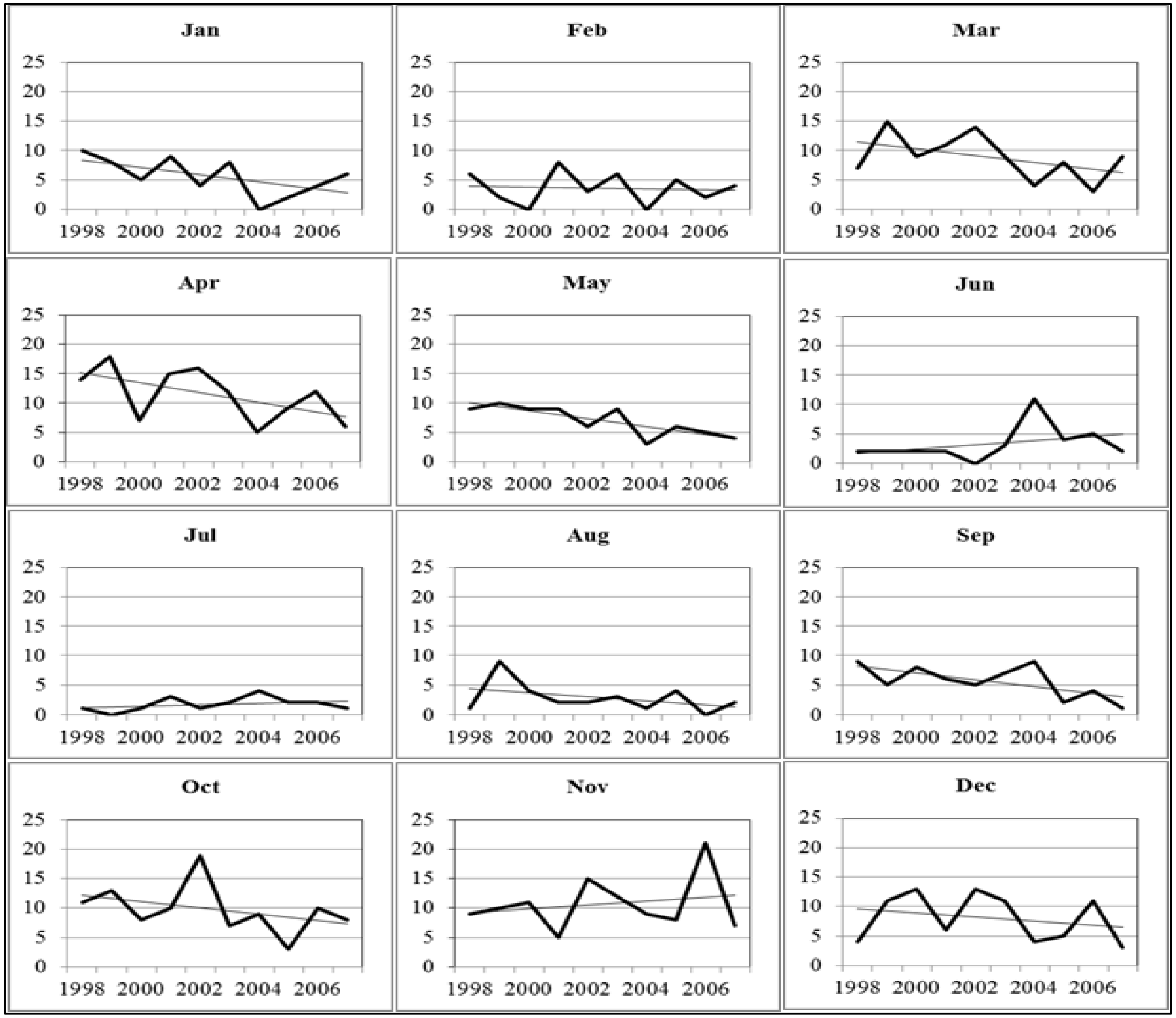


Figure 10. Trends in number of rainy days from 1998-2007 at Kyotera in Rakai district



Jennings and Magrath (2009) observed that, within recognizable seasons, unusual and unseasonable events are occurring more frequently, for example, heavy rains in dry seasons, dry spells in rainy seasons and storms at unusual times. The changes in monthly rainfall and rainy days have significant impact on farm level activities across the entire value chain, ranging from pre-production, production, post-harvest and marketing. During the production stage the changes are more pronounced if these spikes of moisture stress occur at the critical biological stages.

Temperature trends

Trends in average annual maximum and minimum temperatures from 2007–2012 are shown in Figures 11 and 12. There has been an increase in the average maximum temperatures across the two districts. Although Rakai is located in the dry-lands (commonly referred to as the cattle corridor) the mean maximum temperature on average is 2.7°C lower than in Hoima. As earlier stated, due to its geographical location, Hoima is one of the hottest areas in Uganda. Between 2007 and 2012, the average maximum temperature increased by 0.8°C in Hoima and by 0.5°C in Rakai. The increase in temperatures is consistent with historical trends in mean temperature for East Africa. During the last century, Africa as a continent has had a decadal warming of about 0.05°C with slightly larger warming in the June-November seasons than in December-May (Hulme et al. 2001).

Figure 11. Trends in average annual maximum temperatures at Hoima (Bulindi) and Rakai (Kyotera) from 2007-2012

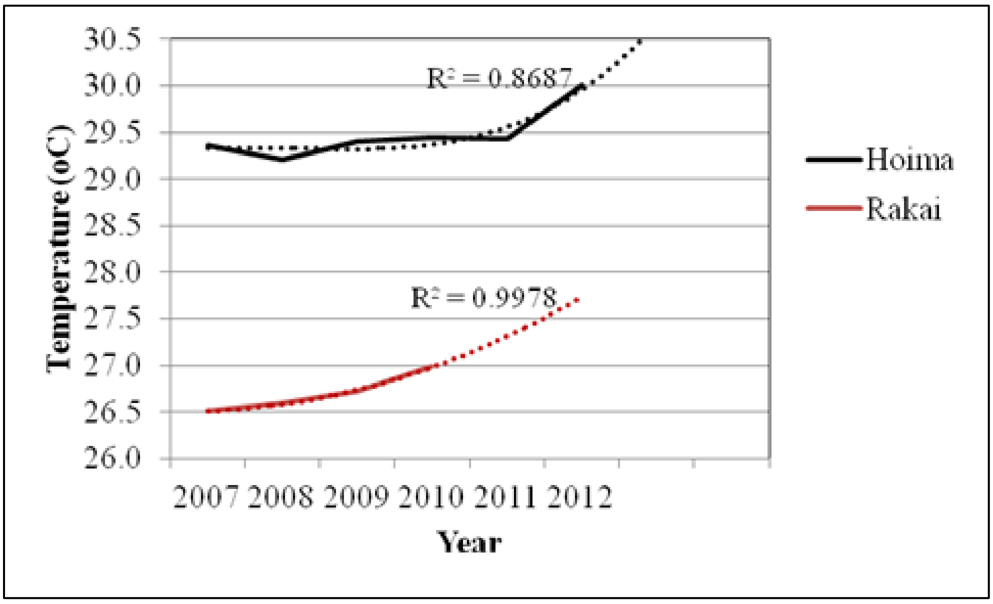
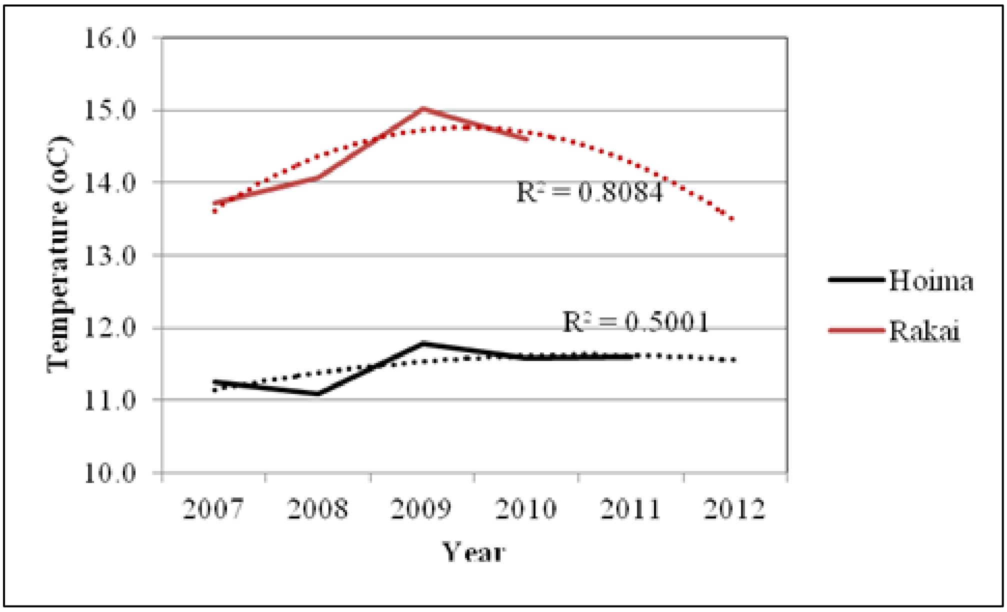


Figure 12. Trends in average annual minimum temperatures in Hoima (Bulindi) and Rakai (Kyotera) from 2007-2012



While the average maximum temperatures at both sites show a quadratic increasing trend, the average minimum temperatures show quadratic declining trends. Although Hoima had higher average maximum temperature, it had a lower average minimum temperature. Other studies have reported that the global mean temperature has increased in a linear trend of 0.74°C over the last 100 years (Schneider et al. 2007). Increase in temperature may influence the length of the growing season, especially in temperate regions. Higher temperatures also increase the atmospheric demand for moisture, or potential evapotranspiration (PET). In areas where average annual maximum temperature will increase from under 30°C to over 30°C, rice and maize yields and other staple crop yields will suffer (Ziervogel and Ericksen 2010). Grazing resources, food safety and disease transmission patterns are also likely to be affected.

3.4 Farmers' perceptions and knowledge of climate change

In this section, we explore farmers' perceptions of climate change and the major climate-related risks over the past 30 years and how these perceptions relate to the observed trends in rainfall and temperature discussed in the previous section. Global weather and climate patterns have changed and continue to change. How are these changes perceived, interpreted and expressed by local farmers in Uganda?

Respondents were asked whether they had noted any changes in weather patterns over the last 5 to 30 years. Majority of the respondents reported changes in the weather patterns. Farmers' perceptions of rainfall onset and cessation, amount and distribution of rainfall, and temperature across the two districts are summarized in Figures 13 to 17. Perceived changes in weather patterns by farmers included erratic rainfall onset and cessation, which was described as either early or late; poor rainfall seasonal distribution; and little rainfall. Majority of the respondents (55%) across the two sites reported late onset of rain. On average, 40% reported variable onset of rain (oscillating from early, normal or late). Overall, less than 10% of the farmers reported early and normal onset of rains. Okonya et al. (2013) found that the proportion of households reporting late onset of rains (47%) were nearly equal to those reporting early onset across six agro-ecological zones[1] in Uganda. In addition, farmer perception of climate change was influenced by the agro-ecological zone.

Farmers' perceptions of rainfall cessation were categorized as early, normal and late. There were, however, mixed perceptions of rainfall cessation across the two sites. Majority of respondents (81.6%) in Rakai reported early rainfall cessation compared to 35% in Hoima. In contrast, majority of the respondents (41.7%) in Hoima reported late cessation relative to 15.3% in Rakai. Late onset of rainfall coupled with early cessation, as reported by majority of the respondent in Rakai, leads to a shorter growing season. This coupled with the increasing mid-season droughts (Table 5) increases the risks in smallholder farming.

[1] The six agro-ecological zones included the Northern farming system, South Western Highlands, Western Rangelands, Lake Albert Cresent, East Savannah and Lake Victoria Cresent.

Figure 13: Rainfall onset

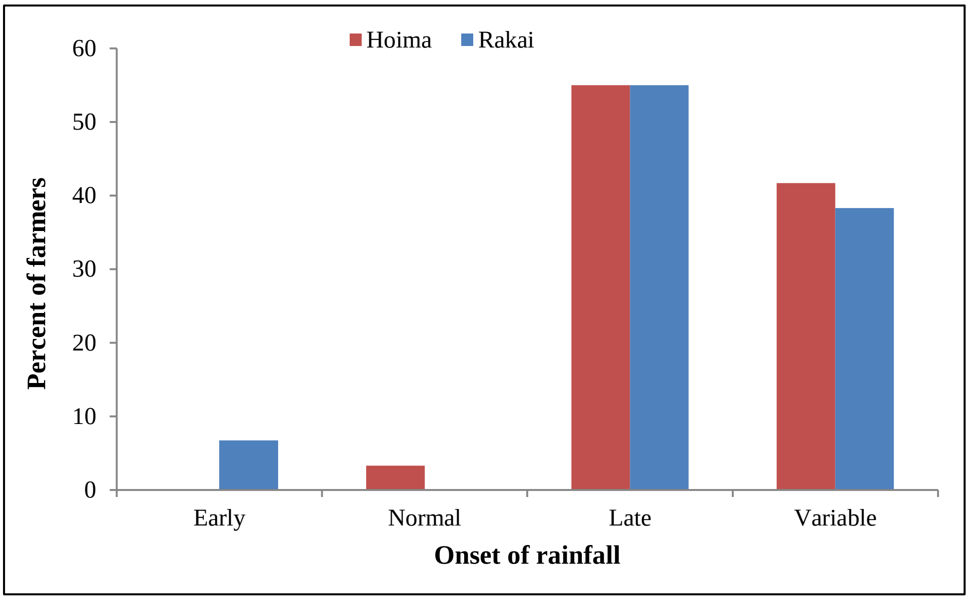
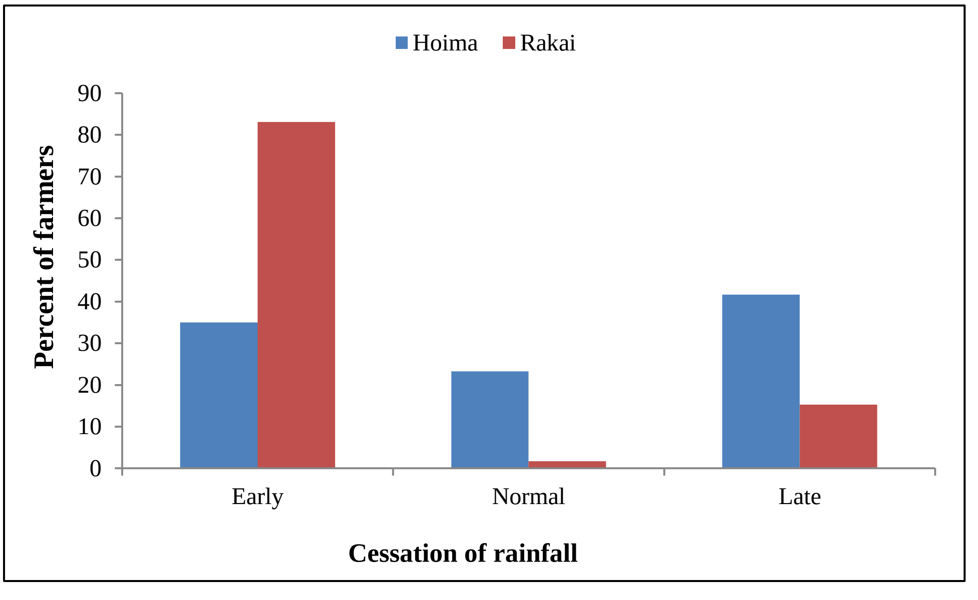


Figure 14: Rainfall cessation



Farmers' perceptions of seasonal distribution of rainfall were divided into five categories: normal, more in first season, more in second season, mid-season droughts, and variable (Figure 15). Majority of respondents, on average 45% reported variable distribution of rainfall, that is, either normal, more in first or second season. This was followed by mid-season droughts, averaging 24.2%. A smaller proportion reported a normal rainfall pattern.

Figure 15. Seasonal distribution of rainfall

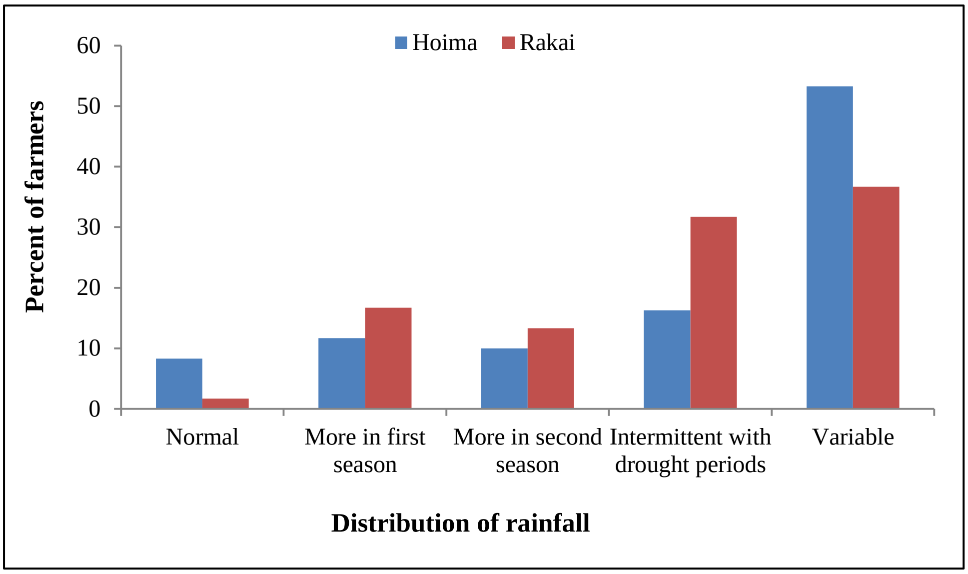
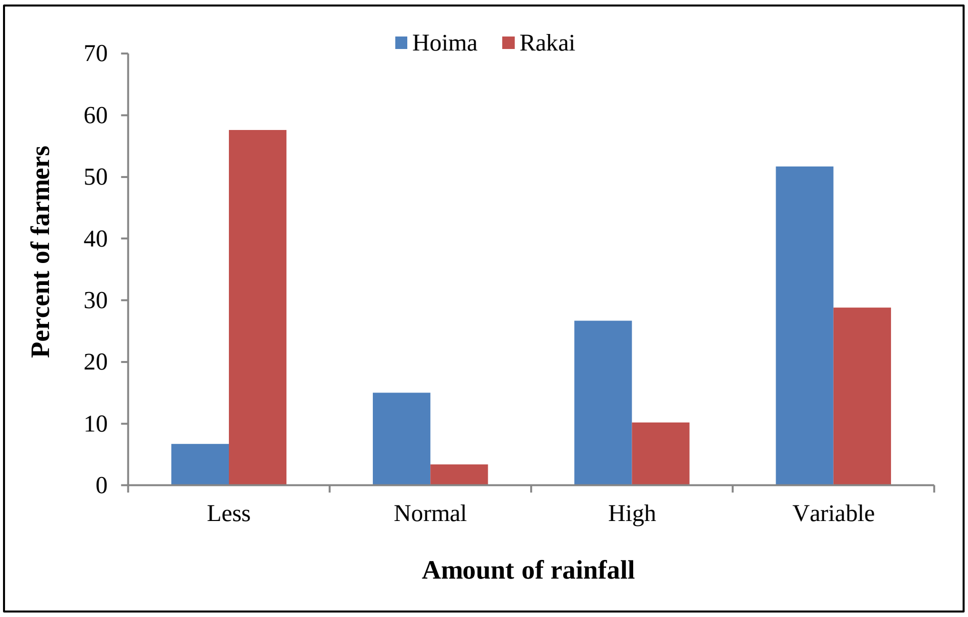


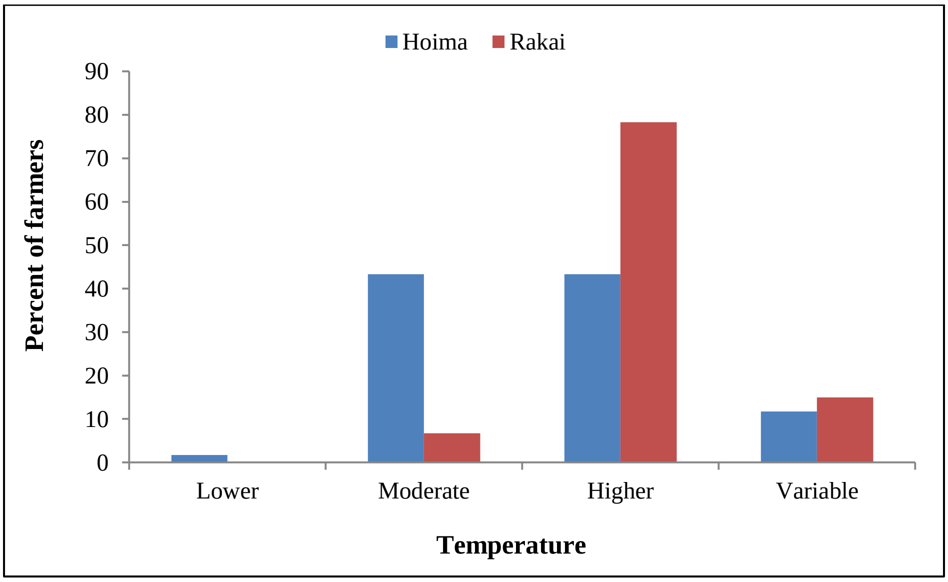
Figure 16. Rainfall amount



The onset and cessation of rainfall also influences perceived characterization of the amount of rainfall received. Over 85% of the respondents across the two districts reported changes in the rainfall amount that is either, less, high or variable (Figure 16). There were, however, differences in the perceived changes across the districts. While majority of respondents in Hoima (51.7%) reported that the rainfall was variable, in Rakai the majority of respondents (56.7%) reported that the rainfall amount was less. Apparently, from the farmers' perceptions, the two sites receive quite different amounts of rainfall, with Hoima receiving relatively more rainfall than Rakai. As mentioned previously, Rakai is characterized by low rainfall and low agricultural potential. Changes in precipitation—onset or cessation, intensity, length of rainy and growing seasons—affect crop production depending on their timing and magnitude. Production uncertainty associated with between and within-season rainfall variability remains a fundamental production constraint (van de Steeg 2009).

Similarly, the farmers reported variations in temperatures. Farmers' perceptions of changes in temperature were grouped into four categories: lower, moderate, higher, and variable (Figure 17). A clear difference in perception across the two sites is evident, with majority of respondents in Rakai (78.3%) reporting an increase in temperature. In Hoima, the proportion of respondents (43.3%) reporting moderate and higher temperatures was equal. These findings on perceived changes in temperature are consistent with those of Okonya et al. (2013) where majority of the farmers (39%) across six agro-ecological zones in Uganda reported an increase in temperature over the last 10 years. However, while perceptions in temperature changes across the two sites slightly differ, average maximum temperature at both sites is 30^{o}C (GOU 2004). The differences in perceptions of temperature changes across the two sites could be explained by the differences between evaporation and rainfall during the dry months. In Rakai, evaporation exceeds rainfall by a factor of six during the dry months, whereas in Hoima it is by a factor of only five (GOU 2004).

Figure 17. Changes in temperature



Overall, the farmers' perceptions of changing rainfall patterns and increasing temperatures across the two sites are consistent with the observed historical trends from historical climate data discussed in section 3.3. The declining trends of monthly rainfall amount and rainy days are manifested in the farmers' perceptions of abnormal rainfall onset, amount and cessation, and the increasing mid-season droughts. These findings are also consistent with a similar study in Tanzania, where the local perceptions by farmers of changes in temperature and increasing rainfall variability were closely related with empirical analysis of rainfall and temperature trends using meteorological data (Mary and Majule 2009).

3.5 Climate-related risks and impacts on crop and livestock production

Farmers in Hoima and Rakai districts have experienced major climate-related risks that threaten current and future agricultural production. The various risks and their level of importance or prevalence (proportion of households reporting the risk) are summarized in Figures 18 and 19. In Hoima, the five most important climate-related risks included drought, disease and pest epidemics (among crops and livestock), hailstorms, lack of pasture and bush fires. Similarly, drought, disease and pest epidemics were among the five most important risks reported for Rakai. Other climate-related risks in Rakai included decreasing water sources, lack of pasture and changes in crop flowering and fruiting times.

Figure 18. Climate-related risks in Hoima district

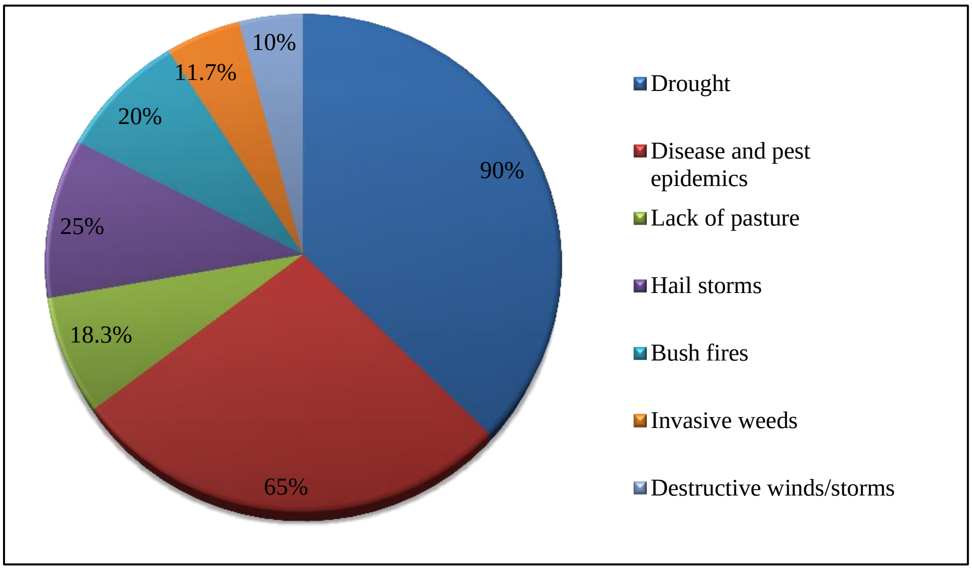
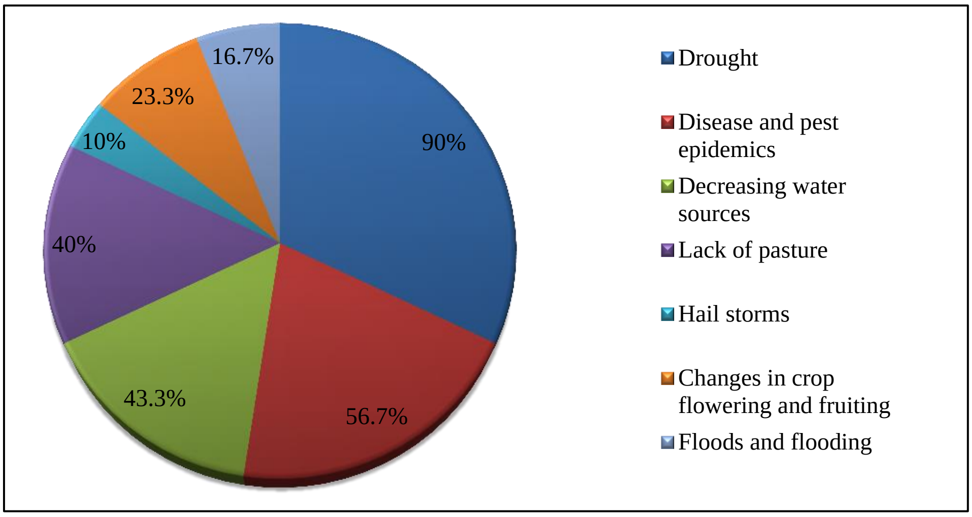


Figure 19. Climate-related risks in Rakai district



Drought, diseases and pests were the most severe climate-related risks in both districts. Drought was reported by 90% of the respondents in both districts, while disease and pests were reported by 65% in Hoima and 56.7% in Rakai. Drought hazard and vulnerability are present risks in Africa and are likely to be the most damaging of all impacts of climate change (Downing et al.1997). However, one should not underestimate the potential of the lesser important climate related-risks (e.g. lightening, floods and invasive weeds) to escalate into more pronounced and severe risks, if not addressed early enough. Climate-related risks can have devastating impacts on crop and livestock production. Urgent practical action is therefore required to reduce the large-scale risks and their adverse impacts.

Table 5 summarizes the adverse effects that may result from the different risks. Crop failure and damage, pest infestation and disease prevalence were the most severe climate related impacts on crop production reported. Crop failure had the greatest impact on crop production among farmers in Rakai (reported by 93.3%) and Hoima (76.3%) districts. Other impacts of climate change such as crop damage, pest infestation and disease prevalence were each reported by more than 45% of respondents in both districts. Similarly, the impacts of climate change on livestock production included lack of feeds, water shortage, low milk production, and vector prevalence. Over 80% of the farmers in Rakai reported lack of feeds as one of the major impacts of climate change on livestock production compared to 78% in Hoima. Disease prevalence was also commonly reported in the two districts (Table 5).

Table 5. Major impacts of climate-related risks on crop and livestock production

Impact on crop and livestock production	Proportion of respondents (%)	
	Rakai (n=60)	Hoima (n=60)
Crop production		
Crop failure	93.3	76.3
Crop damage	45.0	45.8
Pest infestation	48.3	55.9
Disease prevalence	46.7	61.0
Livestock production		
Lack of feeds	85.2	78.0
Water shortage	66.7	34.1
Low milk production	24.1	43.9
Small grazing areas	35.2	19.5
Disease prevalence	48.1	48.8
Vector Prevalence	9.3	7.3

Other impacts of climate related risks from the focus group discussions are summarized in Box 1.

- Drying of water sources - reducing number of water source points.
- Poor or low yields due to water stress resulting from extended droughts. Farmers have encountered reduction in yields of major crops like maize, beans, groundnuts, coffee, and bananas.
- Seeds dry in soil due to variable rainfall on-set periods.
- Increased poverty levels leading to poor standards of living, low education levels and ill-health.
- People walk long distances and take more time to access water, including buying water for domestic use.
- Loss of houses, and animal deaths from hailstorm.
- Rampant food insecurity, consequently leading to malnutrition.
- Reduced water infiltration capacities resulting from soil hardening in dry conditions.
- Increased farm losses due to uncertainties in planting time – rotting of crops, drying of crops.
- Emergence of new diseases and pests for some crop varieties. These include small snails that are common in mulched banana plantations, they also attack beans and eat away flowers and leaves; cassava disease; coffee wilt disease; and banana bacterial wilt.

Box 1. Other impacts of climate-related risks

3.6 Farm-level strategies for coping with climate variability and adapting to climate change

Local farmers in East Africa have developed a number of local coping strategies that have enabled them reduce vulnerability to climate variability and change. Over the years, farmers are increasing their resilience and adaptive potential through indigenous knowledge to cope with the climate-related risks. Traditional coping strategies do provide important lessons on how local communities can better prepare and adapt to climate change in the long-term. However, the increasing climate variability, frequency and more severe shocks are likely to surpass traditional coping strategies. Moreover, some of these local coping strategies can only assist families in the short-term. There is a need to understand, document and strengthen these existing coping strategies. Local coping strategies to shocks such as drought and floods differ among households and communities depending on the farming system or agro-ecological system, resources available and social capacity.

Farmers use a wide range of agricultural technologies and strategies to cope with climate variability and adapt to climate change. Moreover, adaptation has the potential to contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socio-economic conditions (Adger et al. 2003). Table 6 summarizes the different technologies and strategies used by farmers in Hoima and Rakai districts. These include soil moisture conservation, soil fertility enhancement, on-farm diversification, improved inputs and management, local innovations and food storage. Local coping strategies are often not documented, but rather handed down through oral history and local expertise (Mary and Majule 2009). Farmers use different technologies and practices based on their own innovations or through advice from other sources to adapt and cope with the changing climate. While some of the technologies were popular among the farming communities, others were only practiced by a few of the farmers. Mulching (89%), intercropping (85.2%) and planting of food security crops (78.8%), for example, were among the most popular technologies. Notably, these three practices have been in existence for a long time and still feature as important practices. Rainwater harvesting, using plastic water tanks or Ferro-cement cisterns, for domestic consumption (89.6%) is among the fast-growing local innovations in the area. This is not to underestimate the importance of other technologies such as soil bunds, manure, and storage facilities among others. Often, farmers use these technologies in combination to enhance agricultural production.

Table 6. Farm-level climate change adaptation technologies and strategies

Adaptation technologies and practices	Proportion of farmers (%)	
	Rakai (n=60)	Hoima (n=60)
Soil moisture conservation		
Mulching	89.1	54.8
Use of cover crops	1.8	21.4
Agro-forestry	40.0	11.9
Use of grass strips	7.3	4.8
Strip cropping	1.8	0.0
Soil bunds	45.5	7.1
Irrigation	10.9	4.8
Soil fertility enhancement		
Use of backyard manure	55.4	36.7
Use of compost manure	51.8	12.2
Use of inorganic fertilizer	39.3	10.2
Use of green manure	10.7	2.0
On-farm diversification		
Intercropping	85.2	79.2
Integration of livestock and crops	22.2	34.0
Use of new crop varieties e.g. Fhia in banana	38.9	28.3
Planting of fruit trees e.g. mangoes	29.6	15.1
Use of improved inputs and management practices		
Improved seed	48.1	35.7
Proper spacing	63.0	42.9
Timely planting	66.7	78.6
Timely weeding	61.1	66.7
Post-harvest handling	40.7	33.3
Food storage		
Planting of food security crops	78.8	72.5
Use of storage facilities	56.7	21.6
Local innovations		
Kitchen gardens	25.0	66.7
Rain water harvesting for domestic use	89.6	44.4
Rain water harvesting for agricultural production	2.1	11.1
Organic pesticides	6.2	7.4
Micro irrigation	8.3	-
Non-conventional organic fertilizers e.g. urine	12.5	-

Farmers also use soil moisture conservation techniques. Mulching, for example, enhances conservation of soil moisture, controls soil erosion and enhances water catchment. Incentives for adopting soil fertility practices included increased crop yields, improved soil fertility, and enhanced plant germination potential and growth rates. The differences in utilization of soil fertility enhancement technologies between Hoima and Rakai are attributed to differences in livelihood activities. Rakai, for example, has a higher livestock population compared to Hoima. Consequently, 18.3% of the respondents from Rakai reported availability of materials on the farm for soil fertility enhancement compared to only 1.7% in Hoima (data not presented). Trends in fertilizer use across the two sites are similar to the national trends in Uganda, where fertilizer use is very minimal due to various factors including high costs and lack of knowledge on fertilizer use. On average, only 1 kg of nutrients is used per hectare per year (FAOSTAT 2002, GOU 2006). However, at the current level of degradation of most Ugandan soils, 200 kg of nutrients is required per hectare per year (GOU 2006).

According to (Kandlinkar and Risbey 2000), crop diversification is one of the important adaptation options in agriculture. Crop diversification can serve as an insurance (risk management strategy) against rainfall variability as different crops are affected differently (Mary and Majule 2009, Bradshaw et al. 2004). The uptake of crop diversification as a risk management and adaptation strategy across the study sites has been enhanced due to their efficiency on limited land holdings, improvement of soil fertility and boosting crop yields, among other factors.

Poor post-harvest handling of agricultural produce is a major constraint in Uganda, and often results in substantial loss of produce during harvesting, processing, and storage. Poor post-harvest handling also affects the quality of farm produce. In addition, the available marketing schemes do not offer farmers reasonable revenue for their produce. Due to post-harvest handling problems farmers often sell their produce just after harvesting when the supply is much higher than the demand. As a result, the prices are usually low and exploitative, whereas if they could afford to wait for a couple of months the prices could even go up three to five times (Mubiru et al. 2009). With increasing changes in climatic conditions and climate variability there is need to minimize the post-harvest losses. Climate change brings challenges such as low yields, unfavourable conditions for post-harvest handling and storage (Mubiru et al. 2009). Incentives for adoption of food storage technologies included the ability of farmers to store the crops for a longer period; ability to sell at a later date and obtain better prices which improved household incomes; and also increased food security.

Finally, local innovative adaptation strategies included kitchen gardens especially for vegetable growing, rainwater harvesting, micro-irrigation and use of organic pesticide concoctions. The water harvesting techniques were adopted because they offer households clean water for domestic use. The disincentives that impeded uptake of the various techniques discussed above were cross-cutting and included high costs associated with implementation of the technologies, labour requirements and intensity associated with adoption, lack of capital and inputs to implement the technologies in accordance with the scientific recommendations, inadequate technical know-how of using the technologies and uncertainty of rainfall which would impede use of the techniques.

4. Conclusions

Climate change and variability presents new risks and vulnerabilities to smallholder farmers in Uganda. This paper assessed farmers' perceptions of climate change and variability and analysed historical trends in temperature and rainfall in two rural districts of Uganda in order to understand farmers perceptions of climate change at the local scale, determine the major climate-related risks affecting crop and livestock production, and identify existing innovative strategies for coping with and adapting to climate-related risks with potential for up-scaling.

Temperatures have increased steadily over the years across the two districts, with both average maximum and minimum temperatures increasing. Changes were also observed in total annual rainfall patterns. Across the two districts, the average monthly rainfall and the number of rainy days showed a decreasing trend, especially during the critical months of crop growth (April - June and September – November). Although the changes in rainfall patterns were weak as explained by the correlation coefficients, there was a lot of variability. Rainfall intensity has become more variable and erratic impacting negatively on soil moisture content and availability, thus leading to either reduced crop yields or total crop failure. Rainfall patterns within and between seasons are highly variable. The erratic onset and cessation of rains makes it difficult for farmers to plan for their cropping activities. Heavy rains were occurring in dry seasons, dry spells in rainy seasons, and storms at unusual times as indicated by the average monthly rainfall. Rising temperature and increasing rainfall variability have caused declining food security through decreased crop and livestock productivity.

The perceived changes in climatic conditions by the farmers included erratic rainfall onset and cessation, which were either early or late, poor rainfall seasonal distribution and little rainfall. Farmers also reported variations in temperatures. The farmers' perceptions of changing rainfall characteristics and increasing temperatures were consistent with the observed historical trends from meteorological data. Understanding farmers' perceptions of climate change and how climate-related risks impact smallholder crop and livestock production is of paramount importance in designing climate change adaptation strategies and formulation of policy recommendations.

Major climate-related risks included drought, disease and pest epidemics and hailstorms. These risks caused decline in water resources, reduction of pasture productivity, bush fires, crop failure and physiological changes in crop flowering and fruiting times. Drought and associated diseases and pests were the most severe climate-related risks. Farmers are using indigenous traditional innovations and modern technologies to cope with climate risks that include mulching, intercropping, use of manure and improved crop varieties, some of which have been in existence for a long time. Other local innovations for coping with climate-related risks included establishment of kitchen gardens, rain water harvesting for domestic and agricultural use, use of organic pesticides, micro irrigation, and use of non-conventional organic fertilizers. Often, farmers use a combination of these technologies and strategies to cope with climate change and variability and to enhance agricultural productivity.

There is need to promote early maturing, drought tolerant and water efficient crops and crop varieties; pastures and fodder varieties; and rainwater harvesting and soil nutrient and moisture management technologies; and livestock management options and strategies that restore sustainable productivity. Research and farm development initiatives should foster integration of crops and livestock that exploit synergies of indigenous traditional practices and modern technologies and innovations. Efforts should be mobilized to establish effective climate risk management information flow networks to inform farm-level decision making taking into account the already existing communication channels or structures.

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