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Smallholder farmers in the Lake Edward River sub-Basin of Uganda: (Coping or Adapting to Rainfall Variability in Kasese District?)

LION ENGR. ITAFE VICTOR ADACHA, HND (Civil), PGDPM, MNATE, MNSE, COREN

Directorate of Technical Aid Corps, Ministry of Foreign Affairs, Abuja, Nigeria
Kampala International University, Faculty of Engineering Department of Civil Engineering, Western Campus, Ishaka, Uganda
Email: viadacha2006@gmail.com

Abstract—*Climatic change and variability are pervasive contemporary realities in Africa. In this paper, we investigate climate stressors (i.e. rainfall patterns and drought) that have occurred in the Lake Edward River sub-Basin (LERB), Uganda. By making use of a mixed-methods approach, including both quantitative and qualitative data collection, we demonstrate that changes in rainfall pattern experienced by rural farmers in the LERB have increased since the 1990s, as have limiting factors constraining sustainable response options. By interrogating data from focus group discussions with smallholder farmers, household questionnaire surveys, and records from government institutions, we show that sustainable livelihoods in this area are also being compromised by non-climatic stresses such as a lack of coordinated crop markets and poor access to loans, inadequate weather forecast information, and poor irrigation infrastructure and varying climate. As a consequence of climatic stresses, resources utilization, diversification of farming methods, and broader structural and development concerns, smallholder farmers have responded with corresponding changes in coping and adaptation strategies. Smallholder farmers are more frequently resorting to shorter term coping strategies rather than longer term adaptation, and are thus still heavily reliant on social, economic, and policy support to improve both their shorter term coping and longer term adaptive capacity.*

Keywords—River sub-basin; coping strategies; adaptive capacity; smallholder farmers; climate variability; climate change; Uganda; Lake Edward

1. INTRODUCTION

There is increasing evidence that climate change and variability are pervasive realities that strongly impact development on the African continent (Boko et al., 2007 Reference [1]; Niang et al., 2014 Reference [2]). According to climate data available since 1950, evidence suggests that the magnitude and frequency of some extreme weather (e.g. strong winds, excessive rains, and prolonged droughts) and climate events has changed on the continent during at least the last century (IPCC, 2012 Reference [3], 2013 Reference [4]; Shongwe, Van Oldenborgh, & Van Den Hurk, 2011 Reference [5]). Future precipitation projections from CMIP-3 and CMIP-5 models, for example, further suggest that towards the end of the twenty-first century, eastern Africa (the broader area for this paper) will experience wetter rainy seasons (IPCC, 2012 [3], 2013 [4]). The African continent is also considered to be particularly vulnerable to such events, a situation aggravated by the interaction of 'multiple stresses' occurring at various levels, together with a low adaptive capacity (Boko et al., 2007 [1]; Ludi, Jones, & Levine, 2012 Reference [6]; Niang et al., 2014 [2]). Food, water, and health security may be compromised by changes in climate in both the short-term and longer term (e.g. Niang et al., 2014 [2]).

The agricultural sector in Uganda (the focus of this paper) is already suffering the adverse impacts of climate stresses. Poor rainfall distribution (patchiness), periods of drought, intra- and inter-seasonal dry spells, delayed onset of the rain seasons, and poor water management have been amplifying the problem of soil moisture stress (Paavola, 2003 Reference [7]; Tilya & Mhita, 2006 Reference [8]) and associated knock-on effects. Such climatic stresses, it has been argued, may have placed between 20% and 30% of the Uganda population living in semi-arid areas at risk of poor harvests (DFID, 2001 Reference [9]). For example, more than 33% of disasters in Uganda over the last decade, 100-year period were drought related (Hatibu, Mahoo, & Kajiru, 2000 Reference [10]; Morris et al., 2003 Reference [11]). Empirical analysis shows that Uganda has recorded 37 occurrences of drought between 1872 and 1990 (Government of Uganda, 1998 Reference [12]), and in 2006, a major drought triggered serious food and power crises in the country. In some cases droughts are followed by floods, or aggravated by other stresses including land degradation and health-related stresses (e.g. Niang et al., 2014 [2]; Thomas et al., 2004 Reference [13]; Tonang, Kangalawe, & Yanda, 2010 Reference [14]). Such complex, synchronous risk environments (Holloway et al., 2013 Reference [15]) have increased the vulnerability of smallholder farmers to such stresses.

In this paper our aim is to:

(1) Outline the biophysical context facing smallholder farmers in the Lake Edward River sub-Basin (LERB), by examining rainfall trends, both spatially and temporally;
(2) Interrogate the impacts that farmers face in a potentially ever-changing climatic/environmental context; and
(3) Examine the notions of coping and/or adaptation within changing circumstances.

We explore the current context in which small-scale farmers operate and then interrogate how such local realities are being influenced, if at all, by climate stresses. Specifically, we examine the role that a multiple suite of stresses play in exacerbating responses to rainfall variability. In an attempt to answer such themes, and better understand the context and causes of vulnerability of smallholder farmers to climatic stresses, we explore notions of coping and adaptation to climate stresses in the LERB, Uganda. In doing so, we test the challenge presented by Vincent et al. (2013, p. 203 Reference [16]), namely that: determining whether or not the observed strategies are examples of coping or adaptation, is dependent on the particular context in which they were observed, and also requires a consideration of the scale of interest. As a result, it is not possible to universally state that any one response would be an adaptation in any context.By interacting with smallholder farmers growing a wide range of crops, from cereals and vegetables to cash crops, we seek to understand what drives differential vulnerability among smallholder farmers, and then examine the cohort of strategies smallholder farmers use in response to climate stresses over time, including barriers and enablers to climate change adaptation in Sub-Saharan Africa (Shackleton, Ziervogel, Sallu, Gill, & Tschakert, 2015 Reference [17])

2.0 Diverse meanings: coping or adaptation?

The narrative adopted to explore a particular climate related story is usually imbued with a range of meanings, assumptions, and biases (Leach, Scoones, & Stirling, 2010) Reference [18]. The concept of coping strategies to climate variability and change, for example, has been interpreted in various ways by different scholars writing on agriculture. Davies (1996) Reference [19], for example, defines coping strategies as short term measures employed by a farmer in response to food shortages during a poor crop yield season. Similarly, Ellis (1998) Reference [20] defined coping strategies as measures taken in response to a decline in normal sources of food for survival.

To cope with changes, farmers usually make use of assets to respond to a food shortage crisis (Adams, Cekan, & Sauerborn, 1998 Reference [21]; Vincent et al., 2013 [16]). Several studies have highlighted specific climate-related coping strategies including temporary migration, receiving food aid and selling of household assets (e.g. Kangalawe, 2012 Reference [22]; Kangalawe, Mwakalila, & Masolwa, 2011 Reference [23]; Mongi, Majule, & Lyimo, 2010 Reference [24]; Paavola, 2008 Reference [25]; Phillips, 2007 Reference [26]; Yanda & Mubaya, 2011 Reference [27]). In contrast, adapting to climate change entails 'adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts' (Smit et al., 2001, p. 879 Reference [28] in O'Brien, et al., 2012, p. 669 Reference [29]). It is also, in some cases, characterized by adjusting the entire system in a sustainable manner rather than dealing with a few components of the system that are affected, and usually address longer term change as opposed to only short-term change (Schipper, 2007) Reference [30]. Thus, for adaptation to be effective, there need to be some flexibility in the livelihood system that provides resources, such as food and income to farmers (Schipper, 2007) [30].

Systemic adaptation can be categorized into incremental and transformational adaptation process types. Incremental adaptations are characterized by extending previously used actions to reduce losses or enhance gains provided by climatic stresses. Transformational adaptations involve the adoption of new actions, sometimes at a larger scale or magnitude than those of previous actions, and which ultimately transform systems, places, or shift locations (Kates, Travis, & Wilbanks, 2012 Reference [31]; O'Brien, 2012 [29]). In addition, concepts such as transformative, transgressive, and incremental adaptation have recently been suggested to be associated with systemic adaptation (Howden et al., 2007 Reference [32]; Stafford Smith, Horrocks, Harvey, & Hamilton, 2011 Reference [33]). Much recent focus is thus calling attention to clarity on terms used and also on trying to find climate resilient pathways (Leach et al., 2010) [18]. Agrawal (2010, p. 82) Reference [34] presented a different categorization of adaptation strategies, whereby the basic adaptation strategies in the context of climate change can be linked to the following five analytical risk management categories: 'Mobility: the distribution of risk across space. Storage: the distribution of risk across time. Diversification: the distribution of risk across asset classes. Communal pooling: the distribution of risk across households. Market exchange: the purchase and sale of risk via contracts'.

The five-fold classification of adaptation strategies presented above can be applied to both coping and adaptation because both are responses to climatic stresses (Agrawal, 2010 [34]; Vincent et al., 2013) [16]. This classification, however, usually diminishes the distinction between coping and which we argue depends on the duration (short term or longer term) of effects produced on adaptive capacity. The distinction between coping and adaptation also breaks down when climatic extreme events happen repeatedly (Agrawal, 2010 [34]; Campbell, 1990 Reference [35]; Young & Jaspars, 1995) Reference [36]. Repetitive responses, some based on past behaviour, often come face-to-face with the possibility of new risks and challenges of an event, many determined by the magnitude of the event and the underlying vulnerability and exposure. The neat distinctions between coping, adaptation, and resilience remain unclear.

It is also important to note that some of the adaptation strategies may lead to maladaptation practices (Vincent et al., 2013) [16]. For example, the use of motor pump irrigation practices to grow vegetables, tomatoes, and onions in the LERB may be an adaptation, but if removing water from the river adversely affects others downstream, then at a larger scale, and in the long term, this strategy is a maladaptation.

Moreover, adaptation can be affected by different factors that may become enablers or barriers to adaptation (for an extensive review see Shackleton et al., 2015) [17]. These include access to crop markets, financial capital, inputs, and climate services (Bradshaw, Dolan, & Smit, 2004 Reference [37]; Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009 Reference [38]; Hassan &

Nhemachena, 2008 Reference [39]; Kurukulasuriya & Mendelsohn, 2008 Reference [40];Mertz, Mbow, Reenberg,&Diouf, 2009 Reference [41]; Nhemachena & Hassan, 2007) Reference [42].

There is thus a broad sweep of issues that are linked to disentangling practices and responses to climate stresses. Usually these issues are treated; however, in a very superficial manner, and with such 'surface' treatment, a host of the more nuanced practices and behaviours are misinterpreted often at the expense of farmers' livelihoods. A paucity of detailed, context-specific case studies is also missing for many African countries including Uganda. In a detailed review of 64 studies on barriers and limits to adaptation, Shackleton et al. (2015) [17] found only three that made reference to Uganda (Bunce, Rosendo, & Brown, 2010 Reference [43]; Paavola, 2008 [25]; Slegers, 2008) Reference [44]. By undertaking detailed assessments of both the physical and social dynamics underpinning vulnerability to climate stresses, and then exploring possible opportunities and limitations facing farmers as they try to either cope or indeed consider long-term adaptation, we hope to enhance current knowledge on this critical element of climate change responses.

Given this vast but mixed literature on coping and adaptation, in this paper, coping will be classified as short-term responses to a crisis (e.g. Vincent et al., 2013) [16], and adaptation as long-term responses. We have used the two terms and approaches to investigate and probe what smallholder farmers are doing in rural areas of Uganda. A mixed-methods approach has enabled the identification and role played by both biophysical change and social dimensions of change, that in turn either enable or constrain responses to climate change.

3. METHODOLOGY

3.1 THE STUDY AREA

The Kasese District is a district in Western Uganda. Like most other Ugandan districts, the town of Kasese is the sites of the district headquarter. Kasese District is located along the equator. It is bordered by Kabarole District to the north, Kamwenge District to the east, Rubirizi District to the south, and the Democratic Republic of the Congo to the west. The district headquarters at Kasese are located approximately 359 kilometres, by road, west of Kampala, Uganda's capital and largest city.

The district has a total land area of 2,724 square kilometres, of which 885 square kilometres is reserved for Queen Elizabeth National Park and 652 square kilometres for Rwenzori Mountains National Park, leaving 1,187 square kilometres for human habitation and economic utilization. Kasese District is part of the Rwenzururu Kingdom, which is conterminal with the Rwenzururu sub-region, home to an estimated 750,000 inhabitants in 2002, according to the national census conducted that year. Also, it is bordered by Lake George with area of 61,368 sq kilometres, open water 28,922 square kilometres, wetland 765 square kilometres. The sub region consists of Bundibugyo District, Ntoroko District, and Kasese District.

Population

In 1991, the district population was estimated at about 343,600. The 2002 national census put the population of the district at approximately 523,000. It is estimated that in 2012, the population of the district was approximately 747,800.

Ethnicities

Kasese is a multi-ethnic district with many people of different ethnic backgrounds. The main languages and ethnic groups that dominate the area are Rutooro and Rukonjo, the languages of the Batooro and the Bakonjo people respectively. However, there are other ethnic groups in the district who include the Banyankole, the Basongora the Bakiga and the Baganda. There is also common usage of English and Swahili.

Economic Activities

Kasese district is mainly agricultural with over 85 percent of the people being peasant farmers who depend on subsistence farming for their livelihood. It has two rainy seasons that come between March to May and August to November. Temperatures normally range between 23 °C and 30 °C. Crops grown include:

- Millet
- Cassava
- Maize
- Sorghum
- Groundnuts
- Beans
- Irish Potatoes
- Sweet potatoes
- Matooke
- Passion fruit
- Tomatoes
- Cabbage
- Cotton
- Oranges

- Coffee
- Chili peppers
- Mangoes
- Pineapples
- Pears
- Apples
- Sugar cane

Most of the agricultural produce is either sold locally or transported for sale in Kampala and to other cities and towns in Uganda. Fish farming is slowly taking root in the district and demand for the fish is high both locally and in neighboring countries. Livestock kept in the district includes: Cattle, goats, pigs and poultry. Fishing also occurs on Lake Edward and on smaller crater lakes in the district. There are three main landing sites on the shores of Lake Edward, George, Mahyoro and Kayinja.

The district's main border crossing is Mpondwe, where some 25,000 people cross to and from the Democratic Republic of Congo every day. Kasese district map showing in (Figure 1) (KDITG, 2014) Reference [45]. Semi-arid conditions (average of 500 mm) prevail in the area north of the sub-basin, but mean annual rainfall increases southwards, with up to 1172 mm on mountain slopes. The rainy season lasts from mid-November to May, with a tendency for the dry season to set in earlier in the LERB than other sub-basins (Figure 1) (KDITG, 2014) [45]. The major water consumers include the hydropower plants, commercial and subsistence agriculturalists, and rural and urban communities. One village was purposively selected from each of the three agro-ecological areas in the LERB (based on the major crops grown) and on available information from past studies (e.g. Birch-

Thomsen, Frederiksen, & Sano, 2001) Reference [46], thereby enabling comparative assessments that build on existing knowledge. Lake Edward lies completely within the Virunga National Park (Congo) and the Queen Elizabeth National Park (Uganda) and does not have extensive human habitation on its shores, except at Ishango (DRC) in the north, home to a park ranger training facility. About two-thirds of its waters are in the DRC and one third in Uganda. Apart from Ishango, the main Congolese settlement in the south is Vitshumbi, while the Ugandan settlements are Mweya and Katwe in the northeast, near the crater lake of that name, which is the chief producer of salt for Uganda. The nearest cities are Kasese in Uganda to the northeast and Butembo in the DRC to the northwest, which are respectively about 50 kilometres and 150 kilometres distant by road.

The three agro-ecological areas provide a useful range in land-use and crop types from which to address issues such as the causes and contexts of differential vulnerability, perceptions and experiences, coping and adaptation strategies to climatic stresses, and different livelihood activities. Kasese town has 55,300 households and a population of 101,679 residents. The main socio-economic activities include agriculture, livestock keeping, and small businesses. The village is composed of both large-scale and small-scale irrigators (commercial rice farming). The large-scale irrigator is an investor who owns an average of 3000 ha (Mbarali Rice Farm), while small-scale irrigators own an average of 800 ha which is sub-divided among owners. Mweya village has1200 households and a population of 4825 residents, among them 1,115 households are male headed and 85 households are female headed. The main socio-economic activities include agriculture (rain-fed), livestock keeping and small business enterprises (i.e. shops, selling tomatoes and sunflower, tea rooms and local bars selling Ulanzi). katwe is a growing business centre compared to Kasese and Mweya town and village. The village, at the time of the research, comprised just over 300 households. Recently, the village has experienced accelerated population increases due to immigration of people from nearby villages in search of irrigation water, small business, and job opportunities. The main socio-economic activities are agriculture (both irrigated and rain-fed), livestock keeping, and small businesses (i.e. shops, selling onions and tomatoes, hotel, tea rooms, and local bars) (Table 1).

Table 1. Main characteristics of the three villages.

	Main characteristics				
			Main crops		
Village	Altitude (m a.s.l)	Average rainfall (mm/a)	Food crops	Cash crops	Type of farming
Katwe	550	350–500	Rice, maize	Onions, rice	Mainly irrigated farming (both canal and motorized pumps)
Mweya	1050	450–650	Maize	Tomatoes, sunflower	Rain-fed farming in uplands; valley bottom farming on hired land in neighbouring villages
Kasese	1444	500–1000	Rice, maize	Rice, tomatoes	Both rain-fed and irrigated, but mostly irrigated farming of rice (gravity through canals and using motorized pumps)

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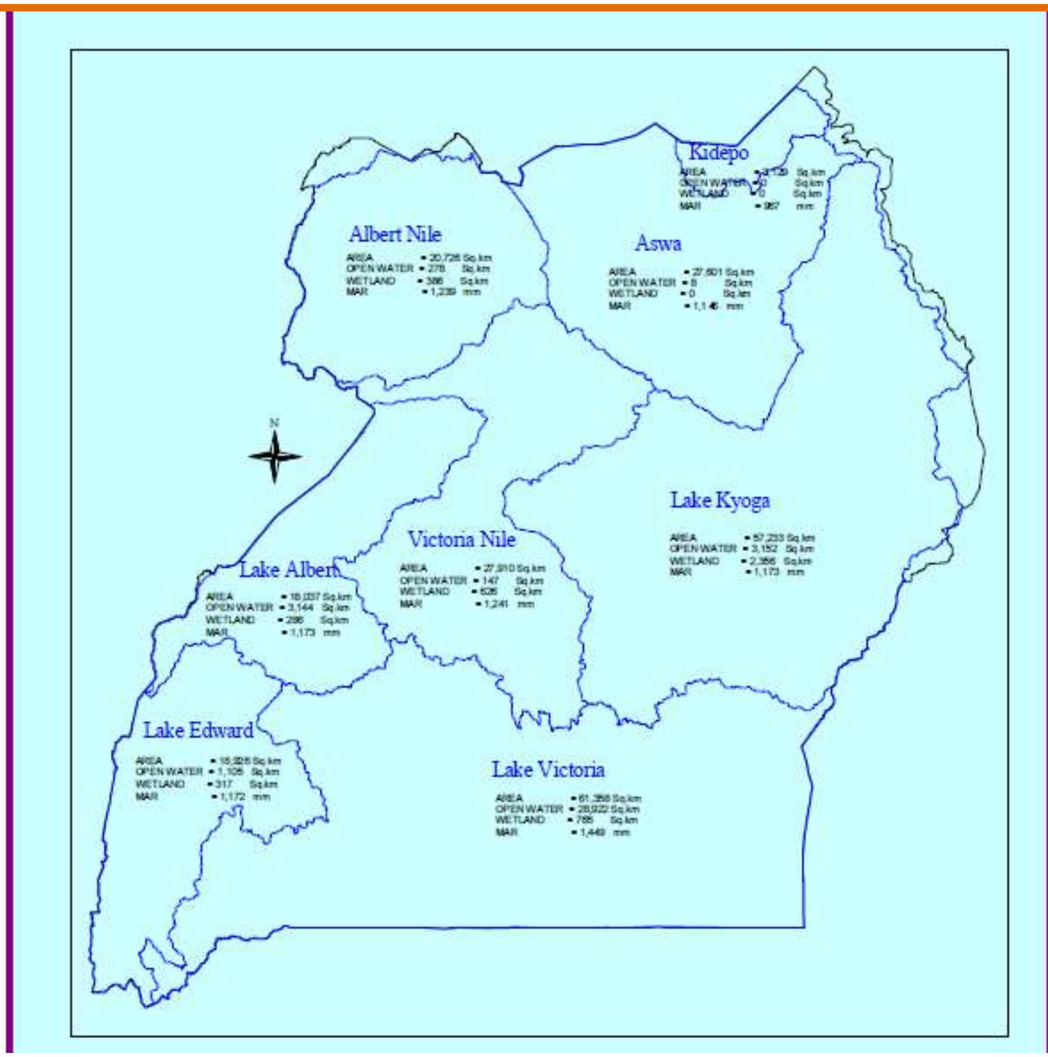

Figure 1 Main drainage sub-basins in Uganda

3.2 Data collection

Secondary data sources for this investigation included documentation from locally available sources in the study area (e.g. village register books and district socio-economic profiles); government agencies such as the Uganda Meteorological Agency (UMA) and the National Archive of Uganda. Daily rainfall data (1960–2012) for Mubuku and Nkenda-Mpondwe-Beni power/meteorological stations were obtained from the UMA. These two stations were selected based on availability of long rainfall records and their close proximity to the study villages. Rainfall trends for Mubuku power/meteorological station are thus used for Kasese town (10 km distant), and those for Nkenda-Mpondwe-Beni power/meteorological station are used for Mweya and Katwe villages (40 km and 80 km distant, respectively) (Figure 1).

More richly informative socio-cultural and socio-economic data were sourced from key informant interviews with village and district officials, household surveys, and focus group discussions (FGDs). The village and district officials provided profiles of the villages and districts, including demographic data, climate, and agricultural activities. Household heads were selected for the household survey, while village register books containing the names of all households were used to select households for interviews.

The study placed emphasis on the random selection of sample units to avoid bias. Ninety households were selected for the questionnaire survey (i.e. 30 households per village). For key informant interviews and FGDs, purposive sampling was used to ensure that particularly knowledgeable people were selected for group interviews.

Several FDGs, each comprising 12 household heads, were undertaken. Interviews and FGDs were communicated in Kiswahili, which is widely spoken in the study area; thus all data collection tools were translated into Kiswahili.

3.3 Data processing and analysis

Data from questionnaire surveys were coded and processed using Statistical Package for Social Science version 16. Content analysis was used to analyse qualitative data from FDGs and key informant interviews. Quality control for missing climate data was performed where necessary, following Mutai (2000) Reference [47]. INSTAT software was used to establish rainfall variability with respect to the drought/wetness indices of rain seasons from the 1960s to 2012 (Stern & Knock, 1998) Reference [48]. Such analyses help determine possible impacts associated with the timing of the rain seasons, as also to establish whether there has been any change in seasonal rainfall patterns over time. The standardized precipitation index (SPI) was computed to determine dry and wet years. In this paper, the focus is on rainfall variability over several years. We firstly describe the climate context in which the farmers operate, followed then by a detailed investigation of the range of additional 'multiple' stresses aggravating vulnerability to such climate risks, threats and where relevant, opportunities.

3.4 Determining drought events using the SPI

The SPI developed by McKee, Doesken, and Kleist (1993) Reference [49] was used to determine dry and wet years. The months selected for this study were those within the rain season, namely October/November to April/May. McKee et al. (1993) [49] defined the criteria for a 'drought event' and classified the SPI to define the various drought intensities (Table 2). Thus, each drought event is characterized with a duration defined by its beginning and end, and its intensity during the period when the event commences. The SPI is defined theoretically as the sub-areas under a normal (Gaussian) probability distribution function. It has many advantages over other drought indices, which require more than two variables. The SPI considers only two parameters, the arithmetic mean and the standard deviation.

Table 2. Drought/wet categories defined for SPI values.

SPI values	Drought and wet category
0 to −0.99	Mild drought
−1.00 to −1.49	Moderate drought
−1.50 to −1.99	Severe drought
≤−2.0	Extreme drought
1.00–1.49	Moderately wet
1.50–1.99	Severely wet
2.00 and above	Extremely wet

Source: McKee et al. (1993).

4 OBSERVED CLIMATE CHANGE AND VARIABILITY

The number of years that exhibited different dry and wet categories for the pre-defined SPI values from Mubuku power/meteorological station were identified and plotted. Consequently, four severe (1964/1965, 1993/1994, 1996/1997, and 2002/2003) and two extreme (2005/2006 and 2011/2012) drought periods are identified. Seven of the nine severe/extreme droughts occurred during the last two decades (1990−2010). The SPI results indicate four moderate drought periods in 1974/1975, 1976/1977, 1992/1993, and 1999/2000; and two extreme (1968/1969 and 2001/2002) and five severe (1972/1973, 1978/1979, 1982/1983, 1986/1987, and 2010/2011) wet periods (Figure 2).

Results indicate a greater number of major wet periods before 1987 and an increasing frequency (0.1 events/decade) of drought events between the 1960s and 2012. Five moderate (1969/1970, 1985/1986, 1991/1992, 1996/1997, and 1998/1999), two severe (1999/2000 and 2005/2006), and two extreme (2009/2010 and 2010/2011) drought periods are identified for Mubuku (Figure 3). Eight of the nine major droughts have occurred between 1985 and 2012. Conversely, two extreme (1967/1968 and 1997/1998) and one severe (1962/1963) wet period are recorded for this middle reach of the sub-basin. Drought events are increasing at a rate of 0.2 events/decade, generally with the middle and lower sections of the LERB being susceptible to moderate droughts, and with occasional severe and extreme droughts.

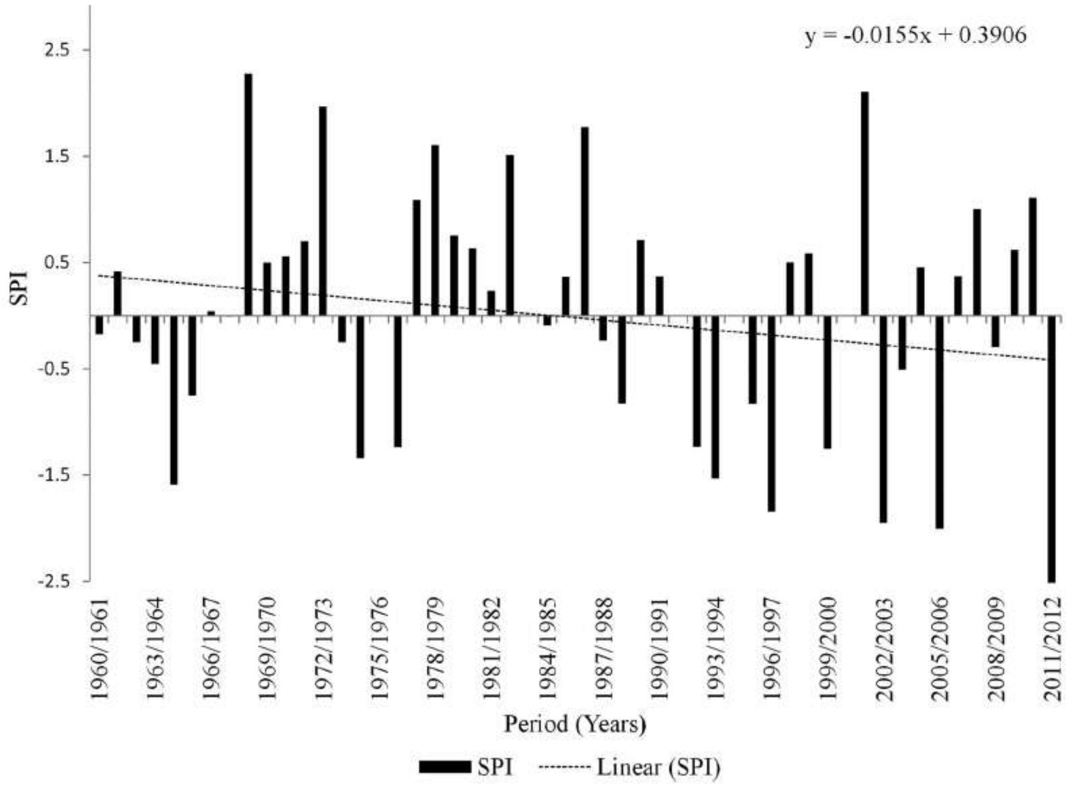

Figure 2. The SPI for Nkenda-Mpondwe-Beni power/meteorological station

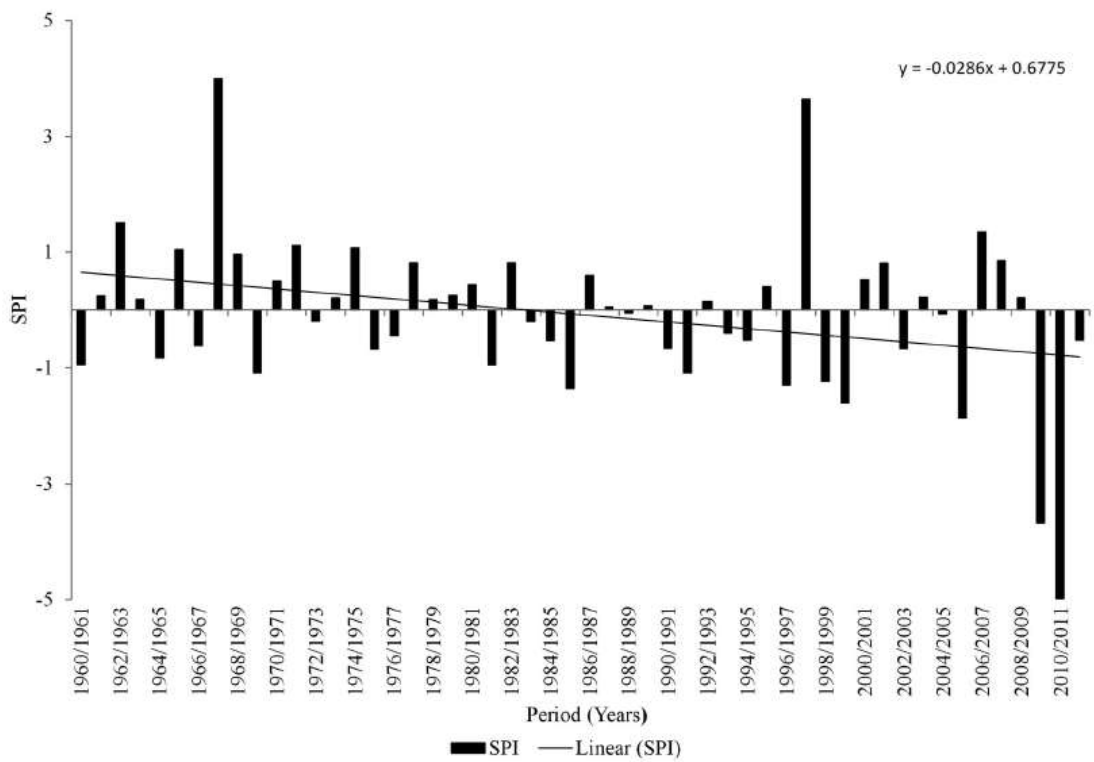

Figure 3. The SPI for Mubuku power/meteorological station

5.0 *Farming practices in response to rainfall variability stress*

Given the recorded changes in rainfall and drought frequency/severity, there have been a variety of responses by farmers in the area. As indicated, knowing the nature of responses is important, particularly if one is trying to link responses to either policy development, disaster risk reduction, and/or to better assess effectiveness of humanitarian interventions. Responses presented in this section result from climatic stressors related explicitly to rainfall variability or drought as established in the previous section.

Most farmers from Katwe (60.6%) and Mweya (78.8%), for example, practice mulching to conserve moisture during droughts, whereas only a small percentage of Kasese residents (24.2%) use mulching. Intercropping in one portion of land (usually irrigated gardens of up to 1 acre) is the response strategy used by most farmers from Katwe (69.7%) and just over half of farmers (51.5%) from Kasese village. A relatively small percentage of farmers (42.4%) from Mweya practise intercropping during drought periods (Figure 4). This might be due to the fact that few residents of Mweya village have access to irrigation farming, where intercropping practices on irrigated gardens are more favourable.

Katwe and Kasese villages have access to irrigation water and practise garden irrigation farming, which favours intercropping. Both drought-tolerant and less drought-tolerant crops are mixed; these include maize, sunflower, vegetables, and legumes. However, few farmers from Mweya village practise intercropping in upland farms, or those who hire irrigable land from neighbouring villages. Although this method has been used for many years, it has become more intensively used during recent decades, with the aim of reducing risk of crop failures.

Many farmers from Kasese village (54.5%), but less than 50% of farmers from Katwe (27.3%) and Mweya (36.4%) villages, practise mono-cropping (Figure 4). The difference between villages may be due to the fact that farmers from Kasese engage predominantly in large-scale rice farming, which is a mono-cropping farming practice in nature. Large-scale commercial farming of rice and maize, for example, is under a monocropping system in all villages. Mono-cropping reduces the risk of diseases and pests between crops, and thus is a favoured technique for large-scale farming. Less than half the farmers from all villages (27.3% from Kasese; 39.4% from Katwe; 27.3% from Mweya) use pump irrigation (Figure 4). Findings indicate that a relatively higher percentage of farmers from Katwe practise irrigation farming using motorized pumps. This has been a common practice in this village, especially in commercial onion and vegetable farming. Some commercial farmers in Kasese have been adopting this irrigation method due to access to irrigation water and the emerging tomato and vegetable business. Some farmers resort to collective hiring of pumps so as to pool resources together. Farmers who do not own a pump or cannot afford to hire a pump acknowledged that this irrigation method is a reliable climate response strategy that can enhance their ability to respond to climatic stresses. A relatively small proportion of smallholder farmers (18.2% from Kasese; 12.1% from Katwe; 6.1% from Mweya) are using drought-tolerant seeds and crop varieties. In addition, only few farmers from the study villages (3.0% from Kasese; 24.2% from Katwe; 12.1% from Mweya) have changed their farming methods over time. Yet, several farming methods have been adopted by a few farmers in the study villages; these include: (a) chemical weed control (practised mostly by onion farmers in Katwe 36.4%); (b) tied ridging (practised mostly in Mweya village to cope with erosion on slopes: 42.4%); (c) using crop residues to conserve moisture and fertilize the land; (d) fallowing; and (e) ripping (Figure 4). It thus seems that farmers, with the exception of a few, are generally reluctant to adjust traditional farming methods or introduce new crop varieties, in response to climatic stressors and/or gradual climate change.

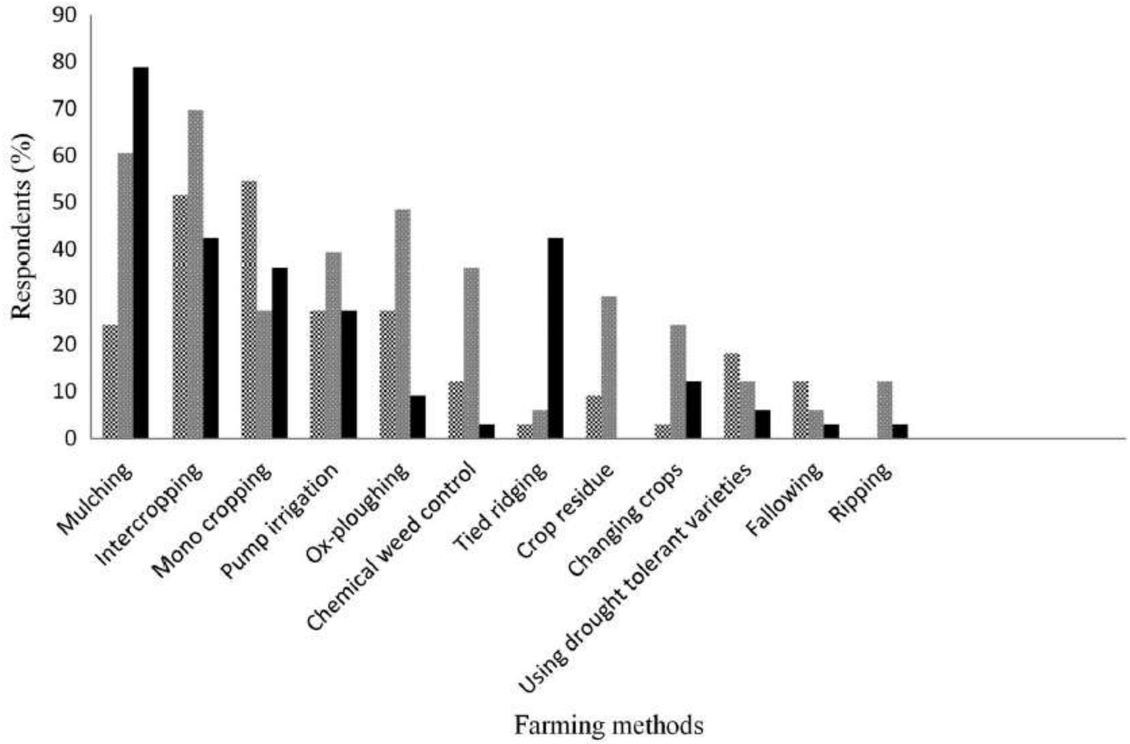

Figure 4. Farming methods used during climate-induced droughts, {Kasese; *Katwe; Mweya}*

6.0 ***Response strategies used during food shortages***

Farmers are not responding to rainfall and drought stress alone; rather, they are also responding to a series of impacts that co-occur with climate stress. Farmers have been adopting different measures so as to sustain their families, particularly during times of scarcity. Although few farmers (21% from Kasese; 9% from Katwe; and 16% from Mweya) reported having had to reduce the number of meals per day in response to food shortages, a relatively high percentage of residents in Mweya (16%) and Kasese (21%) villages do practise this strategy (Figure 5). Residents from Katwe rely on other options to deal with food shortages due to a high diversity of activities in this village; these include small businesses, employment opportunities, access to financial loans, and availability of irrigation water throughout the year.

Farmers reported during group meetings that coping strategies such as eating fewer meals and reducing the amount of food eaten per day were used by poor households only. They chose these strategies due to the fact that they had no other options and few savings, thus forcing them to conserve the little they had, a survival strategy leading up to the next harvest.

Few farmers respond by selling livestock during times of food shortage (Figure 5). A relatively high percentage of them are from Mweye (14%), compare to Kasese (6%) and Katwe (7%), which have a lower proportion of farmers using this strategy. Farmers reported that sales depend on the nature of the need, and they start by selling small-scale livestock before selling cattle, which are a prized possession and indicator of personal wealth. Other reactive response measures include seeking daily work for cash outside farms (18% from Kasese; 9% from Mweye; and 21% from Katwe), working on other people's farms for food (16% from Kasese; 9% from Mweye; and 16% from Katwe), and seeking food aid (16% from Kasese; 9% from Mweye and 11% from Katwe). Extreme measures used by some farmers include selling firewood, selling of household assets, eating food that is normally not eaten (e.g. wild food), renting out land for cash, borrowing food, borrowing cash to buy food, migrating, and withdrawing children from school (Figure 5). Migration is viewed as both a response to stress and a coping strategy used by smallholder farmers in all villages. Farmers from Kasese and Katwe villages reported that both temporary and permanent out-migration is usually more prevalent during droughts, while residents in Mweye village experience more in-migration because of attractions from the onion business, many 'stop-over' restaurants, and small business opportunities brought by the demand created by a more mobile population. Katwe villagers reported temporary rural–rural migration, whereby some inhabitants migrate to nearby villages seeking irrigable land. Mostly men (youth in particular) migrate to nearby urban centres in search of casual work and small business opportunities. Some married men were reported to migrate temporarily during droughts and most of them do not remit back to their villages, and hence leave the burden of taking care of the family to women. Most youths were reported to migrate permanently and settle in nearby urban centres, thereby reducing the labour force required by their rural households. Few households reported

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receiving remittances from their children living in urban centres. This is contrary to what has been observed previously in South Africa (Ziervogel & Taylor, 2008) Reference [50] and Mexico (Eakin, 2005) Reference [51], where young people migrate to find various employment opportunities in cities and remit resources back to their villages.

There is a difference, however, between migration in the study area and that occurring in other parts of Africa. In the study area, migration is a short-term response to a climatic disaster, but in western and southern Africa (e.g. Mertz et al., 2009 [41]; Mutekwa, 2009 Reference [52]; Reid & Vogel, 2006 Reference [53]) migration is regarded as a longer term strategy that provides livelihoods to rural people, regardless of the climatic conditions. Therefore, this phenomenon is becoming more widespread in Africa as a coping strategy.

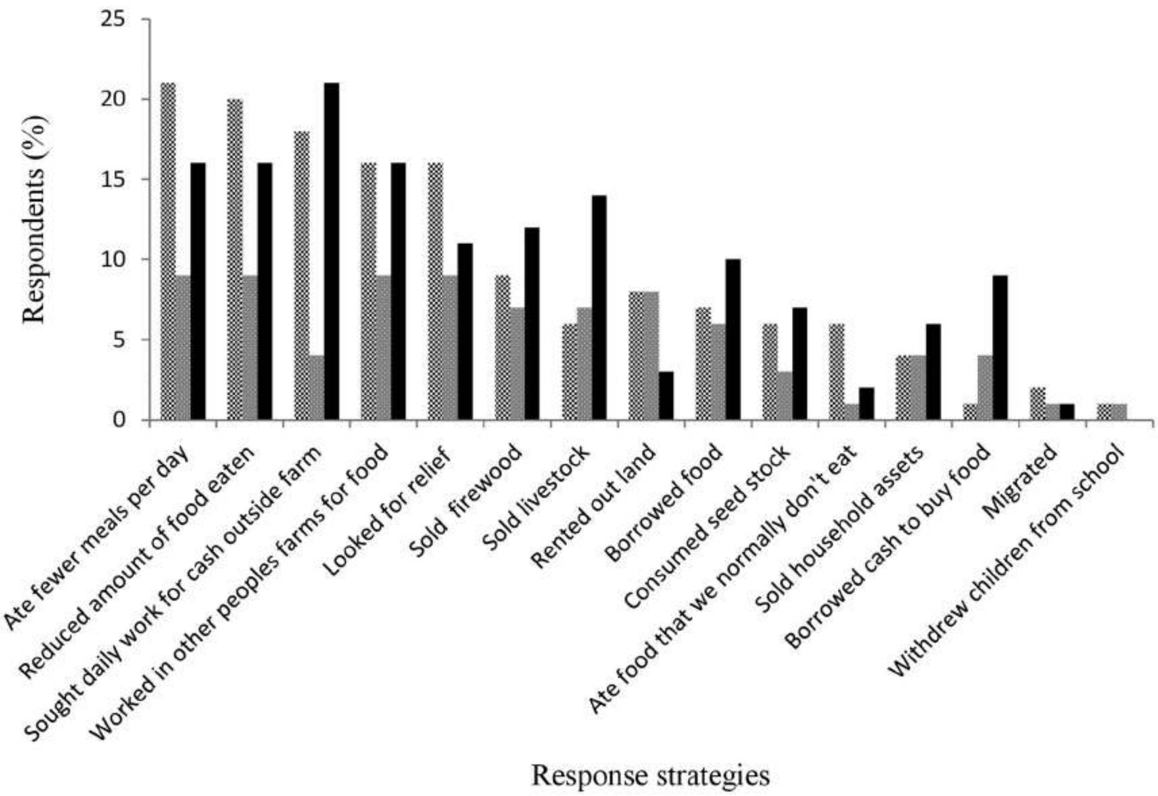

FIGURE 5. RESPONSE STRATEGIES USED DURING FOOD SHORTAGES DURING THE PAST 40 YEARS. *KASESE;* KATWE; MWEYA

7.0 ADAPTING OR MERELY RESPONDING AND COPING WITH RAINFALL VARIABILITY STRESS?

Shifts and changes in rainfall have occurred in the study area since the 1960s. Determining the extent to which variability has occurred and how this may be linked to climate change in the various sub-regions of this study remains difficult to determine, particularly given the absence of high-quality and long-term sub-regional climate data. Notwithstanding these impediments, some note worthy changes in rainfall patterns emerge. Two broad categories of responses to climate stresses have been observed by farmers in the LERB – these include farming practices and strategies used in response to a food crisis. The types and nature of responses depend on the biophysical context of the area. Findings clearly show that most of the response strategies used by smallholder farmers during food shortages can be regarded as merely coping strategies. This is due to the fact that these strategies are used as once-off efforts to address a given food crisis, rather than a continued ongoing practice; these strategies are thus not planned to address any anticipated climate stress and are reactive. Strategies include reducing the number of meals and amount of food consumed each day, selling livestock, seeking daily work for cash outside farms, seeking food aid, selling of household assets, and migration. There is a difference, however, between the pull-factors of migration in the current study area, with those in other regions. In the LERB, migration is primarily a short-term response to a climatic (and associated local economic/sustainability) disaster, but in western and southern Africa (e.g. Mertz et al., 2009 [41]; Mutekwa, 2009 [52]; Reid & Vogel, 2006 [53]) migration is usually considered a longer term strategy to improve rural livelihoods, regardless of the climatic conditions. The variety of coping strategies discussed for the LERB are also identified to solve short-term problems in other Sub-Saharan African regions, as also in developing regions of Central America (Eakin, 2005 [51]; Mertz et al., 2010 Reference [54]). As reported here, Kennedy (1992) Reference [55] and Jaspars and Young (1995) [36] similarly discuss households in North Darfur (Sudan) having to reduce the number of meals per day so as to make food stocks last until the next harvest. The depletion of household assets is among the most important coping strategies used during food shortages in north-western Uganda (World Bank, 2004 Reference [56]). Reduced food consumption and selling of household assets are seemingly widespread strategies used in response to harvest failure throughout much of East Africa (e.g. Kinsey, Burger, & Gunning, 1998 Reference [57]; Kochar, 1995 Reference [58]; Niimi, Thai, & Reilly, 2009 Reference [59]), and implies that response measures to food shortages by smallholder farmers depend first on access to resources locally available, and second, on other options elsewhere. To this end, most farming methods presented in Section 5 are employed autonomously by individual farmers due to available resources to that farmer, including mulching, irrigation farming, and intercropping. Apart from diversification of farming methods, engaging in off-farm livelihood activities is categorized as another option that farmers refer to. The off-farm activities include small business enterprises (i.e. shops, restaurants, selling local brew), building houses for renting in urban centres, and food and cash crop businesses. Diversification to non-farm activities include brick and (the environmentally controversial) charcoal-making, casual labour, and carpentry; these are seemingly becoming widespread strategies in many parts of Sub-Saharan Africa (Bushesha, Lee-Thorp, & Hopkinson, 2009 Reference [60]; Gbetibouo, 2009 Reference [61]; Liwenga, Kangalawe, Lyimo, & Majule, 2008 Reference [62]; Majule, 2008 Reference [63]; Paavola, 2006 Reference [64]; World Bank, 2009 Reference [65]). During the 2002/2003 drought in Mozambique, households diversified into business enterprises such as kiosks and shops (Eriksen & Silva, 2009) Reference [66]. Such activities, however, were not very viable during the prolonged drought and had all but ended by 2003. This was similarly the case in Kasese village where farmers reported that the sustainability of small businesses depends on the purchasing power of local households. During prolonged droughts, households tend to limit expenditure so as to meet their food needs, thus jeopardizing the viability of kiosks which sell various (unessential) commodities. A host of non-climatic stresses undermine the capacity to respond to periods of climate stress. Limited access to agricultural inputs is reported to be the main hindering factor. The high price of fertilizers in addition to reduced soil fertility and inadequate irrigation water are also identified as obstacles causing reduced crop yields in the LERB. The coping capacity in the shorter term and the longer term adaptive capacity of Africa's farmers is thus impacted by multiple factors, including access to resources (e.g. Adger & Vincent, 2005 Reference [67]; Brooks, Adger, & Kelly, 2005 Reference [68]; Ellis & Mdoe, 2003 Reference [69]; Grothmann & Patt, 2005 Reference [70]; Thornton et al., 2006 Reference [71]). In particular, the adaptive capacity of smallholder farmers can be constrained by both climatic and non-climatic stresses (Fazey et al., 2010 Reference [72]; O'Brien, Eriksen, Nygaard, & Schjolden, 2007 Reference [73]; Stringer, Mkwambisi, Dougill, & Dyer, 2010 Reference [74]). Most adaptation strategies (i.e. farming methods) require financial capital while coping strategies depend mostly on locally available resources including personal labour. Farmers have recognized this as a barrier to adaptation. Considering that a large percentage of farmers are poor and receive minimal government support in the adaptation process, most of them have been resorting to coping more frequently than adapting, thus undermining their adaptive capacity to projected impacts of climate change. It is important, therefore, to differentiate between responses that are predicated on coping and those on adaptation strategies so as to determine where potential for more incremental and transformative adaptation exits and where it can be enhanced (Vincent et al., 2013) [16]. Responses to food shortage associated with extreme climatic stresses in the LERB are reactive and thus essentially short-term coping strategies. However, farming methods can be proactive with some becoming entrenched in the farming practices of farmers and arguably become longer term adaptation strategies.

Clustering farmer responses into discrete strategies, as either 'coping' or 'adapting', needs to be cautioned. Precarious livelihoods of households, particularly during periods of food shortages, may be impacted by coping strategies employed by farmers in the study area. Poor households, for example, spend most of the growing season working on other people's farms and engaging in off-farm activities so as to sustain their families. Consequently, there is a high risk of chronic food shortage among the majority of farmers in all the study villages if concerted efforts are not made to support poor farmers with strategies in preparation for anticipated (projected) future climate changes. Factors that could improve longer term responses to climatic stresses include access to affordable agricultural implements and inputs, irrigation infrastructure (both gravity/canal and motorized pumps), tapping into groundwater/boreholes for villages away from rivers, access to small loans, and market development.

In this assessment, it is found that smallholder farmers across the LERB rely mostly on short-term coping strategies in response to climatic stresses. In fact, most of the response strategies to climatic stresses across the African continent are often reactive and short term, and autonomously carried out at the household level (Berrang-Ford, Ford, & Paterson, 2011 Reference [75]; Niang et al., 2014 [2]; Vermuelen, Dossou, Macqueen, Walubengo, & Nangoma, 2008 Reference [76]; Vincent et al., 2013 [16]; Ziervogel, Taylor, Hachigonta, & Hoffmaister, 2008 Reference [77]). Moreover, a range of barriers have been found to aggravate the adaptation process at the local level due to a lack of government support through investment, subsidies, and enabling policies from national to local scales (Niang et al., 2014) [2]. Such practices that show a more nuanced understanding of coping and adaptation to climate stresses have important implications for any interventions that may be designed to assist farmers. The lack of financial assets, the critical role of irrigation water and the lack of information and an appropriate institutional context to live with climate risks are important considerations for the region.

8.0 CONCLUSION

In this paper, we have examined the vulnerability and responses of smallholder farmers to rainfall variability in the LERB of south-western Uganda. By interrogating how farmers are living with climate risks, a more nuanced and informed perspective of response strategies including coping and adaptation is obtained. Such information can help in devising more appropriate and informed policies and practices towards sustainable development of subsistence farmers in Uganda and Sub-Saharan Africa in general.

The observed shifts in rainfall indices of above- or below-average rainfall, in addition to an increased frequency of droughts in the region, are demonstrated to be a real risk to farmers. Impacts related to droughts and excessive wetness usually impair the normal growth pattern of crops grown in the region and increase the risk of food shortages in particular. Farmers have been using a variety of strategies to respond to such impacts; these include the use of short-term responses during food shortages, diversification of farming methods and livelihood sources.

Achieving sustainable livelihoods is further compounded by non-climatic stresses such as a lack of coordinated crop markets and poor access to loans, inadequate weather forecast information, and a lack of irrigation infrastructure. Smallholder farmer responses to climatic stresses have changed over time, and new coping strategies are usually adopted in response to specific stresses. These coping strategies (e.g. selling own labour for cash or food, reducing the number of meals eaten per day and temporary migration) are normally successful because they only require locally available resources. Longer term and more sustained strategies (e.g. diversification of farming methods) normally receive 'little' traction due to the fact that they require insertions of capital or external support.

Notwithstanding climatic stresses that have increased since the 1990s, and limited ability to adapt to such change, smallholder farmers are trying to cope with such change. In a few cases they are building a range of coping strategies that can be developed into longer term adaptation strategies, but these activities are often constrained by non-climatic barriers. There is thus a need for a greater understanding of the local context (in terms of climate variables such as rainfall and temperature, together with various socio-political, socio-economic, and sociocultural factors) to enhance or constrain risk choices and responses. Ultimately, patterns of behaviour are the key for future interventions and climate change action. Interventions designed to enhance capacity of such smallholder farmers should thus be based on a shared understanding of what matters and how decisions are made, and be geared towards co-producing ideas that enable journeys on sustainable pathways of change.

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KIU-WC Staff:
Dr Lawal Abdul Qayoom Tunji
Dean School of Engineering and Applied Science
Kampala International University - Western Campus (KIU-WC), Ishaka, Uganda
Mr Ismail Adedayo Oyagbola
HOD Civil Engineering Department
School of Engineering and Applied Science
Kampala International University - Western Campus (KIU-WC), Ishaka, Uganda
Dr Tyoden Bala
Senior Lecturer Statistics and Computation Department
School of Environmental Studies
Kampala International University - Western Campus (KIU-WC), Ishaka, Uganda
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Authors

Lion Engr. Itafe Victor Adacha
HND (Civil), PGDPM, MNATE, MNSE, COREN
In-view M.ENG (Civil), MNICE
Email: viadacha2006@gmail.com