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Urban Resilience to Climate Change Shocks and Stresses in Mbale Municipality in Uganda

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Urban Resilience to Climate Change Shocks and Stresses in Mbale Municipality in Uganda

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Oriangi George

LUND UNIVERSITY

DOCTORAL DISSERTATION

By due permission of the Faculty of Science, Lund University, Sweden.
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Abstract

Climate change shocks and stresses are expected to increasingly affect urban areas in Sub-Sahara Africa (SSA). However, there remain gaps in understanding local precipitation extremes and influential factors that can enhance urban resilience. This study synthesized determinants of urban resilience, investigated historic and projected precipitation extremes up to the year 2050 and assessed factors perceived to enhance resilience. These factors informed the proposed Municipality Resilience Index (MRI) which was tested to assess the resilience index of Mbale. The study employed cross sectional survey and some elements of grounded theory and fixed qualitative research designs.

A compendium of methods was used to realize the formulated objectives. To synthesize determinants of urban resilience, a review of literature was undertaken and subjected to summative thematic content analysis. To investigate precipitation extremes, historic data for 32 years was obtained from Uganda National Meteorology Authority (UNMA) while for future climate, modelled data was used. Climate data was fitted in a Standardized Precipitation Index (SPI) to compute precipitation extremes. To assess factors perceived to be influential in enhancing household resilience, 389 structured household interviews coupled with nine group interviews were undertaken. Household data was subjected to linear regression analysis to generate relationships while normalization, principle component analysis and summations were used to generate resilience index. Group interview data was subjected to summative thematic content analysis to derive perceptions on priority resilience factors.

Findings revealed that access to basic services, social networks, employment and ownership of productive assets were the most reported determinants of resilience in cities of SSA, with climate related shocks and stresses being the most eminent. SPI results revealed more extremely wet and dry periods in 2004-2014 as compared to 1982-1992 and 1993-2003 with extremely wet periods concentrated in September to January. Household perceptions supported this finding, emphasising that dry periods have become frequent, hotter and longer, in addition to heavy precipitation periods. Modelled data indicated a likelihood of more extremely wet periods during 2021-2030 and 2031-2040 as compared to 2041-2050. Furthermore, future predictions generally predicted more extremely dry periods during 2031-2040 and 2041-2050 as compared to 2021-2030. These threaten to pause risks to the community of Mbale. Regression results showed that the ability of a household to meet its daily expenditure, household size and networks with relatives and NGOs had significant effects on resilience capacities. Most importantly, knowledge that even the lowest income households were substantially more likely to prepare for and recover from climate induced hazards if they are able to meet their daily expenditure needs was valuable particularly in this context, as the poorest population is generally most vulnerable. Summative thematic content analysis revealed that education, healthcare, employment, peace and security were perceived as the most crucial resilience factors. Although the community perceived to have progressed in accessing credit, building productive farms and sustaining peace and security, but they assessed a lack of diverse income generating activities, access to insurance, food security, employment and quality health care. Moreover, more marginalized parts of the municipality were experiencing decreasing resilience while other divisions have increased in resilience. The most crucial resilience factors informed the proposed multidimensional MRI that constituted of 46 variables explaining the physical, social, economic and institutional dimensions. When the MRI was tested, findings revealed that Mbale municipality has a low resilience index (0.2).

The study concluded that future work needs to continue utilizing a multidimensional approach to understand location-specific determinants of household resilience in municipalities given their growing role in the strong urban growth trajectory projected over the next decades. Practitioners and disaster risk reduction policies need to promote: small household size, activities that can boost household ability to meet their daily expenditure needs and social networks that shape household resilience to enhance preparedness, recovery and adaptation. Additionally, policies need to continue focusing on: access to insurance, food security, creating more employment opportunities and provision of quality health care to enhance household resilience. Furthermore, Mbale municipality local government needs to redirect more resources to parts of the municipality with the least resilience index to enhance household resilience.

Key words: Determinants; Precipitation extremes; Demographic; Social networks; Community perceptions; Index.

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Urban Resilience to Climate Change Shocks and Stresses in Mbale Municipality in Uganda

Oriangi George

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A doctoral dissertation in a university in Sweden is originated as either a monograph or as paper compilation. In this case, chapter one to five constitute the formal dissertation which gives a summary of the five papers either published or submitted.

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It is the glory of God to conceal a thing: but the honour of kings is to search out the matter.

Proverb of Solomon 25:2

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List of Papers

This dissertation is based on the following papers/manuscripts which are referred to in the text as "paper", followed by their Roman numeral. Related papers are cited in the text.

Paper I. Oriangi G. (2019). A Synthesis of Determinants of Urban Resilience in Sub-Saharan Africa. In: Bamutaze Y., Kyamanywa S., Singh B., Nabanoga G., & Lal R (eds). Agriculture and Ecosystem Resilience in Sub Saharan Africa. Climate Change Management. *Springer Cham*, 487-507. **(Published)**

Paper II. Oriangi G, Di Baldassarre G, Ridolfi E, Nimusiima A, Bamutaze Y, Ardö J, & Pilesjö P. An Assessment of Precipitation Extremes in Mbale Municipality in Eastern Uganda. In "*contribution to the Hydro-Meteorological Hazards, Risks and Disasters book.* **(Submitted)**

Paper III. Oriangi G, Abrecht F, Di Baldassarre G, Bamutaze Y, Mukwaya P I, Ardö J, & Pilesjö P. (2019). Household Resilience to Climate Change Hazards in Uganda. *International Journal of Climate Change Strategies and Management* **(Accepted).**

Paper IV. Oriangi G, Abrecht F, Bamutaze Y, Mukwaya P I, Nakileza B. Community Perceptions of Resilience to Climate Induced Hazards in Mbale Municipality in Uganda. *Environmental Hazards* **(Submitted).**

Paper V. Oriangi G, Bamutaze Y, Mukwaya P I, Di Baldassarre G, Pilesjö P. Testing the Municipality Resilience Index to Climate Change Shocks and Stresses in Mbale Municipality in Uganda. *American Journal of Climate Change* (**Accepted**)

Contribution of the Author to the Papers

Paper I. Study design, data collection, analysis and writing of the paper.

Paper II. Participated in the study design, partly collected the data and led the writing of the manuscript.

Paper III. Participated in the study design, data collection, partly analysed the data and led the writing of the paper.

Paper IV. Participated in the study design, data collection and analysis and led the writing of the paper.

Paper V. Participated in the study design and data collection and led the writing of the paper.

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Abstract

Climate change shocks and stresses are expected to increasingly affect urban areas in Sub-Sahara Africa (SSA). However, there remain gaps in understanding local precipitation extremes and influential factors that can enhance urban resilience. This study synthesized determinants of urban resilience, investigated historic and projected precipitation extremes up to the year 2050. Also assessed were factors perceived to enhance resilience. These factors informed the proposed Municipality Resilience Index (MRI) which was tested to assess the resilience index of Mbale municipality. The study employed cross sectional survey and some elements of grounded theory and fixed qualitative research designs.

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revealed that education, healthcare, employment, peace and security were perceived as the most crucial resilience factors. Although the community perceived to have progressed in accessing credit, building productive farms and sustaining peace and security, but they assessed a lack of diverse income generating activities, access to insurance, food security, employment and quality health care. Moreover, more marginalized parts of the municipality were experiencing decreasing resilience while other divisions have increased in resilience. The most crucial resilience factors informed the proposed multidimensional MRI that constituted of 46 variables explaining the physical, social, economic and institutional dimensions. When the MRI was tested, findings revealed that Mbale municipality has a low resilience index (0.2).

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Key words: Determinants; Precipitation extremes; Demographic; Social networks; Community perceptions; Index.

Sammanfattning

Klimatextremer förväntas i ökande grad påverka stadsområden i Afrika söder om Sahara. Kunskaperna är fortfarande bristfälliga avseende dessa extremers lokala egenskaper och effekter, samt hur de påverkar städernas motståndskraft (resiliens) mot extremväder. Denna studie sammanställer de faktorer som bestämmer motståndskraften för historiska och kommande extremvädersituationer (både torka och översvämningar) i Mbale samhälle, Uganda, fram till 2050. Vidare bedömds de faktorer vilka uppfattas öka resiliensen i Mbale. Dessa faktorer sammanställs i ett resiliensindex (Municipality Resilience Index) vilket testades för att kvantifiera resiliensen i Mbale. Studien tillämpar en tvärsnittstudieteknik, element av grundad teori och kvalitativ forskningsmetodik.

Studien inkluderar ett flertal metoder för att nå målsättningarna. En litteraturöversikt genomfördes för att sammanställa relevanta faktorer för städernas resiliens. Historiska klimatextremer undersöktes med en 32-års serie med nederbördsdata medan framtida klimatextremer kvantifierades baserat på data från regionala klimatmodeller. Ett standardiserat nederbördsindex användes för beräkning av extremt torra och våta perioder. Faktorer vilka bedömdes som viktiga för att stärka resiliensen skattades baserat på intervjuer genomförda med 389 hushåll, samt nio gruppintervjuer. Data från hushållsintervjuerna tolkades med regressionsanalys och summerades i ett resiliensindex.

Resultaten indikerar att resiliens mot extremväderhändelser påverkas positivt av framförallt grundläggande samhällsservice, sociala nätverk, arbetstillfällen och ägande av produktiva tillgångar. Analysen av nederbördsdata indikerade en ökning av extremt torra och extremt våta perioder för 2004–2014 jämfört med 1982–1992 och 1993–2003. Flest extremt våta perioder förekommer ifrån september till januari. De statistiska resultaten överensstämmer med hushållens uppfattning att torrperioder blivit mer frekventa, varmare och längre de senaste 10 åren. Klimatmodeller predikterar att extremt våta perioder kommer att öka under perioden 2021–2050, vilket innebär en risk för Mbale samhälle. Linjär regression visade att hushållens förmåga att möta sina dagliga behov, hushållen storlek och nätverk av släktingar och icke-statliga organisationer hade signifikant effekt på resilienskapaciteten. Även hushållen med de lägsta inkomsterna var mer benägna att förbereda sig för och att återhämta sig ifrån klimatindicerade problem om de hade förmåga att klara sina dagliga utgifter. Detta är en viktig erfarenhet, då de fattigaste delarna av befolkningen är de mest utsatta. Vidare visades att samhället ansåg utbildning, hälsovård, arbetstillfällen, fred och säkerhet vara de viktigaste faktorerna för resiliens.

Ett multidimensionellt index (MRI) baserat på viktiga variabler för resiliens, inkluderande fysiska, sociala, ekonomiska och institutionella dimensioner, utvecklades. Indexet visade att Mbales resiliens var låg (0,2 på en skala från 0–1) och att den sociala dimensionen bidrar mindre än övriga dimensioner. Sålunda kompletterar resultaten tidigare studier om samhällens resiliens och är relevanta för beslutsfattares förståelse angående resurser och investeringar som kan bygga resiliens

Studien konkluderar att 1) mer forskning krävs för att utveckla det multidimensionella angreppssättet att förstå lokala faktorer som styr resiliensen mot klimatextremer i mindre och mellanstora städer. Detta är av vikt p.g.a. den prognostiserade ökande urbaniseringen. Främjande av små hushåll kan positivt påverka deras resiliens genom att deras ekonomiska och sociala dimensioner stärks. En fortsatt fokusering på utbildning, hälsovård, arbetstillfällen, tillgång till försäkringar samt upprätthållande av fred och säkerhet är viktig för att skapa resiliens för hushåll och samhällen. Mer resurser bör allokeras till de minst resilenta delarna av Mbale samhälle. Slutligen rekommenderas en nationell studie av alla samhällen i Uganda för att skatta resiliensen.

Chapter One

Introduction

1.1 Background of the Study

Over the last decade resilience has emerged as a strategic approach in the global policy discussions as a way of counteracting the unpredictable risks of climate change shocks and stresses (IPCC, 2014; New Urban Agenda, 2016; UNISDR, 2015). However, limited attempts have been made to assess the resilience of urban areas to climate change shocks and stresses in the context of Sub-Saharan Africa (SSA) (Floater *et al*., 2014). Generally, considering the last four decades, the world has experienced several climate change induced shocks and stresses ranging from floods, droughts, heat and cold waves (IPCC, 2014). In the tropics, storms, heavy precipitation events, floods and prolonged droughts have become more frequent since 1970's (Nsubuga & Rautenbach, 2018; Waithaka *et al.,* 2013). In this study, climate change shocks are defined as sudden and rapid disturbances caused by extreme weather conditions (Abdrabo & Hassaan, 2015; The Rockefeller Foundation/Arup, 2016), while climate change stresses refer to slow processes with cumulative effects felt after a long period of time (Joerin *et al.*, 2014; The Rockefeller Foundation/Arup, 2016). In the context of East Africa, climate change studies indicate an increase in climate change shocks and stresses since 1980s (Di Baldassarre *et al*., 2011; IPCC, 2014; Nicholson, 2017; Few *et al.,* 2015). Climate change stresses in the East African region manifest in the form of prolonged droughts crossing over to the rainy season, decline in the long rainy season (Nicholson, 2017) and a significant increase in temperature ranging between 0.5 and 1.2 ^{o}C for the period 1951 to 2010 (Warner *et al*., 2015). While, climate change shocks manifest in the form of increase in seasonal rainfall deficits and overabundance (IPCC, 2014) and an increase in flash floods in areas lying in the lower slopes of high mountains (Lwasa, 2010). These climate induced shocks and stresses coupled with poor living conditions and under resourced socio-economic infrastructure in the tropics (Pharoah & Rose 2016; Thompson *et al*. 2010), are likely to severely affect urban areas in terms of deceleration of industrial production, fluctuation in hydroelectric power supply and deterioration of water quality. (Giglioni, 2015). This is because urban areas concentrate populations at the same time destroying the surrounding ecosystems that protect them from climate extreme events (Dobson *et al*., 2015; Dobson, 2017). Thus, urban areas need to improve

resilience strategies in order to prepare for the uncertain future. Unfortunately, location specific studies that can inform the enhancement of urban resilience to climate changes shocks and stresses are still limited necessitating more empirical investigations on the issue (ACCRA, 2013; Epule *et al.,* 2017).

When it comes to Uganda, progress has been registered in assessing climate change shocks and stresses and reports indicate an increase in temperatures beyond regional figures i.e. 1.3 ^{o}C per decade, an increase in prolonged droughts and heavy precipitation events coupled with flash floods particularly in the second rain season (Nsubuga *et al*., 2014; Egeru, 2016; Kikoyo & Nobert, 2016). Despite the progress, little is known on the resilience of households to climate change shocks and stresses in Uganda's urban areas. Isolated studies that exist include: first, a study by D'Errico and Di Giuseppe (2018) who assessed the resilience of households to food insecurity in rural and urban areas of Northern, Eastern and Central Uganda and reported that highly educated households are more resilient than low educated households while female headed households are less resilient as compared to male headed households. Second, a study by Dobson *et al*. (2015) which was a participatory approach that reported that active participation of the urban poor in improving their earning through the use of environmentally friendly mechanisms, government involvement, partnership with local leaders and non-government organisations are the most influential factors in enhancing resilience. Third, a study by Mugume and Butler (2017) which focused on the functional resilience of drainage systems to extreme rainfall events reported that building flood barriers is important in improving resilience to heavy precipitation events. In fact, the rest of the studies had a rural focus of resilience (Nakileza *et al.,* 2017; Cooper & Wheeler, 2015). What is evident in these illustrated studies is that limited knowledge exists on the understanding of household resilience in Uganda's urban areas against climate change shocks and stresses. Cognizant of these scientific gap and knowledgeable of the fact that Mbale municipality in Eastern Uganda (see Figure 3.1 on page 14) has severally suffered from heavy precipitation events, recurring flash floods, prolonged droughts e.g., in 1980, 1994, 2013 and 2016/2017, coupled with vulnerability to climate related shocks (Dobson *et al.,* 2015; NEMA, 2010; OXFAM, 2017). This study investigated the characteristics of wet and dry extreme periods and the factors perceived to be influential in enhancing resilience to these extreme events in Mbale municipality in Eastern Uganda. This information is vital in informing policies and practitioners that can enhance the resilience of urban areas.

Although there is some disagreement in the definition and measurement of resilience by frameworks and indices, consensus exists that urban areas must become resilient to a wider range of shocks and stresses in order to prepare for future uncertainties (Boyd & Sirkku, 2014; Schipper & Langston, 2015). Thus, several indices have been developed to measure urban resilience to climate change shocks and stresses in the last decade (e.g. Abdrabo & Hassaan, 2015; Gonzales & Ajami, 2017; Kotzee & Reyers, 2016). Although this progress has been made, most indices

focus on mega cities (Suárez *et al*., 2016; Joerin *et al*., 2014) with limited attention on municipalities and townships of developing countries, yet these will play a role in the strong urban growth trajectory projected over the next decades (Floater *et al*., 2014). Furthermore, most indices employ objective approaches that require robust socioeconomic and biophysical data sets that are generally lacking in developing countries (e.g. Dhar & Khirfan, 2017; Kotzee & Reyers, 2016). Additionally, some indices focus on a specific sector such as energy (Lee & Kim, 2017), drainage (Mugume *at el*., 2015), while others focus on detailed investigation of one or two dimension of resilience (Chun, Chi, & Hwang, 2017; Bozza *et al*., 2015). However, urban areas are complex systems constituting but not limited to the natural, physical, social, economic and institutional dimensions. This poses a need for a multidimensional index that is focused on assessing resilience of households to multiple climate change shocks and stresses in municipalities of developing countries where robust socioeconomic and biophysical data are lacking.

Therefore, this study began by synthesizing determinants of urban resilience in Sub-Saharan Africa through a review of literature. This was followed by defining which climate change shocks and stresses affect Mbale municipality and thus, an investigation of extremes in wet and dry periods was conducted. The study then investigated sociodemographic factors that influence household capacity to prepare, recover and adapt when faced with climate change shocks and stresses. This was followed by a community participatory approach to understand the multidimensional components perceived by the community as important in enhancing their resilience when faced with climate change shocks and stresses. The components that the community highlighted informed the variables of the proposed multidimensional Municipality Resilience Index (MRI) which was finally tested to assess the resilience index of Mbale municipality to climate change shocks and stresses.

This dissertation was based on paper compilation and thus some repetition such as: (a) between the general literature review and the literature review of individual papers and (b) between the general methodology and the methodologies of individual papers could not be avoided.

1.2 Statement of the Problem

It is generally known that in the last four decades the world has experienced an increase in climate related shocks and stresses (IPCC, 2014). In the context of Africa, climate change shocks and stresses have become more frequent, severe and widespread since 1970's and have costed an estimated loss of 847,143 lives and affected 362,225,799 people (EM-DAT, 2014). These climate change shocks and stresses are likely to become more severe in the future (Epule *et al*., 2017). These

coupled with poor living conditions and limited socio-economic infrastructure in developing countries are likely to severely affect urban households. In Uganda, climate change shocks and stresses such as wet extremes have often calumniated into increasing flash floods, destruction of crops, houses and roads particularly in the urban areas lying in the lower slopes of high mountains while dry extremes have often resulted into water shortages, reduction of agricultural yields, rising food prices, deceleration of industrial production and reduction of hydroelectric power (Lwasa, 2010; Nsubuga & Rautenbach, 2018). Whereas studies on climate extremes in the region exist e.g. Ogwang, Haishan and Guirong (2012), Ogallo *et al*. (2013) and Awange *et al*. (2007), these studies were based on a regional scale at the same time used regional drought indices such that their results were generalized over the entire region and may not have captured in detail localized conditions. Thus, a need to use localized indices such as the SPI to understand localized characteristics of extremely wet and dry periods in an area like Mbale municipality that lies in a mountainous climate disaster stricken area (UNDP, 2014). Similarly, isolated studies on urban resilience in Uganda exist (Mugume & Butler, 2017; D'Errico & Di Giuseppe, 2018; Dobson *et al.,* 2015). Analysis of these studies shows that limited attempt was made to understand the multidimensional aspects of urban resilience against climate change shocks and stresses. Thus, a need to understand the factors that could be influential in determining urban resilience to climate change shocks and stresses. In order to do this, a diversity of resilience indices exist and since resilience is still a growing concept developing a more applicable and context specific index for measuring urban resilience to climate change shocks and stresses has been an ongoing task. This has created tension within scientific debates but also when transforming "resilience" to practical measures on the ground it becomes difficult to ever reach a common ground of "what resilience really is". Within the multiplicity of indices, most of them utilize objective data which is scarce in developing countries, some focus on assessing resilience of mega cities and metropolitan areas, others focus on specific sectors while others focus on a single dimension of resilience, yet urban areas are complex systems constituted of multiple dimensions. Hence, a need to (a) use a community participatory approach to come up with factors that the community perceives as important towards their resilience, validate these factors through a synthesis of a jungle of indices to suggest a new index that is specifically constructed to fit the needs of developing countries but also accommodates for the variety of previous indices. (b) Explore alternative ways of collecting data and also assessing resilience (through perception/self-evaluation in surveys) that could compliment (not replace) the lack of objective data that could investigate the specific mechanisms for resilience in developing countries such as Uganda and therefore offer deeper explanations and thus solutions than currently possible.

1.3 The Aim

The aim of this study was to contribute knowledge on influential factors that can enhance urban resilience in response to climate change shocks and stresses in Mbale Municipality in Eastern Uganda.

1.4 Specific Objectives and Research Questions

I. To synthesize the determinants of urban resilience to natural and human-induced shocks and stresses in SSA for the period 2000 to 2018. This objective explored how urban resilience is being understood and what determines urban resilience in the context of SSA (paper I).

II. To investigate the characteristics of extremely wet and dry periods in Mbale municipality during the years 1982-2014 and 2021-2050. The following research questions were formulated to answer this objective: what is the frequency of occurrence of extremely wet and dry periods in Mbale Municipality for the years 1982-2014 and 2021-2050? What is the intensity and duration of extremely wet and dry periods in Mbale Municipality for the years 1982-2014? (Paper II).

III. To assess the sociodemographic factors that influence household resilience capacities when faced with climate change shocks and stresses in Mbale municipality. This objective explores which demographic characteristics and social networks influence household capacity to prepare, recover and adapt when faced with climate related shocks and stresses in Mbale municipality? (Paper III).

IV. To determine the multidimensional components that the community of Mbale municipality perceives as important in enhancing their resilience to climate change shocks and stresses. To achieve this objective, the following research questions were formulated: What priority components enhance community resilience in Mbale municipality? To what extent has the community of Mbale municipality achieved these priority components during the climate crisis period and during the normal climate period? What is the trend of household and community resilience in Mbale municipality? And which interventions are perceived to be beneficial in resilience building in Mbale municipality? (Paper IV).

V. To propose and test the MRI in measuring household resilience to climate change shocks and stresses in Mbale municipality. To fulfil this objective, the following research questions were formulated: What dimensions and variables constitute the MRI? What is the resilience index of Mbale

municipality? What is the contribution of the dimensions of the proposed MRI towards the resilience of Mbale municipality? (Paper V).

1.5 Justification of the study

The study is in line with the call by the global community (the Sendai Framework for Action 2015-2030; the United Nations (UN) Sustainable Development Goals 2015, goal number 11 (achieving sustainable cities); the Global Assessment Report on risk reduction (UNISDR, 2015) and the New Urban Agenda (2016)) that strive for immediate action and stronger commitment by member states to prioritize actions that enhance resilience. The study is also in tandem with the Government of Uganda (GoU) policy framework-the National Adaptation Plan of Action (NAPA, 2007) whose agenda is to enhance resilience and the GoU Vision 2040 (Uganda vision 2040, 2013).

Urban areas in Uganda play a significant role in driving economic growth. By the year 2016, 6.4 out of the 34.6 million Ugandans lived in urban areas, 70 percent of non-agricultural GDP in Uganda was generated in urban areas, more than 70 percent of non-agricultural economic activity and non-agricultural jobs were located in urban areas (UBOS, 2016; World Bank, 2016). However, Uganda's urban areas are being threatened by climate change shocks and stresses which can significantly reverse the countries' development trajectory (Dobson *et al*. (2015). Therefore, investigations on characteristics of climate induced extremes and factors contributing to household resilience in urban areas will help inform policies and practitioners that can operationalize actions to enhance urban resilience more so in Mbale municipality in Uganda that lies in a climate disaster prone area characterized with flash floods, landslides and droughts (Nakileza, Majaliwa & Wandera, 2017). In addition, Mbale municipality lies in Uganda's region which is most vulnerable to climate change hazards (Dobson *et al.,* 2015; Kansiime, Wambugu & Shisanya, 2013; Nakileza, Majaliwa & Wandera, 2017).

1.6 Significance of the study

First, this study contributes to urban resilience research by bringing together a pool of knowledge through a synthesis of literature on how urban resilience is understood and what determines urban resilience in the context of SSA. This knowledge may be useful for policy makers and practitioners interested in enhancing urban resilience. Urban resilience is also still a recent and a growing field (Ayyoob, 2016) and thus the synthesis done by this study can aid further understanding of what

constitutes urban resilience in the context of SSA, thus facilitating the formulation of relevant research questions by scholars.

Second, the study assessed multiple factors previously suggested as influential in determining household capacity to prepare, recover and adapt in the context of a developing country. Findings from this assessment provided knowledge that even the lowest income households are substantially more likely to prepare for and recover from climate induced hazards if they are able to meet daily expenditure needs. This is valuable particularly in the context of developing countries where the poorest population is generally most vulnerable to climate related shocks and stresses (Dobson, 2017).

Third, the study provided locally detailed scientific knowledge on the frequency of occurrence, intensity and duration of extremely wet and dry periods, priority factors that the community of Mbale municipality perceives as important in enhancing their resilience and the extent to which the community has achieved the priority factors. Thus, contributing to previous studies on community resilience and bearing relevance for policy makers and practitioners to understand where to invest more resources in order to build resilience.

Finally, the study used the factors perceived by the community as important in enhancing resilience in Mbale municipality to propose the MRI that was used to assess the resilience index of the municipality. The results of the MRI indicated areas of strength and areas of weakness in terms of the resilience of Mbale municipality. This knowledge can inform policy makers and urban planners in Mbale municipality in directing future planning that can build a resilient community.

1.7 The Scope of the Study

In scientific terms, objective one began by synthesizing the determinants of urban resilience to natural and human induced shocks and stresses in SSA through a review of literature. It went beyond the scope of the original study by capturing determinants of urban resilience to natural and human induced shocks and stresses. This was because a very limited number of studies were available on determinants of urban resilience to climate related shocks and stresses. But in order to try satisfy the requirement of systematic reviews, this objective went ahead to synthesize all studies on urban resilience to natural and human induced shocks and stresses. Having found that urban areas in SSA suffer more from climate related shocks and stresses as compared to other shocks and stresses, objective two then investigated the frequency of occurrence, intensity and duration of extremely wet and dry periods in Mbale municipality. Objective three went ahead to single out social factors that may influence household resilience against climate related shocks and stresses in

Mbale municipality. Objective four proceeded to use a community based participatory approach to come up with several priority factors or components that the community of Mbale municipality perceived as important in enhancing their resilience to climate related shocks and stresses. The community priority components were validated with variables proposed by earlier indices informed the proposed multidimensional MRI in objective five. This index was finally tested to assess the resilience index of Mbale municipality against climate change shocks and stresses.

In spatial terms, Mbale municipality was chosen based on its location in the mountainous disaster prone area characterized with erratic rainfall that often manifests inform of heavy precipitation events causing flash floods and droughts (Lwasa, 2010; UNDP, 2013; UBOS, 2014). Additionally, studies on rainfall trends in Mbale region report an increase in both annual and seasonal rainfall which has often culminated into flash floods in low lying areas (Kansiime, Wambugu & Shisanya, 2013; Oratungye *et al.*, 2017). Furthermore, reports indicate that several droughts have affected the region (NEMA, 2010; OXFAM, 2017). Moreover, Mbale municipality is located in one of the regions in Uganda characterized with low social economic status and vulnerability to climate related shocks and stresses (Dobson *et al.,* 2015). These conditions are likely to reduce the resilience of the already vulnerable population and in the process may affect the value of the urban area in providing job opportunities and contributing GDP to the country.

In temporal terms, the study determines both historic and future frequency of occurrence, intensity and duration of extreme precipitation periods in the years ranging from 1982-2014 and 2021-2050. The temporal focus was based on reports that in the last four decades, extreme climate events are on the increase globally (IPCC, 2014). These events are reported to have become more frequent since 1970's in the tropics (Baharen *et al*., 2018; Epule *et al*., 2017; Waithaka *et al.,* 2013). Thus a need to understand the factors that are important in preparedness, recovery and adaptation in order to build both household and community resilience (Lwasa, 2010).

1.8 Theoretical Framework

In the field of ecology, the concept of resilience resonates from the ecological stability theory by Holling (1973, p. 14) who in his seminal work *"resilience and stability of ecological systems"* defined resilience as *"the measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables".* The concept is also linked to the idea in the complex adaptive systems theory (CAS) which is premised

on the interplay between continuity and change in self-organizing systems subject to internal or external disturbances and the capacity of systems to be well prepared in advance, absorb and adapt to such disturbances (Martin & Sunley, 2013). Although the CAS theory does not use the term resilience, it focuses firstly, on the notion "robustness" which has recently been re-conceptualized as the ability of a system to resist internal and external disruptions in order to maintain or restore some of its core functions (Kitano, 2004; Martin & Sunley, 2013). Secondly, it focusses on the concept adaptation which is one of the core concepts studied under the resilience concept.

1.9 The Conceptual Framework

This section presents the development and definition of important concepts used in this study. It also identifies the variables measured to achieve the study objectives.

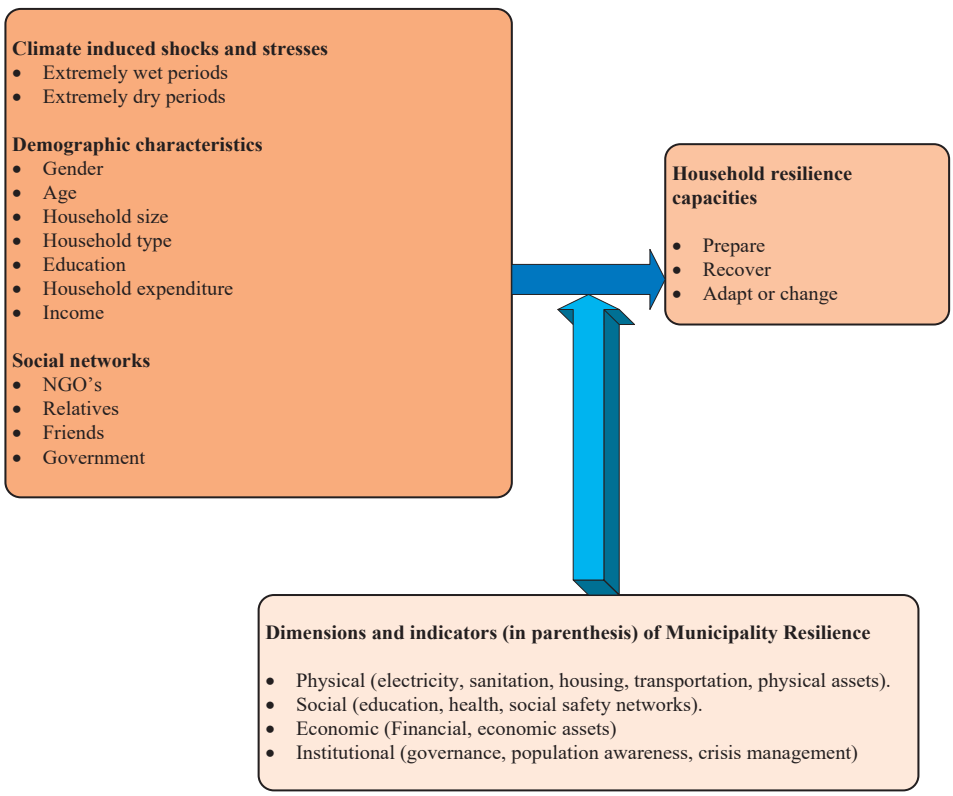

Figure 1.1:
The conceptual framework of this study (self-constructed)

Referring to Figure 1.1, although the concept of resilience began receiving more attention in policy and academia in the 1990's (Department for International Development, 2011), but it emerged from Psychology as early as 1940's and 1950's where it was defined as the ability of individuals to withstand the negative effects of adverse life circumstances such as trauma, exclusion and poverty (Glantz & Johnson, 1996 in Sudmeier-rieux, 2014). In psychology, resilience is generally taken to mean a positive outcome of successful adaptation and thus the ability to "bounce back" to pre-disaster state (Mastens, Labella & Naryan, 2016). In ecology, relating to ecosystem disturbances, resilience was defined as the capacity of a system to adapt to and either maintain its pre-disaster condition ("bouncing back") or the ability of a system to adapt, innovate and transform to a different state as a consequence of shocks or stresses ("bouncing forward") (Holling, 1973). Later, Holling (1996) in the field of engineering, defined resilience as the capacity of material objects and physical structures to withstand disturbances without undergoing structural change. In this conceptualization, resilience was taken to mean maintenance of pre-disaster status and hence maintenance of equilibrium state ("bouncing back"). In the fields of disaster risk reduction and climate change resilience studies, resilience is generally defined as the ability of a society or community to anticipate, respond and recover from shocks and stresses, innovate and change its functioning (Abdrabo & Hassaan, 2015; Batica & Gourbesville, 2016; Kotzee & Reyers, 2016). In this conceptualization, resilience is generally taken to mean a process of "bouncing forward". IPCC (2007) defined resilience as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity to self-organize and adapt to shocks and stresses. In this conceptualization resilience is an outcome thus maintenance of the status quo ("bouncing back"). However, Kelman (2015) noted that if resilience involves maintenance of pre-disaster state then it means a return to pre-disaster conditions, including vulnerability which led to a disaster in the first place for example if post-earthquake Haiti rebuilt to its status prior to the 2010 disaster, then the country would be deliberately constructing the conditions which killed over 200,000 people in the first place. Notwithstanding, the variations inherent in these definitions are based on whether resilience should be taken to mean a process ("bounce forward"), or outcome (maintenance of pre-disaster state), the relation of resilience to vulnerability and the time scale (Sudmeier-rieux, 2014). This study borrows from disaster risk reduction and climate change resilience studies and will view resilience as a process of "bouncing forward". This study defines resilience as the ability of a household, a community, or a socio-ecological system to absorb climate change shocks and stresses, self-organize, innovate, change its basic structure and ways of functioning and adapt to climate change shocks and stresses.

This study determined resilience at two levels i.e. household and Municipality (community) level. Household resilience has been defined differently. FAO (2012) defined household resilience as the ability of a household to prevent disaster and

crisis as well as anticipate, absorb, accommodate and recover in a timely, efficient and sustainable manner. While Jones and Tanner (2015) defined house hold resilience as the ability of a house hold to prepare (anticipate and reduce), recover (absorb and cope) and adapt (adjust, modify or change) to the impacts of climate change. This study borrowed from Jones and Tanner (2016) and will define house hold resilience as the ability of a house hold to prepare, absorb and recover and adapt or change its source of income or livelihood when faced with climate change shocks and stresses. Thus in assessing the resilience of households to climate change shocks and stresses in Mbale Municipality, this study adopts a subjective resilience framework developed by Jones and Tanner (2015). This is premised on a bottom-up process which relies on peoples self-evaluation of the factors that are most important in contributing to household resilience (Lindsey *et al*., 2018). In this perspective, demographic factors (gender, age, household size, education and daily expenditure) and social networks (i.e., networks with friends, relatives, NGO's and government) were treated as independent variables while perceived capacities to prepare, recover and adapt or change were treated as dependent variables. The capacity to prepare describes the ability of households to anticipate and lessen the effects of climate change related shocks and stresses, the capacity to recover describes the ability to absorb and continue thriving, while the capacity to adapt or change describes the ability of a household to adjust and modify its sources of income or livelihood if needed and take advantage of new opportunities presented by climate change shocks and stresses (Aldrich, 2014; Jones & Tanner, 2015).

Similarly, urban resilience has been defined variously. First, ADB (2014) defined urban resilience as the ability of urban areas to continue functioning so that their inhabitant's more so the vulnerable can be able to thrive in the midst of whatever stresses or shocks they face. Second, Abdrabo and Hassaan (2015 p.556) defined urban resilience as *"the ability of an urban system in all its dynamism to support, in the face of a hazard or pressure, the provision and accessibility to services and functions essential for the wellbeing of all residents, especially those lacking the means to buffer stresses"*. Third, Batica and Gourbesville (2016) defined urban resilience as the ability of a system to function during and after a shock. Fourth, the United Nations University and Centre for Policy Research (UNU-CPR) (2016, p. 6) defined urban resilience as *"the ability to activate protective qualities and processes at individual, community, institutional and systems level to engage with hazards and stresses and cooperate with each other in order to maintain or recover functionality and prosper while adapting to a new equilibrium and minimizing the accumulation of pre-existing or additional risks and vulnerabilities*". Fifth, The Rockefeller Foundation/Arup (2016) defined urban resilience as the ability of an urban area to continue functioning such that its inhabitants can be able to survive and thrive in the midst of shocks and stresses. Several studies have thus defined the concept of urban resilience. This study draws from Abdrabo and Hassaan (2015), Batica and Gourbesville (2016); Joerin *et al.* (2014) and The Rockefeller Foundation/Arup (2016) and defines urban resilience as the capacity of an urban system and all its

constituent socio-ecological networks to absorb climate change shocks and stresses through preparedness and the capacity to recover, innovate and adapt to climate change shocks and stresses. In this essence resilience is taken to mean an ongoing process of change and transformation.

Furthermore, several indices have been developed to measure urban resilience to climate change shocks and stresses (Abdrabo & Hassaan, 2015; Gonzales & Ajami, 2017; Kotzee & Reyers, 2016). This study used community perception which were validated by expert knowledge drawn from previous indices to propose a MRI. The MRI was used to assess the resilience of Mbale municipality to climate change shocks and stresses. Obtaining community perceptions on what is considered important in enhancing their resilience was facilitated by employing a qualitative Community Based Resilience Analysis approach (CoBRA) (UNDP Drylands Development Centre, 2013) which is premised on the fact that it is the communities themselves that understand those factors which are important in enhancing their resilience. The existing urban resilience indices that were used to validate community perceptions include: the climate disaster resilience index (CDRI) (Joerin *et al*., 2014), the spatial disaster assessment model of social resilience (SDAMSR) (Chun, Chi, & Hwang, 2017), the flood disaster resilience index (FDRI) (Kamh *et al.,* 2016), the climate hazard resilience indicator for localities (CHRIL) (Hung, Yang, Chien, & Liu, 2016), the flood resilience index (FRI) (Batica & Gourbesville, 2016), the socio-ecological index (SI) (Kotzee & Reyers, 2016) and the integrated resilience index (IRI) (Abdrabo & Hassaan, 2015).

Furthermore, in proposing the MRI, the study employed the methodology put forward by Nardo *et al*. (2008) and OECD (2008). The proposed MRI contains 46 variables and 14 indicators explaining the physical, social, economic and institutional dimensions as explained below.

- Dimension 1-physical: indicators and variables of interest (in parenthesis); Water (access, safety, alternative capacity). Electricity (access, reliability, alternative supply). Sanitation (toilets, diversity of solid waste management, connected to reliable sewage network). Housing (ownership, type, ability to withstand shocks). Transportation (access to roads, status of interruption after heavy rain, road side covered drains). Physical assets (land ownership, crops and livestock ownership, television, radio, mobile phone and motorized vehicle).
- Dimension 2-social: indicators and variables of interest (in parenthesis); Education (level, quality, climate change training programs). Health (access, stockpiles for emergencies, good health). Social safety networks (with NGO's, relatives, friends, government).
- Dimension 3-economic: indicators and variables of interest (in parenthesis). Finance (monthly income, alternative income sources,

savings, access to credit, employment). Economic assets (pensions, insurance, remittances).

- Dimension 4-Institutional: indicators and variables of interest (in parenthesis); Good governance (vulnerability assessment, ecosystems protection, stakeholder's involvement in decision making, implementation of climate change management plans, disaster preparedness plans, representation of marginalized groups). Population awareness (early warnings, climate change awareness programs). Crisis management (Authority dealing in climate change, trained emergency teams, emergency centres).

In this study, the terms "climate change shocks and stresses" as defined in sub section 1.1 are used interchangeably with "climate extreme events" or "extremely wet and dry periods" or precipitation extremes. Extreme events are generally defined as exceeding above or below pre-existing threshold (UN Secretariat General, 1994; Giglioni, 2015). Climatic variable of interest in this study were wet and dry extreme events.

1.10 The Dissertation Structure

This dissertation consists of five chapters and the appended papers as follows:

Chapter one gives the introduction of the study which provides the background of the study, the problem statement, objectives and research questions, justification and significance of the study, the study scope, theoretical and the conceptual framework and organisation of the thesis.

Chapter two synthesizes relevant literature on: urban resilience to natural and human-induced shocks and stresses, climate change extreme events, sociodemographic factors that influence household resilience to climate change shocks and stresses and the multidimensional components that enhance community resilience to climate change shocks and stresses.

Chapter three focuses on the general methodology constituting of the background information of the study area, the philosophical position that the study leans on, the research design employed to undertake the study and the methods used in data collection and analysis.

Chapter four presents the study results and discussion.

Chapter five provides the summary of key findings, conclusion and recommendations of the study.

Chapter Two:

Literature Review

2.1 Introduction

In this chapter, relevant literature to the issues which the study addresses are synthesized and presented. It covers literature on: (a) Urban resilience to natural and human-induced shocks and stresses (b) climate change extreme events (c) sociodemographic factors influencing urban resilience to climate change shocks and stresses (d) components that enhance community resilience to climate change shocks and stresses and (e) proposing the municipality resilience index.

2.2 Urban Resilience to Natural and Human-Induced Shocks and Stresses

Urban resilience to natural and human-induced shocks and stresses has been raised as an important objective in the global agenda (the Sendai Framework for Action 2015-2030; UNISDR, 2015). This is because more than half of the 7.7 billion of the world's population now lives in urban areas, making the globe to experience the largest urban growth in its history (Saghir & Santoro 2018; Pharoah *et al*., 2016). It is projected that by 2020, the number of people that live in urban areas will increase to approximately five billion with a greater proportion of the increase experienced in Africa and Asia (Pharoah *et al.,* 2016). However, natural and human-induced shocks and stresses more so climate induced extremes threaten to pose risks to urban areas due to concentrations of population and socio-economic infrastructure (Bozza *et al*., 2015; Boyd & Juhola 2014; NCEA, 2015). Therefore, understanding the resilience of urban areas is imperative in informing policy makers and practitioners that can help enhance the resilience of urban areas. This would also help to maintain the significant role that urban areas play in driving economic growth and poverty reduction (Saghir & Santoro, 2018). For the case of Sub-Saharan Africa (SSA), natural and human-induced shocks and stresses are increasingly affecting urban areas (NCEA, 2015). This is because urban areas is in SSA tend to be ill prepared, have limited ability to accommodate and recover, have low adaptation capabilities coupled with under-resourced socio-economic infrastructure (Pharoah & Rose

2016; Thompson *et al*., 2010). These often make urban areas in SSA hotspots to risks posed by natural and human-induced shocks and stresses (Greenwalt & Raasakka, 2018; Pharoahet & Rose, 2016; Solecki, 2015). Much as isolated reports on the determinants of urban resilience in SSA exist e.g., (Dobson, 2017; Kotzee & Reyers, 2016; Mugume & Butler, 2017), scarcity of studies that bring together a pool of several findings on what determines urban resilience in SSA exists. Thus, the first task of this study was to review and synthesize both peer-reviewed and grey literature with the purpose of coming up with a pool of findings on the determinants of urban resilience to natural and human induced shocks and stresses in SSA.

Although some reviews have been undertaken on the subject of urban resilience (Meerow *et al*., 2016; Ilmola, 2016; Juan-García *et al*., 2017; Ayyoob, 2016), but analysis of these reviews showed that there was a limited focus on the determinants of urban resilience in the context of sub-Saharan Africa. The need to integrate findings on determinants of urban resilience to create a pool of knowledge thus existed. This can be beneficial for urban planners and civil society organisations in the selection of the most effective combination of short- and long-term resilience strategies that can be relevant in enhancing the resilience of urban areas (FAO-UNICEF-WPF, 2014). Additionally, urban resilience is also still a recent and a growing field (Ayyoob, 2016), thus integrating a pool of knowledge on urban resilience can aid further understanding of what constitutes urban resilience in the context of SSA and thus facilitating future studies in this field.

2.3 Climate Change Extreme Events

A considerable increase in climate extreme events has been reported globally in the last four decades (Awange *et al.,* 2007; Katsanos *et al*., 2018; Mishra & Singh, 2010). Some of these extreme events were attributed to El-Nino-South Oscillation (ENSO), increase in the tropical Atlantic sea surface temperatures and Asian monsoons (Dai, 2011; Marengo & Espinoza, 2016). These extreme events are likely to become more severe in the future (Spinoni *et al*., 2018). Moreover, the effects of these extreme events will be much felt in the urban areas of developing countries due to high population concentrations and inadequate socio-economic infrastructure that would help manage the effects (Pharoah & Ross, 2016). In the context of Africa, extreme precipitation and droughts have become more frequent, severe and widespread, often resulting into several challenges (Awange *et al*., 2007; Epule *et al.,* 2017; Mishra & Singh, 2010). Available estimates on droughts indicate that during the period 1900-2013, Africa has been faced with 291 droughts (EM-DAT, 2014). These droughts have resulted into reduction of agricultural yields, deceleration of industrial production, reduction of hydroelectric power, deterioration of water quality and general ecosystem degeneration (Baharen *et al.,* 2018; Giglioni, 2015). Mishra and Singh (2010) indicated that the unprecedented

severity of droughts that has often been experienced in SSA was the major reason for the institutionalization of the United Nations Convention on combating desertification and droughts. On the other hand, wet extreme events in SSA have often culminated into flash floods, destruction of crops, houses, roads and worsening health challenges in communities (Dobson, 2017; Patz *et al*., 2000). Although the effects of climate extreme are a global concern facing humanity and terrestrial ecosystems in the twenty first century, but the greatest risks will be manifested locally (Bengal, Palchaudhuri, & Biswas, 2013; Katsanos *et al*., 2018; Schöll *et al*., 2007). Therefore, the understanding of the past, present and future characteristics of climate extremes such as frequency of occurrence, intensity, magnitude and duration at the local scale is imperative not only for community preparedness but also for the development of adaptation strategies that would guarantee the safety of the population, ensure adequate water quality and supply for domestic and industrial use, support agricultural production and ecosystem protection (Baharen *et al.,* 2018; Res *et al*., 2007). However, what is evident is limited location specific knowledge regarding the past, present and future characteristics of precipitation extremes in the context of Sub Saharan Africa.

For the case of Uganda, climate extreme events have become a common phenomenon (Nsubuga & Rautenbach, 2018; Ogwang, Haishan, & Guirong, 2012). Reports indicate that wet extreme events in Uganda often occur in times of El-Nino events while dry extreme events are likely to be experienced during La-Nina events (Nicholson, 2017; Nsubuga *et al*., 2014). Wet extreme events in Uganda have often resulted into flash floods particularly in the urban areas lying in the lower slopes of high mountains (Lwasa, 2010) while extreme dry periods have often led to problems such as water shortages and rising food prices. Researchers such as Egeru, (2016); Hepworth (2010); Nimusiima, Basalirwa, & Majaliwa (2013); Nsubuga et al. (2014) and others have made a good attempt in assessing trends in climate variability. Furthermore, researchers such as Ogwang, Haishan and Guirong (2012) investigated drought events and associated circulation anomalies over Uganda for the period 1962-2007, Ogallo *et al*. (2013) assessed daily rainfall and temperature extremes over ten countries in the great horn of Africa for the period 1971-2006 while Awange *et al*. (2007) assessed droughts in the Lake Victoria region of East Africa. These previous studies focusing on the regional scale did a great deal of work in assessing climate extremes such that their results were generalized over the entire region. In addition, they used regional drought indices thus may not have captured in detail localized climate extremes. The second objective of this study deviated from the previous studies by focusing on a localized scale while investigating the frequency of occurrence, intensity and duration of wet and dry extreme periods. The study also deviated in terms of methodology by employing the Standardized Precipitation Index (SPI) put forward by McKee *et al*. (1993). The time scales also varied (1982-2014 and 2021-2050).

An evaluation of projected changes in precipitation extremes is inconclusive and gives mixed results. Many studies report an increase in extremely wet periods globally (Masih *et al*., 2014; Prein *et al.,* 2017) while others indicate a reduction of extremely wet periods (Davis, Hoffman & Roberts, 2016). For the case of dry extremes, Dai (2011), Masih *et al*. (2014) and Spinoni *et al*. (2018) reported an increase over most of Africa, Southern Europe, Middle East, most of America, Australia and South Asia while, Shongwe *et al*. (2011) projects a near future of likely far less dry extreme events over the East African region. Climate model results are not consistent and tend to vary from region to region or even in the same region. This is due to model limitations and complexities in the natural processes (Masih *et al*., 2014; Prein *et al.,* 2017). However, historic evidence suggests that the African continent is likely to face widespread extremely dry periods in the future (Masih *et al*., 2014). It is thus apparent that expected changes in extremely wet and dry periods are spatially constrained, particularly in Africa where a large natural variability exists necessitating more localized studies to understand future characteristics of wet and dry extremes so us to guide planning. In terms of trends in future projections in wet periods for Uganda, most studies consistently indicate an increase in the proportion of precipitation that falls in heavy events and the December to February dry season becoming wetter (Lindsey *et al*., 2012; Nimusiima *et al*., 2014). This increase in Uganda's future precipitation shows much to be desired on the resilience of Uganda's urban areas. While projections in extreme climate events are useful in informing future preparedness plans, knowledge on historic and present climate events are important in informing current policy decisions in different planning processes.

2.4 Sociodemographic Factors that Influence Household Resilience to Climate Change Shocks and Stresses

Several studies have indicated the relevance of sociodemographic factors in determining household resilience when faced with shocks and stresses (Aldrich & Meyer, 2014; D'Errico & Di Giuseppe, 2018; IPCC, 2015). To illustrate this, the Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment report highlighted that demographic characteristics such as age, gender, income and the health status influence the resilience of urban population (IPCC, 2015). Furthermore, the relevance of demographic factors such as type of household head, household size and level of education in influencing resilience to food insecurity were assessed by D'Errico and Di Giuseppe (2018) and their finding indicated that female headed households were less resilient as compared to male headed households, while highly educated households were more resilient than low educated households. In addition, Jones and Samman (2016) reported that age and

advance knowledge of previous floods were more crucial than the level of education, gender and occupation in determining household resilience.

Additionally, the importance of social networks in enhancing community and household resilience has also been reported severally (Aldrich, 2014; Sadri *et al.*, 2017; Tawodzera, 2012; Tippens, 2016). This is because social networks such as networks with relatives, friends, NGOs and government often act as first responders during times of shocks and stresses and are helpful in providing emotional support, gifts and early warnings (Aldrich & Meyer, 2014; Tippens, 2016). For example, Tawodzera (2012) reported that networks with friends and relatives from the rural communities in Harare in Zimbabwe were so important in enhancing the resilience of urban household against food insecurity. Further still, Tippens (2016) reported that the resilience of urban refugees in Nairobi, Kenya was enhanced by establishing networks with NGO's particularly religious organisations. A synthesis of the above studies give important insights on which factors are significant in resilience enhancement. However, the above studies focused on different types of shocks and stresses, e.g. food insecurity (D'Errico & Di Giuseppe, 2018; Tawodzera, 2012), psychological stress (Tippens, 2016) and floods (Jones & Samman 2016). Furthermore, the above studies generally restricted predictors to either more objective demographic and economic factors (D'Errico & Di Giuseppe, 2018), or focused solely on the role of social networks (Aldrich, 2014; Sadri *et al.*, 2017; Tawodzera, 2012; Tippens, 2016). Therefore, the third objective of this study adds on to the previous studies by using a broader subjective approach that includes multiple demographic, economic and social factors at the same time capturing a wider range of climate related shocks and stresses.

Further evidence also suggests that although some studies on resilience have been conducted in Uganda's urban areas (Mugume & Butler, 2017; Dobson *et al.,* 2015; D'Errico & Di Giuseppe, 2018), they did not focus on assessing demographic characteristics and social networks in influencing resilience capacities of urban households to climate change shocks and stresses. Thus, the third objective of this study was focused on investigating demographic characteristics and social networks that may influence household capacity to prepare, recover and adapt or change their source of income or livelihood if needed in the face of prolonged droughts or erratic rainfall events in Mbale municipality in Eastern Uganda. This knowledge is important since it may present a potential policy impact given the fact that Uganda's level of resilience to climate change shocks and stresses is low (Warner *et al.,* 2015). The task of assessing multidimensional components that influence urban resilience was left for the fourth and fifth objectives of this study.

To achieve the third objective of this study, several frameworks developed to measure urban resilience to climate change shocks and stresses were synthesized (Bozza, Asprone and Manfredi, 2015; Gonzales & Ajami, 2017; Chun *et al,* 2017). Most of these frameworks measure common capacities although not limited

to the capacity to prepare, recover and adapt or change (Lindsey *et al.,* 2018). However, most of these frameworks employ objective approaches that make use of secondary socio-economic and bio-physical data sets as proxies for understanding resilience factors (Abdrabo & Hassaan, 2015; Chun *et al,* 2017). Moreover, such data is often lacking in developing countries (Jones & Tanner, 2015). This makes the use of objective resilience approaches in many less developed countries limited. Additionally, objective resilience approaches miss out the ability of people to self-evaluate their resilience capacities. To reduce these challenge, Jones and Tanner (2015) proposed a subjective resilience approach which was adopted to achieve the third objective of this study. This approach was also used by Lindsey *et al*. (2018) to assess household resilience to floods in Tanzania. This approach was chosen due to its ability to capture people's cognitive self-evaluation of their resilience capacities to prepare, recover and adapt which were difficult to achieve by objective frameworks. At the same time focusing on context specific sociodemographic issues (e.g., networks with friends, relatives, NGO's, gender, age, household size and type) which are significant in determining resilience of households (Aldrich, 2014; Lindsey *et al*., 2018).

2.5 Measuring the Multidimensional Components that Enhance Community Resilience to Climate Change Shocks and Stresses

Although the resilience of communities has been taken as one of the major objectives within the disaster risk reduction and Sustainable Livelihood Frameworks (SLF) (UNISDR, 2015; Klein, Nicholls & Thomalla, 2003; Conway & Chambers, 1991), it has remained difficult to translate these global objectives into actual location specific improvements of resilience. Research by Hollis (2017) shows how important local contexts are for disaster risk reduction and why international organizations fail with their projects if they do not close the gap between community understanding and global frameworks. Similarly, studies by Ostrom, 1992; Feeny, Berkes, Bonnie and McCay (1990); and Smith and Frankenberger (2018), argue that it is the communities themselves that have the best understanding of what increases their resilience. The need to understand how communities perceive resilience and assess the multidimensional components that contribute to increased resilience thus existed. More so in Mbale municipality located in one of the regions in Uganda characterized with high poverty levels and vulnerability to climate related shocks and stresses such as erratic rainfall events and droughts (Dobson *et al.,* 2015; UNDP, 2012). Therefore, the fourth objective of this study focused on determining the multidimensional components that the community of Mbale municipality perceives as important in enhancing their

resilience to climate change shocks and stresses. The objective borrows insights and the methodology of the CoBRA approach (UNDP Drylands Development Centre, 2013) in framing the research questions i.e., (a) what does the community perceive as priority components that enhance resilience?, (b) to what extent has the community achieved the priority components of resilience during the normal climate period and during the last significant shock or stress in climate?, (c) what is the trend of household resilience? And (d) which interventions have been beneficial in resilience building in Mbale municipality in Eastern Uganda? The CoBRA approach categorizes resilience components into the physical, human, financial, natural and social. The physical elements include the basic infrastructure such as roads, railways, telecommunication, markets, sanitation, shelter and water. The human elements include education, food security and health care. The financial elements include access to credit, productive farms, employment and diversified income generating activities (DIGA) and livestock, while peace and security constitutes the social element. The CoBRA approach explains that more access to the physical, human, financial, natural and social elements will enhance community resilience. The CoBRA approach uses the Sustainable Livelihood Framework (SLF) by Chambers and Conway (1991) to classify resilience components. This is because the SLF forms the building block of resilience and also eases the grouping of components identified by the community (UNDP, 2014a). The CoBRA approach is chosen based on its premise that the communities themselves are better placed to evaluate the most important components in resilience building. The study deviates from the traditional top-bottom approaches of objective indicators that assume that experts have a better understanding of factors that drive peoples resilience using predefined frameworks (Jones & Tanner, 2015; Jones & Samman, 2018). While objective approaches have numerous strengths (Suárez *et al*., 2016; Chun, Chi, & Hwang, 2017), subjective resilience assessments such as the CoBRA, can be useful in informing objective approaches on what defines community resilience, thus providing valuable insights for building objective resilience indicators.

These components highlighted by the community as important in enhancing their resilience were used to inform objective five of this study which proposed and tested MRI to determine the resilience index of Mbale municipality and assess the contribution of the resilience dimensions towards household resilience against climate change shocks and stresses. This knowledge is important as it can inform policy-makers and practitioners on community priority components that can enhance resilience as well as informing objective indices on the key indicators of resilience.

2.6 Proposing the MRI for Measuring Household Resilience to Climate Change Shocks and Stresses

Several indices have been developed in several fields to measure urban resilience to climate related shocks and stresses (e.g., Chun, Chi, & Hwang, 2017; Batica & Gourbesville, 2016; Bozza *et al*., 2015; Dhar & Khirfan, 2017). But because of the complex nature of resilience as a concept, defining and developing a more applicable and context specific index for measuring urban resilience to climate related shocks and stresses is still an ongoing task (Chun, Chi, & Hwang, 2017). Indices such as: the Climate Disaster Resilience Index (Joerin *et al*., 2014), The Integrated Resilience Index (Abdrabo & Hassaan, 2015), The socio-ecological index (Kotzee & Reyers, 2016) and the Urban Resilience Index (Suárez, Gómez-Baggethun, Benayas, & Tilbury, 2016) have been developed and proposed to be used to measure urban resilience to climate related shocks and stresses. Despite the progress, most indices focus on mega cities and metropolitan areas in developed countries (Kamh & El-Bahrawy, 2016; Gonzales & Ajami, 2017; Sharifi & Boland, 2017; Miguez & Verol, 2016). Thereby giving little attention on municipalities and townships. Additionally, most indices employ objective approaches that require robust socioeconomic and biophysical data sets that are generally lacking in developing countries (Abdrabo & Hassaan, 2015; Chun *et al*., 2017; Gonzales & Ajami, 2017; Forino, MacKee & von Meding, 2016a). Furthermore, some indices focus on specific sectors such as energy (Elena *et al*., 2017), drainage (Lee & Kim 2017; Mugume *et al*., 2015), cultural heritage (Forino *et al*., 2016) with limited mention of the principles of resilience that the variables address. While others focus on one dimension of resilience (Chun *et al*., 2017; Bozza *et al*., 2015). Thus, a need for a multidimensional, subjective approach which focuses on municipalities and townships of developing countries, at the same time considering the qualities of resilience that variables measure exists.

Indices that measure urban resilience try to refine urban resilience into generally related dimensions which may include but not limited to the physical, natural, social, economic and institutional (Abdrabo & Hassaan, 2015; Batica & Gourbesville, 2016; Hung *et al*., 2016). The physical component refers to the basic infrastructure (roads, telecommunication, markets, sanitation, shelter, water, electricity and housing) that facilitates the well-functioning of the community, enhances people's ability to respond, absorb and recover easily when faced with shocks and stresses (Joerin *et al*., 2014; The Rockefeller Foundation/Arup, 2016). The natural component is where other resource base activities depend on i.e. land, forests and wet lands (UNDP Drylands Development Centre, 2013). The social dimension such as education sector can promote human development and enables people to easily understand early warnings which creates awareness about potential shocks and stresses while inclusive health sector can support citizens to recover during shocks and stresses. The social networks among residents shows how people are connected

in supporting each other to manage challenges (Joerin *et al*., 2014). The economic dimension shows the ability of people to get income which is important in accessing basic needs of life and enhances the ability to thrive during shocks and stresses. It also shows the ability to save which provides the spare capacity that can be used during shocks and stresses. Elements of the economic dimension include income, savings, access to credit and employment (Joerin, 2014). The institution dimension includes good governance, population awareness and crisis management. It looks at the local and national government functioning to be able to manage shocks and stresses. It enables protection of important ecosystems which are essential in enabling the urban area to thrive during climate change chocks and stresses (The Rockefeller Foundation/Arup, 2016).

The variables of the proposed MRI were informed by the priority factors perceived by the community of Mbale municipality as important in enhancing their resilience. The study also synthesized eight indices that have been used to measure urban resilience to climate related shocks and stresses to validate what was derived from the community. The indices selected have dimensions, indicators and variables related to the physical, social, economic and institutional factors. The study followed the methodology employed by Nardo *et al*. (2008) and OECD (2008) in formulating the proposed MRI index. The indices selected include: the CDRI developed by Joerin, Shaw, Takeuchi, & Krishnamurthy (2014) consisting of the physical, social, economic, institutional and natural dimensions. The IFUR developed by Abdrabo and Hassaan (2015) consisting of the socio-economic, physical, environmental, institutional and climate change hazards. The SI developed by Kotzee and Reyers (2016) composed of the social, ecological, infrastructural, economic and institutional dimensions. The FDRI developed by Kamh, Khalifa and El-Bahrawy (2016) composed of governance, economic, natural, physical and social dimensions. The FRI developed by Batica and Gourbesville (2016) composed of the social, economic, physical, natural and institutional dimensions. The CHRIL developed by Hung et al. (2016) constituting of the biophysical, socioeconomic, institutional, infrastructural and adaptive capacity and learning dimensions. The SDAMSR developed by Chun, Chi and Hwang (2017) having the human, community, economic and organizational dimensions and the CRI developed by The Rockefeller Foundation/Arup (2014) which has four dimensions (i.e. health and wellbeing, economy and society, infrastructure and ecosystem and leadership and strategy).

Further still, most urban resilience indices either focus on the physical assets viewpoint while disregarding the intangible assets such as the social capital and safety nets (Jones & Tanner, 2015), while others focus on adaptive capacity which views an urban area as a system encapsulating the physical, social, economic and institutional dimensions (Abdrabo & Hassaan, 2015). Similarly, this study views an urban area as a complex system comprising of the social, economic, physical and institutional dimensions and thus, the complex adaptive systems theory is one of the

theories that were used to anchor this piece of work (Ilmola, 2016; Meerow *et al*., 2016; Cole *et al.*, 2013). Furthermore, household resilience capacities are process-oriented, context specific and do not only constitute the tangible objective livelihood assets but also such things like community cohesion, social networks and perceived capabilities which are also significant in determining resilience of households (Abdrabo & Hassaan, 2015; Jones & Samman, 2016; Wong-Parodi *et al*., 2015). Therefore attempts to measure resilience of households need to recognize people's intangible assets and their perceptions of resilience in the face of shocks and stresses (Aldunce *et al*., 2015; Jones & Tanner, 2015). Current assessments of urban resilience rarely consider subjective aspects and yet this facilitates comprehensive understanding of resilience indicators that are difficult to be assessed by objective assessments (Jones & Tanner, 2015; Walker *et al*., 2017). It is cognizant that subjective approaches can complement objective resilience approaches by allowing individuals to self-evaluate their own households on factors that influence their resilience capacities. Thus, this study draws from the community perceptions attained from the study objective four and validated using the eight frameworks reviewed to propose a MRI which was piloted to assess resilience in Mbale municipality in Uganda where robust socioeconomic and biophysical data sets are generally lacking at the same time observing the qualities that resilience indicators should measure.

Chapter Three:

Methodology

3.1 Introduction

In this chapter, the background information of the study area, the philosophical position that the study leans on, the research design employed to undertake the study and the methods used in data collection and analysis are presented.

3.2 Description of the Study Area

3.2.1 Location

The study was conducted in Mbale Municipality in eastern Uganda (Figure 3.1). Mbale Municipality is bordered by Nakaloke town Council to the North West, Namanyonyi Sub County to the north east, Bungokho-Mutoto Sub County to the south east and Bukasakya Sub County to the south west (Mbale District Local Government Statistical Abstract, 2012). The municipality lies in an altitude ranging between 1100m and 2438m above sea level and has a total land area of 518 square kilometres (UNDP, 2010). The municipality was selected based on its location on the lower slopes of mount Elgon which is prone to climate disasters and characterized with heavy precipitation events, recurring flash floods and droughts (UNDP, 2010; Mbale District Local Government Statistical Abstract, 2012). The municipality was also selected due to its location in one of the regions in Uganda characterized with low social economic status and high level of vulnerability to climate related shocks and stresses (Dobson *et al.,* 2015). These conditions are likely to reduce the resilience of the already vulnerable population and in the process may affect the value of the urban area to contribute towards the development of the region.

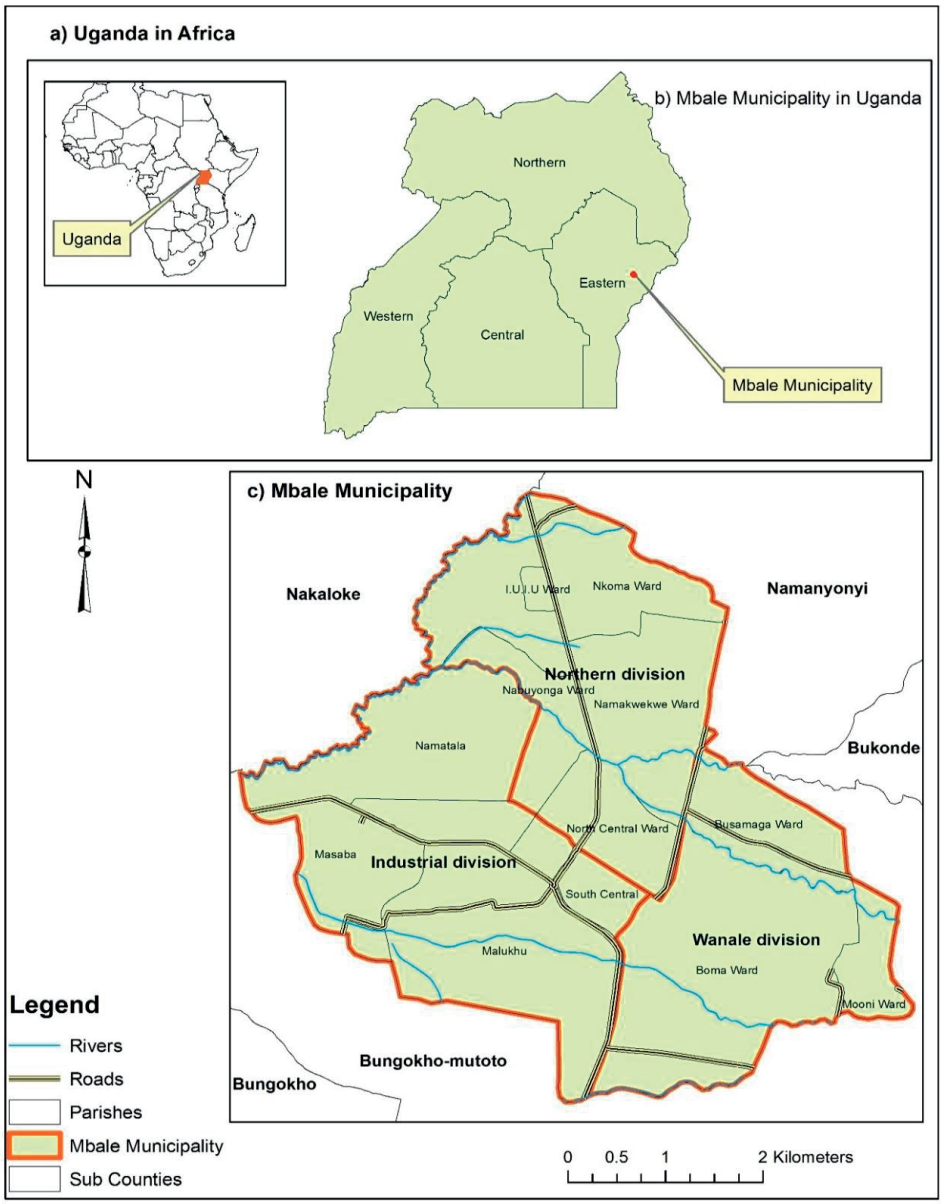

Figure 3.1:
Location of Mbale Municipality in Eastern Uganda based on UBOS shape files, 2014

3.2.2 Climate

Mbale Municipality experiences humid tropical type of climate (UNDP, 2010). It experiences bimodal type of rainfall during March to June and September to November while the dry season extends from December to February and in July (UNDP, 2012) (Figure 3.2). The average total annual rainfall received was 1500 mm and the average annual temperature was 23 ˚C for the period 1960-2009 (Mbale District Local Government Statistical Abstract, 2012). Climatic changes are manifesting mainly through increasingly erratic rainfall regime and increasing temperatures which is expected to increase the frequency and intensity of extreme events such as droughts, flash floods, landslides and heat waves (UNDP, 2012).

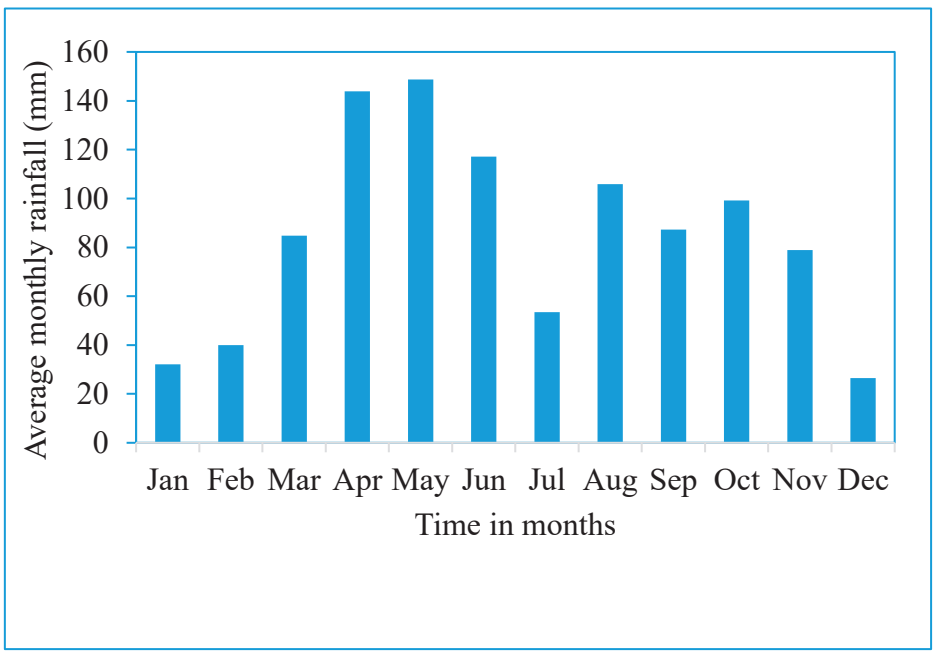

Figure 3.2:
Monthly average rainfall (mm) for Mbale municipality for the period ranging from 1986-2014. Source: Self constructed using data from Uganda National Meteorology Authority

3.2.3. Population of Mbale Municipality

The population of Mbale Municipality is illustrated in the Table 3.1.

Table 3. 1:
The population of Mbale municipality

The population of Mbale municipality for the period 1960-2014	
Year	Total population
1960	23,544
1980	28,039
1991	53,987
2002	71,130
2014	92,857
The population of the three divisions in Mbale Municipality in the year 2014	
Industrial	40, 395
Northern	37,908
Wanale	14,554
Total	92,857

Source: (Uganda Bureau of Statistics (UBOS), 2006, 2016)

3.3 The Research Philosophy

The study adopts the pragmatic philosophical position which argues that the most important determinant of the nature of knowledge the research is looking for (epistemology), our assumptions of how we view the world i.e., whether it consists mostly of social order or constant change (ontology) and methodology is the research question (Bhattacherjee, 2012). Different research questions may require different approaches (Saunders *et al*., 2007). Consequently, because of the varied research questions involved in this study, some requiring the positivist approach which employs quantitative methods and others requiring the interpretivist approach that employs qualitative methods (Hatch & Cunliffe, 2006), the pragmatic approach become the most appropriate. The positivist philosophy was derived from natural sciences and is characterized by testing of hypothesis developed from existing theories. It involves deductive or testing of theories through measurement of observable social realities. The positivist philosophy was adopted in this study to help answer the following research questions:

I. Which demographic characteristics and social networks have a significant influence on household resilience capacities when faced with climate change shocks and stresses in Mbale municipality?

II. What is the frequency of occurrence, intensity and duration of extremely wet and dry periods during the years 1982-2014 and 2021-2050 in Mbale municipality?

III. What is the resilience index of Mbale municipality?

IV. What is the contribution of the dimensions of the proposed Municipality Resilience Index towards the resilience of Mbale municipality?

The interpretivist philosophy which refers to "constructed and constantly (overtime) reconstructed through experience resulting in many differing interpretations" normally associated with qualitative data collection and analysis (Flower, 2009) was utilized in this study in trying to answer the following research questions:

V. What does the community perceive as priority components that enhance their resilience?

VI. To what extent has the community achieved the priority components of resilience during the normal climate period and during the last significant shock or stress in climate?

VII. What is the trend of household and community resilience in Mbale municipality?

VIII. Which interventions are perceived to be beneficial in resilience building in Mbale municipality?

3.4 Research Design

The study employed a cross sectional research design, some elements of grounded theory and fixed qualitative research designs as described by Lyberg *et al*. (1997) and Parahoo (1997) respectively to capture a representative sample of the population. The cross-sectional research design was utilized by quantitative sub studies while grounded theory and the fixed qualitative research designs were utilized by the qualitative sub study. Using cross sectional survey research design, the study was able to derive insights, opinions, perceptions and knowledge on climate change shocks and stresses, household demographic characteristics, social networks, resilience related capacities and the indicators of the physical, social, economic and institutional dimensions of resilience to climate change shocks and stresses. On the other hand, using some elements of grounded theory and fixed qualitative research design, the study explored the priority components that the community of Mbale municipality perceived as important in enhancing their resilience, the extent to which they have achieved these priority components, the trend of resilience and the interventions that have been beneficial in enhancing resilience. The community priority components that were derived informed the formulation of the MRI that was proposed and tested. The elements of the research design of the study i.e. the target population and unit of analysis, sample size and sampling procedures are described in sub section 3.4.1 to 3.4.3.

3.4.1 Target Population and Unit of Analysis

Because the study issues were focused on climate change shocks and stresses, household demographic characteristics, household social networks, household resilience capacities and the physical, social, economic and institutional dimensions of resilience, the target population of the study constituted of the general population in the study area. The unit of analysis for the study was households and the local government officials since they enabled the study to capture and investigate a range of socio-economic and institutional characteristics at that level.

3.4.2 Sample Size and Sample Selection

The sample size of households considered during household interviews was determined on the basis of household population. To capture an appropriate sample of households, the UBOS census report was used (UBOS, 2016). The total sample size of households was 389 respondents obtained from seven wards in the three divisions (Table 3.2). Although the three divisions of Mbale municipality constitute fourteen wards, only seven wards were selected taking into consideration sensitivity and fragility of the wards to precipitation extremes and the population characteristics (UNDP, 2013; UBOS, 2014). The sample size of the study was statistically determined using Yamane (1967) procedure at 5% level of precision (Equation 3.1).

$$n = \frac{N}{1+N\,(e)^2} \qquad \text{(Equation 3.1)}$$

where: n = sample size,

N = total population of households in the three divisions of Mbale municipality and e is the level of precision.

The household-based data and the determined sample size collapsed for the seven wards from the three Divisions are given in Table 3.2.

Table 3.2:
Sample size of the seven sampled wards in the three divisions of Mbale municipality in Eastern Uganda

Division	Ward	Number of households	Sample size
Industrial	Namatala	6640	129
	Malukhu	2335	46
Northern	Namakwekwe	4082	76
	Nkoma	3003	58
	Nabuyonga	2573	50
Wanale	Busamaga West	965	19
	Boma	544	11

Source of data: UBOS: 2016

Also sampled were eight local government officials i.e. six local council officials from the three divisions, the municipality environmental officer and the municipality urban planner. Furthermore, 97 participants were sampled in nine group interviews. Finally, eight households perceived to have attained partial or full resilience in the community by the participants of the group interview were sampled as key informants. The sample size for the key informants and group interviews were arrived at when the saturation level was reached following Braun and Clerk (2006) procedure.

3.4.3 Sampling Procedures

Multi-stage sampling procedure was undertaken by the study. This was based on its high level of flexibility, cost effectiveness, more than two sampling stages and sampling methods required (Bennett & Iiyanagec, 1988). The first stage involved a purposive selection of seven wards out of fourteen wards in the three divisions in Mbale Municipality. The second stage involved random sampling of households while using a structured household interview questionnaire. Random sampling was deemed appropriate at this stage because every household in the selected wards were likely to be affected by climate change shocks and stresses, thus assumed to be uniform and selecting any household would be representative of the total population. The third stage involved purposive sampling of local government officials (Key informants) because of their knowledge, experience and expert judgment on issues relating to climate change shocks and stresses in the municipality. Similarly, the fourth stage of sampling involved purposive sampling of members of the group interviews. This was based on their ability to freely express themselves on study issues. Fifth stage also involved purposive sampling of households perceived to be resilient by members who participated in the group interviews.

3.5 Data Collection Methods

A wealth of quantitative and qualitative data was required to address the objectives of the study. The data was obtained from primary and secondary sources. Details of how the data was collected are given in sub sections 3.5.1 to 3.5.4.

3.5.1 Household Interviews

Structured household interviews were used to collect the socio-economic data of the study. The data collection tool was pre-tested on fifteen households in the study area and consent from the participants was obtained before engaging them in the study.

The data obtained using this method included demographic characteristics of households, social networks of households, perceptions of households on their resilience capacity to prepare, recover and adapt or change when faced with climate change shocks and stresses and indicators of the physical, social, economic and institutional dimension of resilience. Structured household interviews were administered to the target respondents using an interview questionnaire. The questionnaire consisting of 47 closed ended questions was administered to respondents in their homes (Appendix). Closed ended questions were used because they provide an expeditious instrument in data collection, coding, interpretation, quantification and comparison of outcomes across space (Jones & Tanner, 2015). Each interview with the respondent took approximately one hour. This data served to address objective three and five of the study (paper III and V).

3.5.2 Group Interview

Formal group interviews were conducted to obtain perceptions of the participants on: the components that enhance community resilience, community achievement of priority resilience components, the trends of resilience and interventions in local resilience building. Group interviews were used not only because of their power to employ group dynamics to attain additional knowledge, reduces the distance between the researcher and the social context, but also due to its cost effectiveness (Frey & Fontana, 1991). A structured group interview tool was administered to 9 groups. Each group interview consisted of a minimum of seven and a maximum of twelve participants (Figure 3.3) in order to reduce the complexity of responses and also reduce the time and financial costs. Three categories of people were met separately since mixing participants would make others such as the young and the women not to express themselves freely as noted by Bob (2011) and Cavestro (2003). Thus, a total of nine group interviews were conducted. Three separate meetings were held in each of the three divisions of Mbale municipality. One meeting with men aged above 30 years, another with women aged above 30 years and another with the youth defined as young men and women aged between 18-30 years (Gemma *et al.,* 2013). The local government representatives at village zone level and the research assistants who were from that locality were responsible for mobilizing suitable participants for the group interviews. In every group interview, consent was sought from the participants before beginning the discussion. Each group interview took approximately 2-3 hours. A consistent and easily understood definition of resilience was developed since it is a highly technical concept with no direct interpretation. Thus, resilience was defined as the ability of people or households to withstand hardships related to climate change. Consequently, participants were asked to list at least 15 components which enhance their resilience. Members were then asked to concurrently rank and score three most important components from those listed. Each member was given six beans, where they were to allocate three beans to the most important component, two for the second, and

one for the third most important. Furthermore, members of the group interviews were requested to concurrently rank and score the extent to which the community has achieved the priority components of resilience. Each priority component was scored twice i.e. for the normal period agreed to be the time when group interviews were conducted (July 2017), and for the last significant climate crisis period agreed to be the most recent drought experienced from August 2016 to April 2017. The scores were ranked on a scale of 0-10, with a zero indicating no attainment of resilience component e.g. no one in the community is food secure while 10 indicating full attainment of the characteristic e.g. everyone in the community is food secure (UNDP Drylands Development Centre, 2013). This data served to address objective four of the study (paper IV).

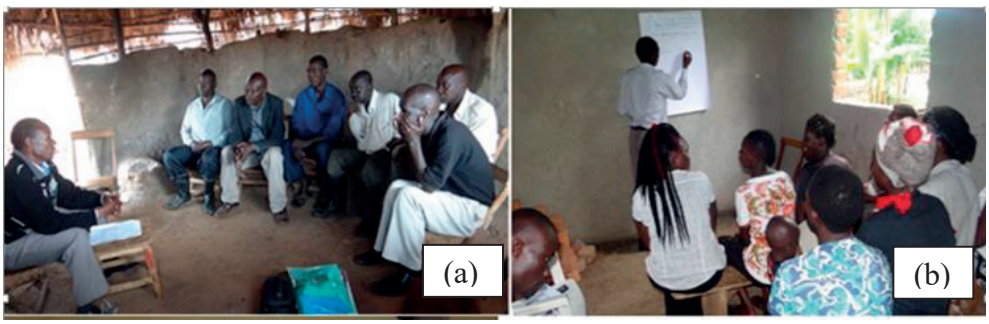

Figure 3.1:
Group interviews with men (a) and women (b) in Mbale Municipality in Eastern Uganda in July 2017 (Photo by Omella Evans).

3.5.3 Key Informant Interviews (KII)

A structured KII tool was administered to local government officials and households perceived to have attained partially or fully the resilience characteristics by participants of group interviews. The data collected from households perceived to have attained partially or fully the resilience characteristics included: demographic characteristics, components contributing to resilience and interventions that would best build wider resilience in the community. While data collected from local government officials included the occurrence of climate change shocks and stresses affecting the municipality. Face to face structured KII interviews were administered to the target respondents using an interview questionnaire. The interview questionnaire consisting of 6 open ended questions (Appendix) was administered to respondents in a place agreed by the researcher and the respondent. Each interview with the respondent took approximately 30 minutes. This data served to address objective two and four of the study (paper II and IV).

3.5.4 Climate Data Collection

Historic climatic data for the study area was required to determine the past frequency of occurrence, duration and intensity of extremely wet and dry periods and to facilitate projections of future occurrence of extreme wet and dry periods. The data was obtained from Uganda National Meteorology Authority (UNEMA). The climate data used in the study consisted of precipitation data from one station spanning for a period of 32 years ranging from 1982 to 2014. The obtained precipitation data was on monthly temporal scale. This data contributed to addressing objective two of the study (paper II).

For future climate projections, downscaled monthly precipitation data was obtained from the Rossby Center Swedish Meteorological and Hydrological Institute (SMHI). Precipitation data from the Coordinated Downscaling Experiments (CORDEX) were extracted from three General Circulation Models (GCMs), EC Earth (European Community Earth system model), Had GEM ES (Hadley Centre Global Environment Model of the Earth System) and Nor ESM1 (Norwegian Earth System Model) (Jones, Giorgi & Asrar, 2011). These models were chosen because they have been used in other studies such as Nimusiima *et al.* (2014), Ongoma et al. (2016) and Ongoma and Chen (2017) and have been found to represent well the climate in the region. The medium scenario (RCP 4.5) was used for future projections and the downscaled data was at 50 km resolution (Arora *et al.,* 2011). For this study, projections of future extremely wet and dry periods were confined to a medium temporal scale (year 2050) to obviate the uncertainty associated with long timescale projections (Arora *et al.,* 2011). The obtained future precipitation data was on monthly temporal scale. This data contributed to addressing objective two of the study (paper II).

3.5.5 Document Analysis

Literature on relevant articles was collected following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol (Shamseer *et al*., 2015). While using the PRISMA protocol, details on the search strategy, inclusion and exclusion criteria used, the screening and eligibility criteria employed to select relevant articles for the synthesis are shown in paper I sub sections 3.1 to 3.3. The literature gathered using this method included literature on how urban resilience is understood in SSA and the determinants of urban resilience in SSA. This data contributed to addressing objective one of this study (paper I).

3.6 Data Analysis

The study obtained a range of both biophysical and socio-economic data which was subjected to a range of statistical and qualitative analysis techniques. To analyze the interview data the following analytical tools were employed:

a) Linear regression was used to investigate which demographic characteristics and social networks are significant predictors of household capacity to prepare, recover and adapt or change when faced with prolonged drought and erratic rainfall. Linear regression was used because the predictor and the outcome variables were linearly related. The outcome variables were households capacities to prepare, recover and adapt or change its source of income or livelihood if needed when a prolonged drought or erratic rainfall event occurred, while the predictor variables were demographic characteristics (i.e. gender and age of the respondent, monthly income of household head, household size, type or gender of household head, the ability of a household to meet its daily expenditure needs and education level of the respondent) and social networks (i.e. networks with relatives, friends, NGOs and government). Significance in relationships were determined at $P<0.05$ (paper III).

b) To test the robustness of the results of the linear regression analysis, the study added the logistic regression model with a dichotomous variable (unlikely/likely) for all the three resilience capacities. This is because the logistic regression model accounts for the potential restrictions of the linear regression with scales that are not metric.

c) Descriptive statistics were used to explore perceptions on the severity of prolonged drought and erratic rainfall events, resilience capacity to prepare, recover and adapt or change and perceived spatial distributions of resilience related capacities in the three divisions of Mbale municipality. Linear regression analysis and descriptive statistics covered the analysis needed for objective three (paper III).

d) An index was used to compute the resilience of Mbale municipality and investigate the contribution of the four dimensions of the MRI towards household resilience against climate change shocks and stresses. The resilience index was computed using the methodology adopted from Freudenberg (2003), Nardo et al. (2008) and from climate disaster resilience studies (Kamh *et al*., 2016; Shaw *et al*., 2009; Mayunga, 2007). First, variables were normalized since different measurement units and scales were used. Normalization enables variables to have a common basis and avoids the problems of mixing measurement units (Freudenberg, 2003; Nardo *et al.*, 2008). This study used a rescaling "Min-max" normalization method that adjusts observed variables to take a value of 0 to 1 as proposed

by Nardo *et al.* (2008). This method has been used by climate change resilience studies e.g., Kamh *et al*. (2016), Kotzee and Reyers (2016) as indicated in Equation 3.2.

$$\text{Normalised value} = \frac{E_i - E_{min}}{E_{max} - E_{min}} \qquad \text{(Equation 3.2)}$$

where: E_i is the observed variable, E_{min} is the minimum value of the observed variable, E_{max} is the maximum value of the observed variable.

Second, Principal Component Analysis (PCA) was used to assign weights to the normalized variables. This helps to reflect the contribution of each variable to the overall composite (Mayunga, 2007; Nardo *et al.,* 2008). In order to generate the resilience index, all dimensions/indictors/variables are considered to have same weights after normalization and therefore all variables are equally important in the final outcome of the MRI (Kamh, 2016; Freudenberg, 2003). Therefore, Equation 3.3 proposed by Freudenberg (2003), modified and used by Mayunga (2007) and Kamh *et al.* (2016) was adopted by this study to combine the variables to generate the resilience index for each individual variable/dimension.

$$y_i = \sum(X_1 W_1 + X_2 W_2 + X_3 W_3 + \cdots X_n W_n) \qquad \text{(Equation 3.3)}$$

where: y is the dimension of the resilience index, X is any normalized variable, W is the weight of any variable, n is the number of variables or weights considered and i is the number of variables.

Thirdly, to generate the overall Municipality Resilience Index of Mbale Municipality, the Equation 3.4 proposed by Mayunga (2007) was used.

$$MRI = \frac{\sum(W_1 PD_i + W_2 SD_i + W_3 ED_i + W_4 ID_i)}{n} \qquad \text{(Equation 3.4)}$$

where: Where: PD_i is the index of the physical dimension, SD_i is the index of the social dimension, Ed_i is the index of the economic dimension, ID_i is the index of the institutional dimension, W is the weight, n is the number of variables in the dimensions and i is the variable number. This constituted the analysis required by objective five (paper V).

To analyze historic and future precipitation data, the Standardized Precipitation Index (SPI) was used to assess the frequency, intensity and duration of occurrence of extremely wet and dry periods during the years 1982-2014 and 2021- 2050. SPI is the number of standard deviations that the observed cumulative precipitation at a given time scale and location could deviate from the long-term mean (Mckee *et al.,* 1993). According to Mckee and his colleagues, SPI values between 1 to -1 is considered a normal period, Negative SPI values represent rainfall scarcity (drought) i.e., SPI values lower than -2 are often classified as extremely dry period,

between -2 to -1.5 is considered moderately dry and between -1.49 to -1 is dry while positive SPI values indicate wet periods i.e., SPI between 1 to 1.49 is considered a wet period, 1.5 to 2 is moderately wet, while SPI of more than 2 indicates an extremely wet period (Figure 3.4).

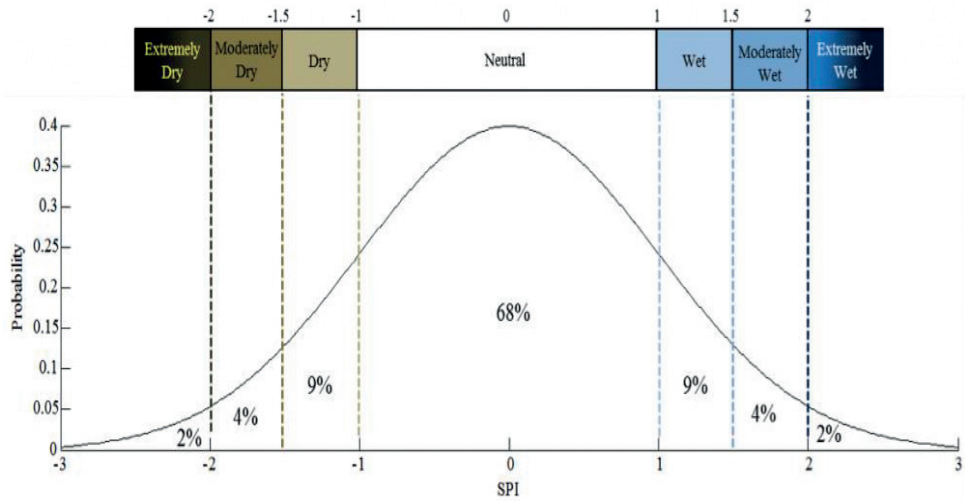

Figure 3.2.
SPI values and the corresponding climatic characteristics Source: "The Climate Data Guide: Standardized Precipitation Index (SPI)." Retrieved from https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi)

The SPI estimation is based on long term precipitation record for a specific period (Hayes *et al.,* 2000). The SPI allows precipitation deficit to be quantified over different time scales (e.g. 3-, 6-, 12-, 24-, 36- and 48-month precipitation). Depending on the time scale, it is possible to understand the impact of wet and dry periods on different water resource needs. In this study, the standardized precipitation index was calculated for annual (12-months scale), medium term (6-months) and seasonal (3-month scale) time series to identify the relative tendency towards above or below normal annual and seasonal precipitation. The 3-Months SPI provides a comparison between a specific 3-months period with the same period recorded in all the other years included in the historical or future records. For instance, a 3-month SPI estimated at the end of June 2014 is the comparison between the precipitation total recorded during the months April-May-June 2014 and the precipitation total recorded during the same set of months in all prior years in the record of observation. A 3-months SPI measures the short-term moisture conditions and provides seasonal estimations of precipitation. While the 6-months and 12-months SPI indicates medium term and long-term moisture conditions respectively. Information retrieved from the-6 months and 12-months SPI can be used to capture anomalous stream flows and reservoir levels (Hayes & Svoboda, 2000). Moreover,

it can provide information about the precipitation fallen during a 6-months and 12-months period. It is very important to compare short term SPI with medium- and longer-term scales. The rationale of this is the fact that a relatively normal or even a wet 3-month period can occur in the middle of a long-term drought that in turn can be captured only by a long-term SPI. This constituted the analysis required by objective two of this study (paper II).

To analyse data from group interviews, KII and the reviewed articles, summative thematic content analysis was used to: (a) derive how urban resilience is being understood and the determinants of urban resilience in SSA. (b) Derive the major climate change shocks and stresses, the priority components that enhance community resilience, community's level of achievement of priority components, factors that have contributed to household resilience among resilient households and interventions that would best build wider resilience in the community. This involved sorting the data and generating initial codes from the data using open coding and vivo coding (Gioia, Corley & Hamilton, 2013). This was followed by categorization of texts into emerging patterns grouped into relevant resilience themes (Braun & Clarke, 2006). This constituted the analysis required for objective one, two and four of this study (paper I and IV).

3.8 Limitations of the Study

The linear regression model has restriction with scales that are not metric. However, to test the robustness of the linear regression results, a logistic regression model was estimated with a dichotomous variable to circumvent the potential restrictions of the linear regression model.

Precipitation model results are often inconsistent even in the same region due to model limitations and complexities in the natural processes more so in Africa with a high natural variability (Masih, 2014). However, modelled precipitation data was calibrated using historic data.

Measuring resilience requires complex indicators and variables and it is always a challenge for a single index such as the MRI to capture all variables (Rader & Cole, 2013). Despite the limitation, the study presents an assessment index that can help in understanding of urban resilience in a developing country.

Chapter Four:

Results and Discussion

4.1 Introduction

In this chapter, the findings of this study are presented and linked to the existing theory. The study findings were on (a) urban resilience to natural and human-induced shocks and stresses in SSA, (b) the frequency of occurrence and duration of extremely wet and dry periods for the years 1982-2014 and 2021-2050 in Mbale municipality, (c) sociodemographic factors that could influence urban resilience to climate change shocks and stresses, (d) the multidimensional components that the community of Mbale municipality perceived as important in enhancing their resilience to climate change shocks and stresses and (e) the proposed MRI, the resilience index of Mbale municipality and the contribution of the dimensions of the MRI towards the resilience index of Mbale municipality against climate change shocks and stresses.

4.2 Urban Resilience to Natural and Human-Induced Shocks and Stresses in SSA

A synthesis of studies on how urban resilience is being understood in SSA shows that some studies understood urban resilience as a social construct, emphasizing that resilience of urban communities is a result of social and organizational factors. Notwithstanding, Kotzee and Reyers (2016) indicated that this understanding of resilience has a potential limitation of ignoring the biophysical component which has been shown to play an important role in determining resilience (Joerin *et al.,* 2014; Kamh *et al.,* 2016). The other category of studies understood urban resilience as a socioecological construct (Kotzee & Reyers, 2016; D'Errico & Di Giuseppe, 2018). In addition, most studies take on the current popular understanding of resilience as a dynamic process (Dhar & Khirfan, 2017; Kamh *et al.,* 2016; Abdrabo & Hassaan, 2015), while a few, mostly from the engineering perspective understand it as maintenance of the pre-disaster status (Mugume *et al.,* 2015; Mugume & Butler, 2017) (paper I).

Furthermore, findings revealed that the most important determinants of urban resilience in SSA include: access to basic services, social networks, employment, ownership of productive assets and building flood barriers (Figure 4.1). This finding corroborate with several reports (The Rockefeller Foundation/Arup, 2014; Dobson *et al.,* 2015; Sadri *et al.,* 2017). Access to robust and inclusive basic services such as water, electricity, health care, education, housing and transportation can aid the effective operation of an urban area and thus can facilitate the resilience of urban residents when faced with natural and human induced shocks and stresses (The Rockefeller Foundation/Arup, 2014; FAO-UNICEF-WFP, 2014). FAO-UNICEF-WFP (2014) noted that access to basic services such as water, electricity, waste disposal, education, means of transport and markets had a significant influence on resilience as compared to other dimensions of resilience in Dolow district in Somalia (paper I).

Further still, the importance of social networks such as networks with relatives, friends, NGOs, government and charity organisations in enhancing resilience has been highlighted by several reports (Albrecht, 2018; Aldrich, 2014; Sadri *et al.,* 2017; Bizikova *et al.,* 2016). To illustrate these, Joerin *et al.* (2014) and Sadri *et al.* (2017) reported that stronger social networks were very important in enhancing community resilience to climate related shocks and stresses in China and Indonesia respectively. Moreover, a strong social network of urban households with the rural community was shown to have a significant contribution towards the resilience of urban households to food insecurity in Harare (Tawodzera, 2012). Dobson (2017) noted that one of the factors that will drive urban resilience in SSA is networks with organized communities such as Slum Dwellers International (SDI), Rockefeller Foundation International, Cities Alliance and Slum Dwellers Federation (SDF). SDI and SDF for instance have improved over 13,000 housing facilities in South Africa, they have also given households access to solar energy in the East, West and Southern regions of Africa (paper I).

Additionally, employment has been proved to enhance the resilience of urban people in SSA (D'Errico & Di Giuseppe, 2018; Tutu, 2012). Tutu (2012) found out that employment significantly improved the resilience of young youth in Accra in Ghana. Similarly, D'Errico and Di Giuseppe (2018) found out that employment significantly contributed to household resilience to food insecurity in Northern, Eastern and Central Uganda. The importance of employment in enhancing resilience could be because it provides people with a source of income which is important in providing access to basic needs of life thus, enhancing people's capacity to thrive during shocks and stresses.

More still, ownership of productive assets such as land, livestock and durables are important determinants of resilience because they are key elements of livelihood that facilitate production of consumable and tradeable commodities (FAO-UNICEF-WFP, 2014; The Rockefeller Foundation/Arup, 2014). Households who

had more productive assets were more resilient than those with limited productive assets in Dolow in Somalia (FAO-UNICEF-WFP, 2014) (paper I).

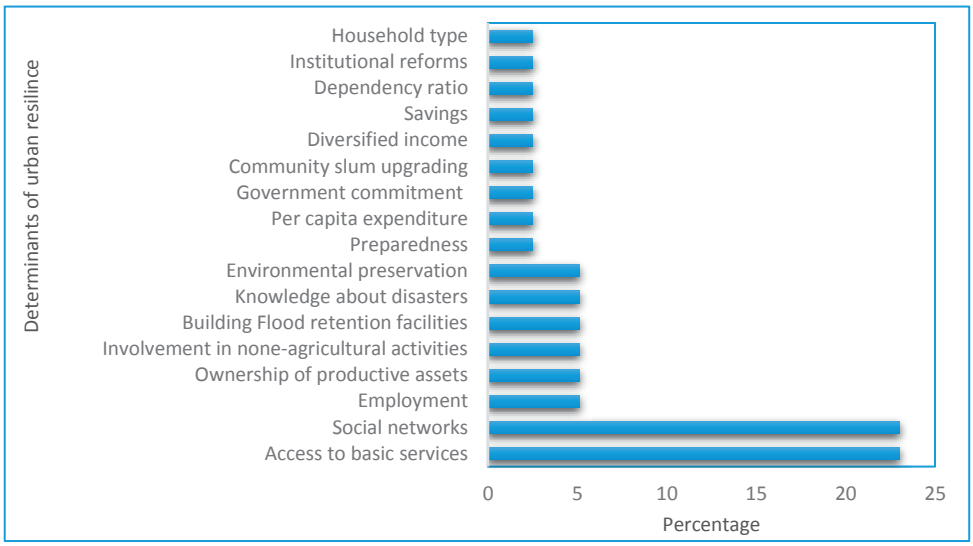

Figure 4.1:
Determinants of urban resilience to natural and human induced shocks and stresses reported by reviewed studies in cities of SSA for the period 2000-2018.

Findings on shocks and stresses assessed by studies (Figure 4.2) revealed that 38.5% of the studies were on determinants of urban resilience to climate change-induced shocks and stresses, 38.5% were on resilience to other natural and human-induced shocks and stresses, 15.4% were on resilience to food insecurity and 7.7% were on resilience to psychological stress. The large number of studies on urban resilience to climate related shocks and stresses confirms reports that climate change is one of the key challenge that cities in the world are contending with (Bozza *et al.,* 2015; Forino *et al.,* 2016; Joerin *et al.,* 2014). In an attempt to search for better ways to enable urban areas prepare, recover and adapt when faced with shocks and stresses, scholars are becoming more interested in the subject of urban resilience (paper I).

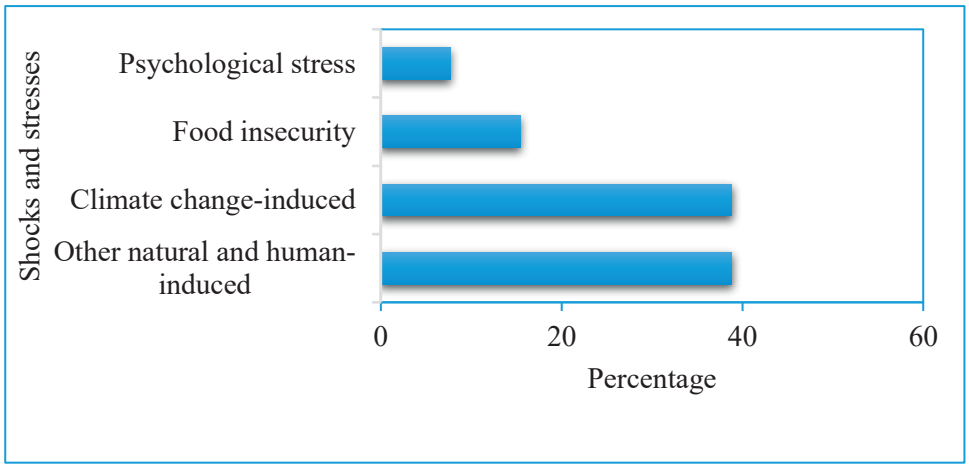

Figure 4.2:
Shocks and stresses focused by studies on determinants of urban resilience in SSA.

4.3 The Frequency and Duration of Occurrence of Extremely Wet and Dry Periods for the Years 1982-2014 and 2021-2050 in Mbale Municipality

Based on the finding that climate change shocks and stresses are the most common hazards facing cities is SSA, the study proceeded to investigate the past and future frequency of occurrence and duration of extremely wet and dry periods in Mbale municipality. Findings from the 3-, 6- and 12-months SPI (Figure 4.3) revealed that on average, Mbale municipality experienced two extremely wet periods between the years 1982 and 1992, one extremely wet period between 1993 and 2003 and three extremely wet periods between 2004 and 2014. This suggests that Mbale municipality experienced more extremely wet periods during the most recent period. These extremely wet periods were concentrated in the months of September, October, November, December and January. Similarly, key informant perceptions confirmed that heavy precipitation events have become more frequent in the recent decade as compared to the previous decades. One of the participants in the KII stated that *"These days, the weather patterns have changed, the rainy season delays and when it comes, it is so heavy causing flash floods in many areas, making roads impassable, filling up pit latrines and increasing the spread of waterborne diseases. Heavy rainfall occurrences have also become more common than it was in the past"*. Other wet periods were categorized as normal and moderately wet. Details of all the years that experienced extremely wet periods can be seen in Figures 4.3. The occurrence of extremely wet periods in Uganda is associated to climate variability mainly through the ENSO phenomena (IPCC, 2015; Nimusiima *et al.,*

2013; Shongwe *et al.,* 2011). This study finding relates to the findings of Nsubuga *et al.* (2014) and Lindsey *et al.* (2012) who reported an increase in Uganda's annual rainfall in the short rainy season (October-November-December) (paper II).

In terms of dry periods, findings from the 3-, 6- and 12-months SPI (Figure 4.3) revealed that on average, Mbale municipality did not experience any extremely dry period between 1982 and 1992 but rather only dry to moderately dry periods. In 1993-2003 there was 1 extremely dry period and from 2004-2014, there were 2 extremely dry periods detected. This also suggests an increase in the frequency of occurrence in extremely dry periods in the later decade as compared to the previous decades. This finding was further supported by perceptions from key informants that dry periods have become more frequent, hotter and longer in the current decade as compared to the previous decades. One of the participants in the key informant interviews stated that *"Mbale used to be cool even during the dry seasons i.e. in January, February and March; and in July but this days Mbale is like a desert during the dry season*". Other dry periods were categorized as normal and moderately dry. Details of all the years that experienced extremely dry periods can be seen in Figures 4.3. Globally, some studies report that the increase in dry periods since 1970's is connected to the recent drying over South Africa, Southern Europe, East and South Asia and Eastern Australia. This recent drying is attributed to ENSO phenomenon, tropical Atlantic sea surface temperatures and Asian monsoons (Dai, 2011). Extremely dry periods tend to worsen problems of water access, water quality, health and affecting crop yields leading to increase in food prices. This study finding corroborate with the findings of a review on drought literature from 1900-2013 by Masih *et al.* (2014) who reported that droughts have become more frequent, intense and widespread over the African continent. This finding is also in agreement with reports NEMA (2010) and OXFAM (2017) that indicated that several droughts have affected Uganda for instance in 1993/1994, 2011/2012, 2013 and 2016/2017 (paper II).

In terms of duration of extremely wet periods, the longest duration using the 3-months SPI lasted for three months recorded between January and March 1998. For the 6-months SPI, it lasted for four months between May and September 1992. And for the 12-months SPI, it also lasted for four months between May and September 1988 (Figure 4.3 and Table 4.1). The longest durations of wet extremes comes along with several challenges on communities such as flash floods, destruction of crops, houses, roads and worsening health problems (Hyland & Russ, 2019; Fang & Chhetri, 2015). This can affect several socio-economic activities in the region. The longer duration of extremely wet periods in Uganda have been associated with sea surface temperature gradients in the tropical Indian Ocean, the influence of trade winds and the sub-tropical high and jet streams (Manatsa *et al.,* 2014; Masarirambi *et al.,* 2010) (paper II).

In terms of duration of extremely dry periods, the longest duration using the 3-months SPI lasted for four months recorded between May and August 2004. For the

6-months SPI, it lasted for three months between July and September 2004. And for the 12-months SPI, it lasted for three months between January and March 1994 (Figure 4.3 and Table 4.1). To sum up, it is the 3-months SPI and the 6-months SPI that showed more dry and wet extreme periods for Mbale municipality (paper II).

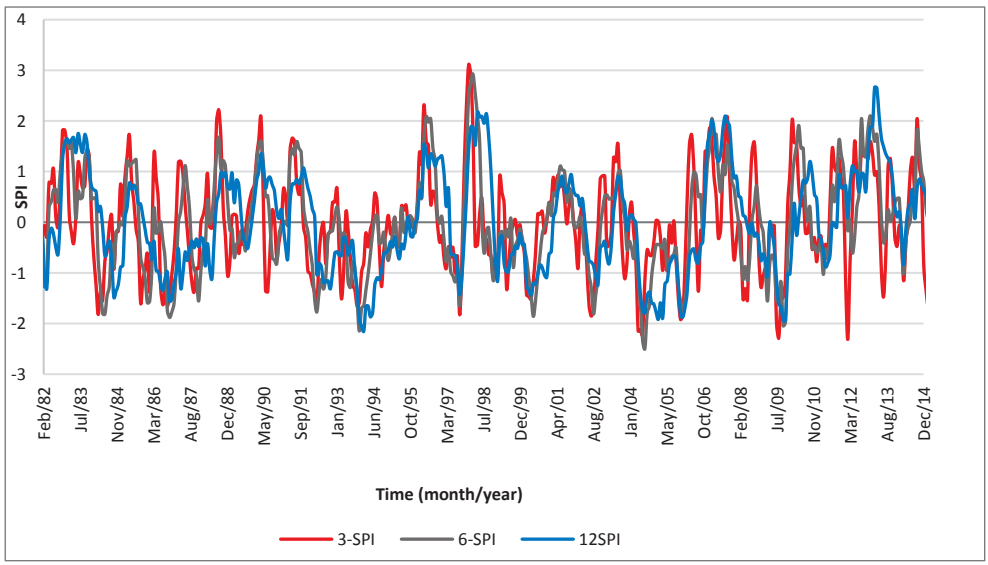

Figure 4.3:
The 3-, 6- and 12-months SPI during the period 1982-2014 for Mbale municipality in Eastern Uganda.

Table 4.1:
The durations (month), years, and peak intensities for the 3-, 6-, and 12-months SPI intervals for extremely wet and dry periods for Mbale municipality during 1982-2014.

Extremely wet periods for the 3-months SPI interval		**Extremely wet periods for the 6-months SPI interval**		**Extremely wet periods for the 12-months SPI interval**	
Duration (months)	Year	Duration (months)	Year	Duration (months)	Year
August-October	1988	May-September	1992	May-September	1988
April	1990	March-June	1998	March	2007
May-June	1996	February	2007	August-September	2007
December	1997	May	2010	March-June	2013
January-March	1998	September-October	2012		
September-October	2007	January-March	2013		
March-April	2010				
October-November	2014				
Extremely dry periods for the 3-months SPI interval		**Extremely dry periods for the 6-months SPI interval**		**Extremely dry periods for the 12-months SPI interval**	
May-August	2004	December	1993	December	1993
January	2006	January-February	1994	January-March	1994
July-September	2009	July-September	2004	October-November	2009
March-April	2012	October-December	2009		

As a result of the detection of more extremely wet and dry periods in the more recent decade in Mbale municipality, the study explored what is likely to happen in the near future (2021-2050). Results revealed that, more extremely wet periods are likely to be experienced during 2021-2030 and 2031-2040 as compared to 2041-2050 while, more drought are likely to be experienced during 2030-2040 and 2041-2050 as compared to 2021-2030 (Figure 4.4). This finding confirms a report by *Shongwe et al.* (2011) who indicated that Africa is likely to suffer from more severe droughts in the twenty first century. Similarly, Panteli *et al.* (2017) and Spinoni *et al.* (2018) reported that climate extreme events are likely to become more severe in the future. This implies that urban households and their livelihoods particularly in developing countries are under threat from increasing climate related extreme events. This is not only due to the inadequate level of preparedness, recovery and adaptation (Pharoah *et al.,* 2016), but also due to large concentrations of population and socio-economic infrastructure which degrade the surrounding ecosystems (Dobson, 2017; Solecki *et al.,* 2015). This finding presented a need to assess the factors that could be important in enhancing the resilience of urban households and the community at large in Mbale municipality to climate change shocks and stresses since this could be important in informing resilience strategies by households, practitioners and government (paper II).

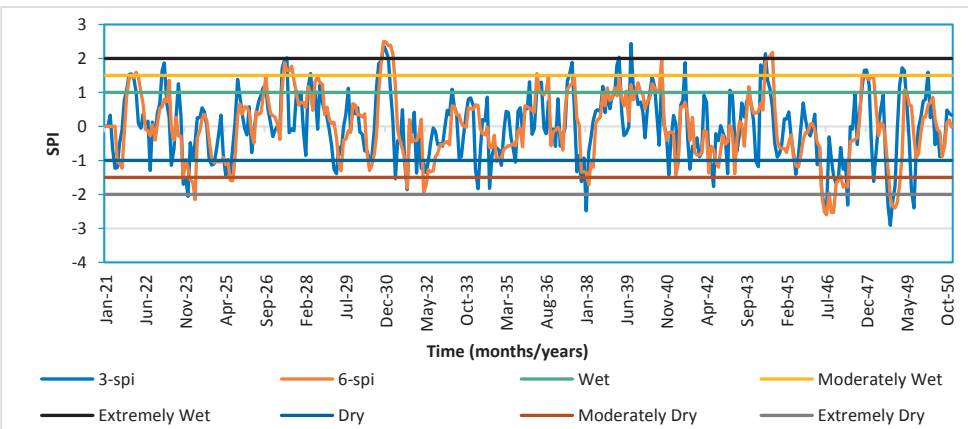

Figure 4.4:
Prediction of wet and dry periods using 3-months and 6-months SPI during the period 2021 to 2050 for Mbale municipality using EC Earth modelled data.

4.4 Sociodemographic Factors that Influence Household Resilience to Climate Change Shocks and Stresses in Mbale Municipality

The third objective of the study first took a social perspective and thus, investigated the sociodemographic factors that could be influential in enhancing household resilience capacities when faced with climate change shocks and stresses. Linear regression results (Table 4.2) (model 4) revealed that household size had a significant negative effect on household capacity to prepare (-0.0319**). Implying that households with many members are less likely to prepare as compared to those with few members. This finding corroborates with the report by D'Errico and Di Giuseppe (2018), who found out that large household size negatively affects household resilience to food insecurity in Northern, Eastern and Central Uganda (paper III).

Furthermore, the study tested the interaction effects between income and household's ability to meet its daily expenditure needs in influencing household resilience capacities (Table 4.2 model 1, 2 and 3). Interaction effects was interpreted through marginal effects, in this case the effect of a household's ability to meet its daily expenditure needs on resilience capacities for the different categories of income. Figure 4.5 illustrates how the marginal effect of a household's ability to meet the daily expenditure needs changes with increasing income. The effect is significantly different from zero for low household incomes for the capacity to prepare and recover. This implies that the lowest income households are substantially more likely to prepare for and recover from prolonged droughts and erratic rainfall events if the household is able to meet the daily expenditure needs. It is possible that low income households may be engaged in alternative none cash activities like subsistence livestock raring, subsistence crop farming and other activities which do not directly translate to income but help the household to satisfactorily meet its daily expenditure needs. This gained knowledge is particularly relevant in this context as the poorest population is generally most vulnerable (Eriksen & O'Brien, 2007). Thus, this finding offers a more nuanced approach to arguments that would assume income alone decides over the degree of resilience (paper III).

Findings also revealed that gender has a significant effect on household ability to adapt or change (0.242**) its source of income or livelihood if needed when faced with prolonged drought or erratic rainfall events (Table 4.2, model 6). This finding implies that the male gender is more capable to adapt or change as compared to their female counterparts who are in most cases more vulnerable due to their socio-economic and political confines (Shabib & Khan, 2014). In many African traditions the females have less access to socio-economic resources which constrains their ability to adapt. Gender studies by Meinzen-Dick *et al.* (2010) reported unequal

distribution of assets between males and females in developing countries which was in favour of males. This makes women less capable to adapt or change (Resurrección, 2013). This study finding corresponds with those of Nabikolo *et al.* (2012) in Eastern Uganda who found out a significant influence of gender on adaptation to climate change shocks and stresses (paper III).

Furthermore, results show that social networks with relatives have a significant positive effect on household capacity to prepare (0.178**) and recover (0.248**) (Table 4.2, model 4-5). Aldrich and Meyer (2014) reported that relatives can speed up or improve recovery with financial and non-financial support. Additionally, social networks with NGOs (Table 4.2, model 6) have a significant positive effect on the capacity to adapt or change the source of income or livelihood if needed when faced with climate change shocks and stresses (0.346**). The significant positive effect of networks with NGOs on household capacity to adapt or change in Mbale Municipality is likely to be a result of NGO activity in the municipality who have reached out to help households with climate change adaptation and this assistance has been appreciated. Several NGOs exist in Mbale Municipality such as World Vision which builds schools, toilets, water sources and provides food and education for the vulnerable. Compassion International which provides school fees, shelter and other basic needs of life. Child Restoration Outreach which helps the vulnerable with basic needs of life, lends money to women for business purposes, provides art and craft trainings to women and promotes games and sports. Hence, this finding indicates that international aid through NGOs is an important factor that can increase household resilience. This finding relates to the finding by Sadri *et al.* (2017) in Indonesia who indicated that stronger personal networks with NGOs and relatives positively influences people's resilience capacity.[1] Networks with friends and government did not have a significant effect on household capacity to prepare, recover and adapt. In summary, this finding implies that tight horizontal networks (with relatives) are a very important resource for households, while looser horizontal networks (with friends) do not appear to affect resilience significantly in Mbale municipality. Vertical ties that link households to NGOs can contribute positively to household resilience particularly when it comes to assisting households to adapt to climate related hazards, as they may not be capable to do so by themselves. In contrast, networks with the government appear to not have been beneficial to household resilience in the present case. This could be due to an overall lack of ties to the government, but cannot be fully explained with the quantitative survey results alone (paper III).

[1] Logistic regression of demographic characteristics and social networks that influence resilience capacities showed similar findings except for the significance of gender in household capacity to adapt or change and networks with relatives for household capacity to recover.

Table 4.2:
Linear regression of demographic characteristics and social networks that influence household resilience capacities when faced with prolonged droughts or erratic rainfall events in Mbale Municipality (n=389).

Variable	Unstandardized coefficients (Standard error in brackets), ***p<0.01 **p<0.05 *p<0.1					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Prepare	Recover	Adapt/change	Prepare	Recover	Adapt/change
Gender	0.0477	0.133	0.265**	0.0243	0.0950	0.242**
	(0.0877)	(0.0993)	(0.112)	(0.0882)	(0.100)	(0.113)
Age	-0.00293	-0.00530	-0.00419	-0.00210	-0.00413	-0.00260
	(0.00322)	(0.00361)	(0.00412)	(0.00324)	(0.00363)	(0.00413)
Household size	-0.0342**	-0.0304*	-0.00884	-0.0319**	-0.0270*	-0.00211
	(0.0140)	(0.0159)	(0.0179)	(0.0141)	(0.0159)	(0.0180)
Household head	-0.0593	-0.0283	-0.182	-0.0578	-0.0146	-0.192
	(0.0954)	(0.108)	(0.122)	(0.0953)	(0.108)	(0.121)
Education	0.0374	0.00928	0.0103	0.0396	0.0181	0.0255
	(0.0422)	(0.0477)	(0.0544)	(0.0423)	(0.0478)	(0.0543)
Expenditure	0.584***	0.323**	0.320*	0.552***	0.266	0.243
	(0.144)	(0.161)	(0.185)	(0.145)	(0.163)	(0.186)
Income=1	0.186	0.0481	0.0589	0.205	0.0501	0.0225
	(0.124)	(0.140)	(0.159)	(0.125)	(0.140)	(0.159)
Income=2	0.337*	0.0644	-0.00166	0.336*	0.0248	-0.0758
	(0.202)	(0.224)	(0.256)	(0.203)	(0.226)	(0.256)
Income=3	0.460	0.286	0.431	0.458	0.308	0.406
	(0.312)	(0.348)	(0.424)	(0.311)	(0.347)	(0.421)
Exp*income=1	-0.386**	-0.0362	-0.308	-0.406**	-0.0320	-0.241
	(0.193)	(0.216)	(0.247)	(0.193)	(0.216)	(0.247)
Exp*income=2	-0.348	0.150	-0.124	-0.367	0.188	-0.0594
	(0.263)	(0.297)	(0.336)	(0.267)	(0.300)	(0.339)
Exp*income=3	-0.499	-0.148	-0.802*	-0.472	-0.149	-0.790*
	(0.344)	(0.385)	(0.464)	(0.344)	(0.384)	(0.463)
Nets_Friends				-0.0104	0.00419	0.0810
				(0.0878)	(0.0983)	(0.112)
Nets_Relatives				0.178**	0.248**	0.147
				(0.0884)	(0.0994)	(0.113)
Nets_NGO				-0.0106	0.0109	0.346**
				(0.119)	(0.134)	(0.153)
Government				0.179	-0.0348	-0.183
				(0.121)	(0.137)	(0.157)
Constant	1.327***	1.457***	1.362***	1.177***	1.265***	1.143***
	(0.185)	(0.209)	(0.237)	(0.198)	(0.225)	(0.253)
Observations	383	377	378	383	377	378
R-squared	0.107	0.082	0.033	0.125	0.100	0.058

Notes: Unstandardized coefficients are reported with standard errors in brackets; ***p<0.01, **p<0.05, *p<0.1.

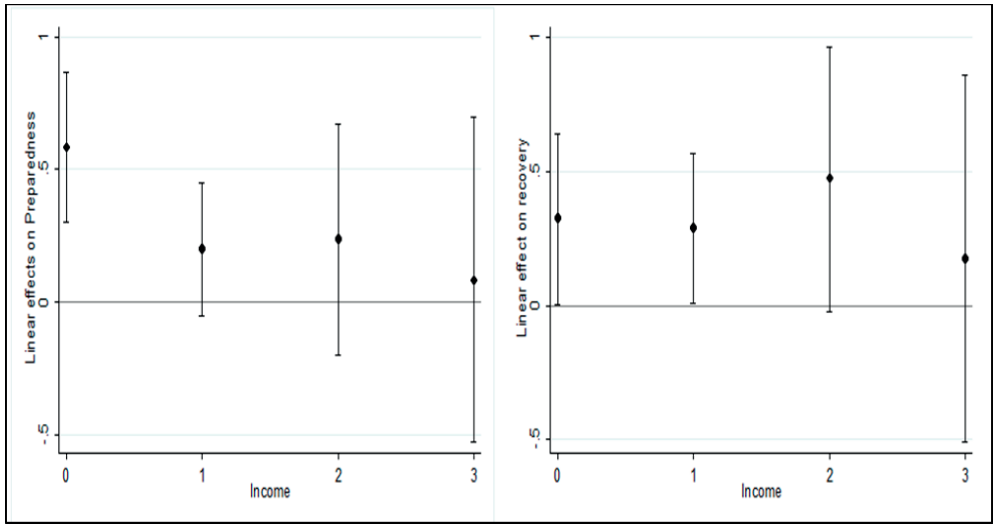

Figure 4.5:
Marginal effect of household's capacity to meet daily expenditures with increasing income (no significant effect for capacity to adapt or change) (n=389).

4.5 The Multidimensional Components that the Community of Mbale Municipality Perceives as Important in Enhancing their Resilience to Climate Change Shocks and Stresses

Scholars seem to suggest that in order to better understand household or community resilience, it may be better to undertake a multidimensional approach which looks at several components of resilience (Kotzee & Reyers, 2016; The Rockefeller Foundation/Arup, 2016). These aspects may range from the social, physical, economic, natural and institutional dimensions. Thus, the fourth objective of this study investigated the multidimensional components that the community of Mbale municipality perceives as important in enhancing their resilience. Findings revealed that education, healthcare, employment, peace and security were ranked as the most important priority components perceived by the community of Mbale municipality to determine their resilience. This could be the core components that development partners need to focus on in this municipality. Statements on education and health care emphasized better quality education and health care services. Statements on employment emphasized better-paying jobs for all people. In terms of SLF categories, the human capital scored the highest number of bean scores (205), followed by financial capital (112) and physical (44) (Figure 4.6). While the lowest number of bean scores were attained by the natural capital (24) and the social capital

(33). The highest scoring component in the human capital was education followed by health. This shows the importance of education and health in human development. People who are educated can easily get employment which improves people's capacity to earn income and access basic needs of life. Furthermore, education as an important factor in enhancing resilience has been reported by UNDP (2014) in the dry lands of Northern Kenya and North Eastern Uganda. Further still, health care is important in supporting citizens in recovery during shocks and stresses particularly in this context where most of the population lacks health insurance. Several studies have reported the importance of health care in enhancing community resilience (FAO-UNICEF-WFP, 2014; Joerin *et al.*, 2014; The Rockefeller Foundation/Arup, 2016; Twigg, 2009; Woolf *et al.*, 2016). In addition, the less importance accrued to the natural factors could be because of the humanized nature of the urban environment where the physical factors are less recognized and also that people are likely to perceive these as issues that one cannot change (paper IV).

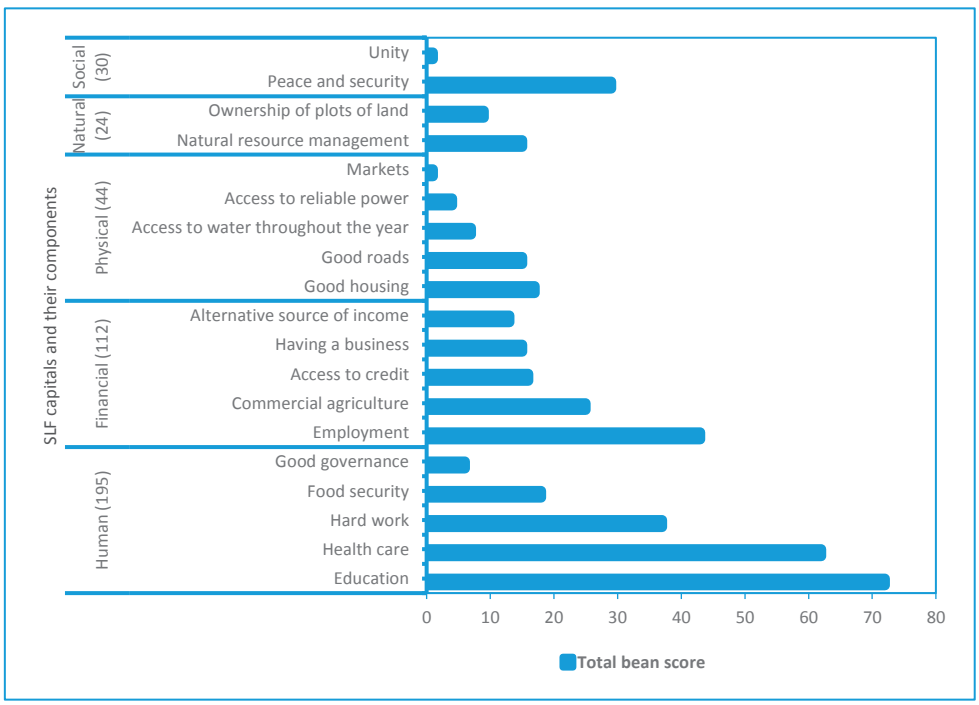

Figure 4.6:
Community bean scores for the components that enhance resilience in Mbale municipality categorized according to the SLF (n=97)

When members of group interviews were asked the extent to which they have achieved the components of resilience, findings showed that the top ranked resilience components were not uniform in all the three divisions but rather tend to

vary as follows (Table 4.3). Access to credit, had work and productive farms were the highest achieved components in Industrial division. Hard work, natural resource management (NRM) and peace and security were ranked high in Northern division while access to credit, productive farms and good roads were ranked high in Wanale division (Figure 4.7). In contrast, the following were ranked as lowest achieved components: diversified income generating activities (DIGA's), roads and food security in Industrial division. Insurance, employment and health care in Wanale division and better housing, good governance and employment in Northern division. Industrial division for example is faced with the problem of food insecurity and incomes could be because it is where the biggest slum of the municipality lies with most of the inhabitants being immigrants from the semi-arid region of north eastern Uganda. This population is characterized by low socio-economic status as compared to populations of other divisions of the municipality. The non-uniformity in attainment of resilience components for the different divisions is likely to be due to differences in the division's local government priorities, natural resource endowment and human development aspects. This implies variation in the level of achievement of resilience components in time and space even within a small geographic confine. This finding is in agreement with the finding of Cutter & Derakhshan (2018) who found out that resilience varied over time and space. In summary, access to credit, hard work, productive farms, natural resource management (NRM) and peace and security were ranked the highest achieved components of resilience while, DIGA's, food security, employment and health care were ranked the lowest achieved components. The blank cells in the table indicate that the component is not mentioned in that location and period. The scores on the components of resilience represent context specific perceptions of the members in the group interviews. They indicate where the different divisions are prospering and where they still struggle and points to where government and other actors should target in order to enhance resilience. Furthermore, there seems to be "second order disaster" that affect the community of Mbale municipality e.g., when a climate crisis occurs, it begins by affecting production in farms and work on these farms, by implication it creates food insecurity. This is the "first order disaster. Food insecurity situations will in turn lead to a reduction in peace and security. This is a "second order disaster". One of the participants indicated that *"After a long dry season has occurred, there is often an increase in theft as many people are unable to meet their food needs and the only way to meet their needs is going to steal"* (paper IV).

Table 4.3:
Community attainment of resilience components-(three highest and three lowest ranked) in the three divisions of Mbale Municipality during the normal climate periods and during the climate crisis periods (n=97)

Characteristic	Industrial		Wanale		Northern	
	Normal period	Crisis period	Normal period	Crisis period	Normal period	Crisis period
Overall average rank	5.7	4.3	6	4.1	7.3	5.4
Three highest ranking characteristics scored						
Access to credit	8.5	7.5	8	5.7	-	-
Hard work	7.5	5.7	-	-	8.7	6.3
Productive farms	7.5	4.9	8.2	5	-	-
Good roads	-	-	9	7	-	-
NRM	-	-	-	-	9.1	8.1
Security	-	-	-	-	8.9	6.2
Three lowest scoring characteristics						
DIGA's	3	1.75	-	-	-	-
Goods roads	2.8	3	-	-	-	-
Food security	4.7	2.9	-	-	-	-
Insurance	-	-	1	1	-	-
Employment	-	-	5.4	2.3	5.8	3.8
Health care	-	-	4.2	3.7	-	-
Better housing	-	-	-	-	6.4	3
Good governance	-	-	-	-	4.6	5

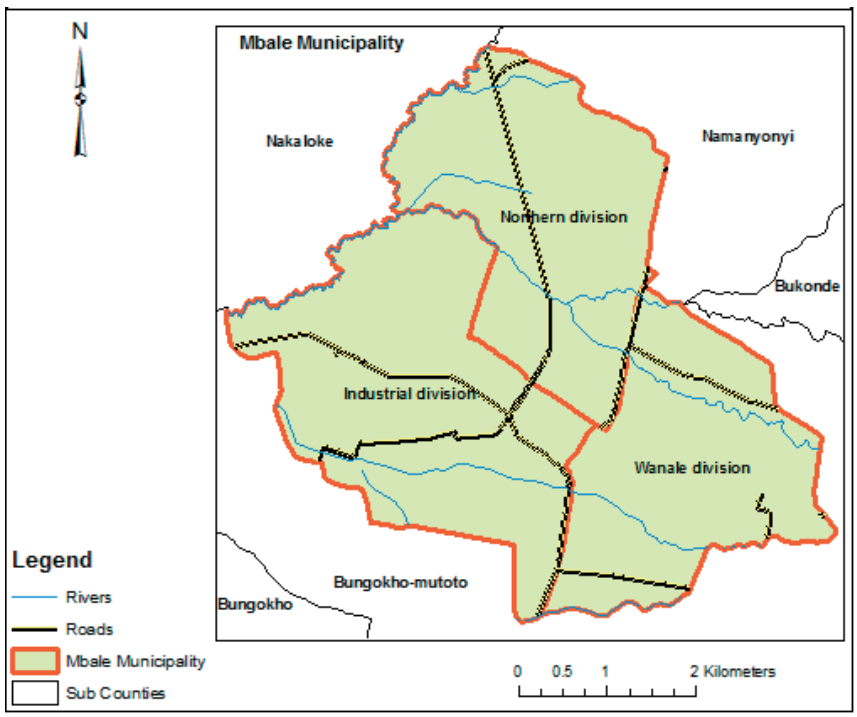

Figure 4.7:
The location of the three divisions in Mbale municipality in Eastern Uganda based on UBOS shapefiles of 2014

The most important priority components of resilience perceived by the community were important in understanding local contextual factors that drive resilience and thus, bear relevance to policy and practitioners. Furthermore, these components perceived by the community informed the formulation of the proposed multidimensional MRI in objective five of this study.

4.6 The Proposed MRI and the Resilience Index of Mbale Municipality to Climate Change Shocks and Stresses

The proposed MRI includes 46 variables describing the physical, social, economic and institutional dimensions. When the MRI was tested, findings revealed that the overall resilience index of Mbale Municipality is very low (0.2). The low resilience index of Mbale municipality confirms reports that the municipality is located in a less socio-economically developed regions of Uganda, characterized by poor population, high level of vulnerability to flash floods, droughts and other hazards (Kansiime, Wambugu, & Shisanya, 2013) (paper V).

In terms of the three divisions, (Figure 4.8), results revealed that Industrial division had the highest average resilience index (1.7), followed by Northern division (0.9), while Wanale division was the least resilient (-1.9). The relatively higher resilience score by Industrial division is surprising because this is a division with the biggest slum dwellers and with low income population as indicated in the description of the sampled population in section 3.5 of paper IV and also in paper III. However, as found out in sub study III, low income earners who are able to meet their daily expenditure needs from none income generating activities can still be resilient (Oriangi *et al.,* 2019). Although Wanale division is known to be the division with high income earners, this finding indicate that it is the least resilience. This gives an implication that resilience may not be well understood by using one or two dimensions but rather by using several dimensions. This confirms studies that argue that resilience can better be understood by exploring its multidimensional aspects (Kamh *et al.,* 2016; Hung *et al.,* 2016).

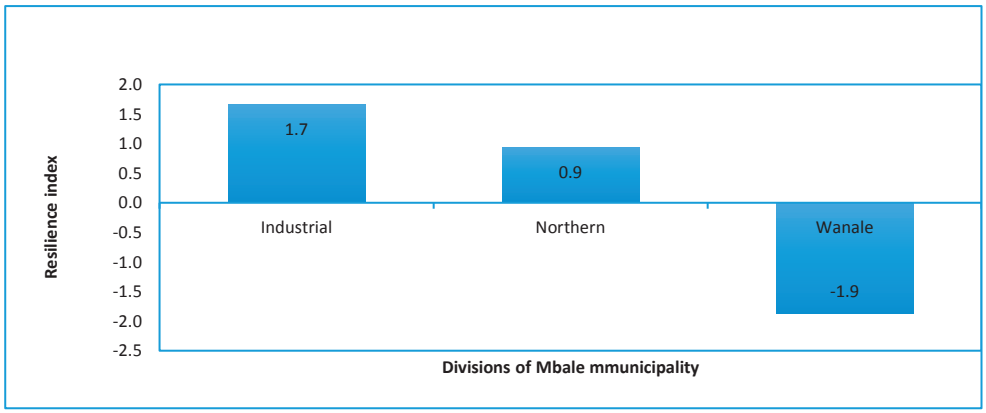

Figure 4.8:
The average resilience index of the three divisions of Mbale Municipality in Eastern Uganda in the year 2017 (n=389).

Furthermore, findings revealed that, the physical dimension scored the highest resilience index (1.3), followed by the economic (1.2), institutional (1.1) and the social (0.7) (Figure 4.9). The highest score from the physical dimension and the lowest score from the social dimension implies that household in Mbale municipality have currently achieved more from the variables of the physical dimension and less from the social dimension. The low contribution of the social dimension towards the resilience score implies that livelihoods in the urban environment may be less defined by the social variables. This corroborates with the report by FAO-UNICEF-WFP (2014) who reported that the social dimension contributed less towards the resilience score of the urban livelihoods in Dolow district in Somalia but rather, it was the physical dimension that had a high contribution towards the resilience score. Moreover, the finding of this study contradicts with a report by Kotzee and Reyers (2016) in Eden district in South Africa who reported that it was the social factors which had a high resilience score. These variations could be resulting from how much the different governments and stake holders have invested towards the development of the different sectors and thus points towards where more efforts need to be vested in order to achieve a holistic and multidimensional resilience (paper V).

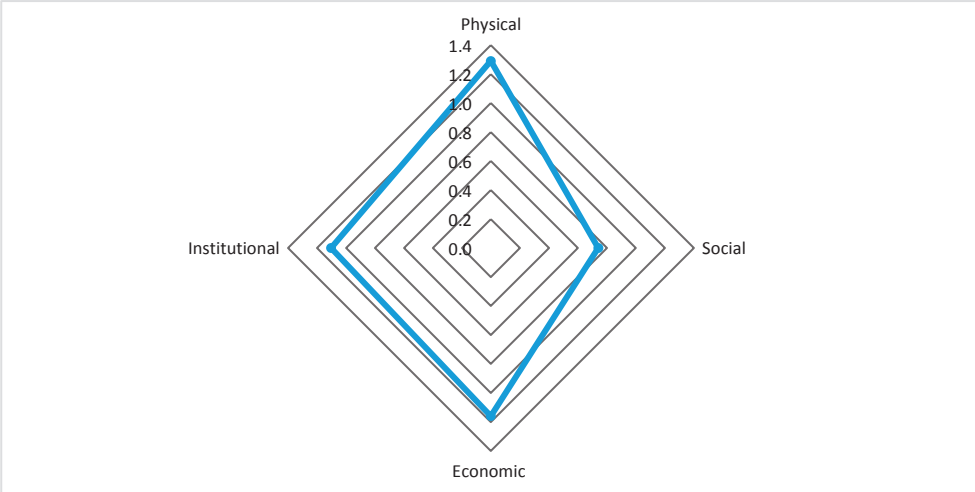

Figure 4.9:
The overall contribution of the four dimensions towards the resilience index of Mbale Municipality (n=389).

Additionally, findings revealed that the following variables under the four dimensions of the MRI contribute more than rest (Figure 4.10a to 4.10d): In the physical dimension: access to water, ownership of toilets, diversified solid waste management and housing. In the social dimension: networks with NGO's, relatives, friends and government. In the economic dimension: monthly income, savings and access to credit while, in the institutional dimension: existence of an authority dealing in climate change, stakeholders' involvement, climate awareness programs, existence of emergency teams and early weather warnings. However, the following are the low contributors of resilience. In the physical dimension: water safety and alternative capacity, electricity supply and reliability, connection to reliable sewage network, means of communication and adequate nutritious food. Among the social variables: level and quality of education and access to health. In the economic dimension: alternative income sources, employment, pension and insurance cover while, in the institutional dimension: ecosystem protection, preparedness plans, representation of marginalized groups, vulnerability assessment and emergency facilities. The performance of the variables under the four dimensions gives a picture on the contribution of each variable as shown by their factor loading. Factor loading indicate the relative statistical contribution of the observed variables within each of the four dimensions (FAO-UNICEF-WFP, 2014). A high factor loading suggests that the variance of the latent variable is highly correlated to the absolute value of the observed variable. "A variable with a high factor loading within a dimension that has a high factor loading in the resilience index is a variable which, if improved by one standard deviation unit would affect the resilience index most positively" (FAO-UNICEF-WFP, 2014). While a low factor loading suggests a low correlation between the observed variable and the latent variable at given point in

time. These indicate weak contributors to the current resilience index and may indicate variables which have consistently low values; however, the impact of an improvement on resilience could be important. For example, very few people in the sample having reliable electricity, safe water, access to quality education and access to employment would not be correct to conclude that these variables are irrelevant (FAO-UNICEF-WFP, 2014) (paper V).

Figure 4.10a: Factor loading for variables in the physical dimension

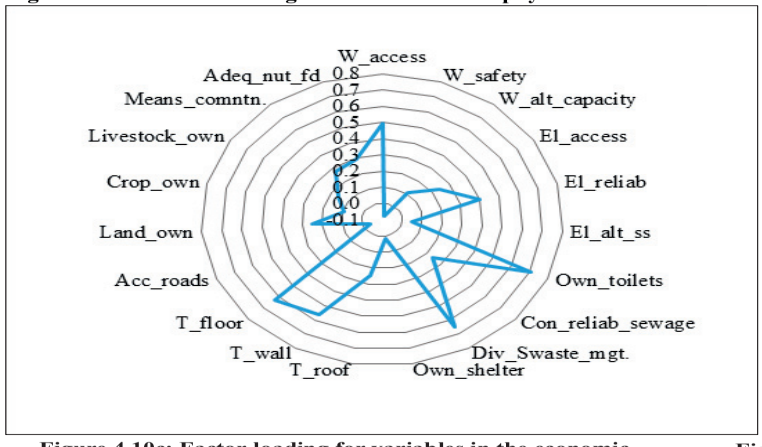

Figure 4.10b: Factor loading for variables in the social dimension

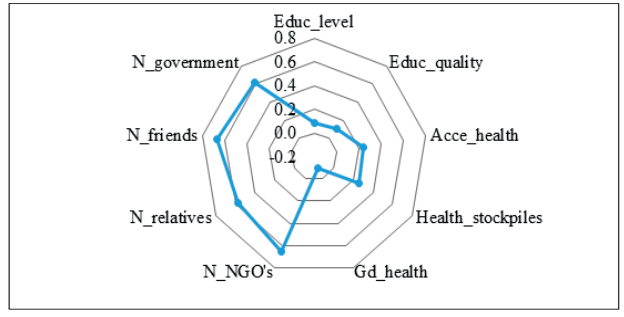

Figure 4.10c: Factor loading for variables in the economic dimension

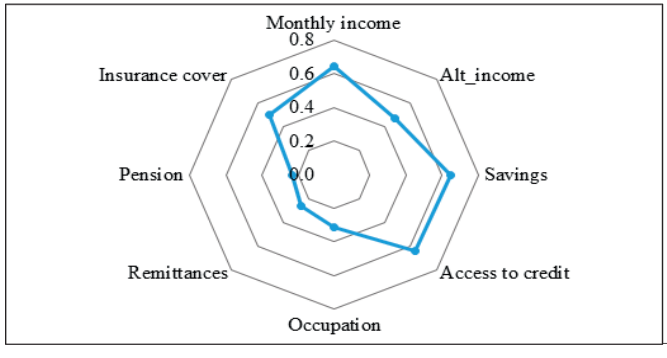

Figure 4.10d: Factor loading for variables in the institutional dimension

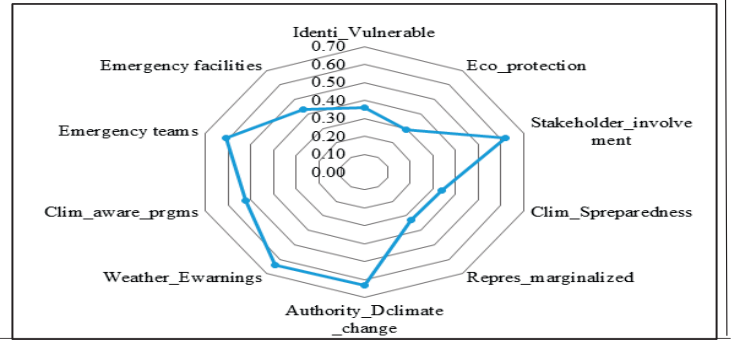

Figure 4. 10a to 4.10d:
The performance of the variables in the four dimensions of the MRI in Mbale municipality in Eastern Uganda for the period 2017 (n=389).

Chapter Five:

Summary of Key Findings, Conclusion and Recommendations

5.1 Introduction

This study set out to understand how urban resilience is being understood and what determines it in SSA, assess the characteristics of extremely wet and dry periods and investigate the sociodemographic factors that influence urban resilience. It also determined the multidimensional priority components that the community of Mbale municipality perceives as important in enhancing their resilience and propose and test the MRI that measures resilience against climate change shocks and stresses in Mbale municipality. The summary of key findings, the conclusion and the recommendations of the study are given below.

5.2 Summary of Key Findings

Question 1: How is urban resilience being understood and what determines urban resilience in SSA?

- Urban resilience is being understood as either a social and organizational construct or as a social, organizational and ecological construct.
- The most important determinants of urban resilience in SSA include: access to basic services, social networks, employment, ownership of productive assets and building flood barriers.

Question 2: What is the frequency of occurrence of extremely wet and dry periods in Mbale Municipality for the years 1982-2014 and 2021-2050?

- More extremely wet and dry periods have been experienced during the most recent period (2004-2014) as compared to 1982-1992 and 1993-2003. Key informant perceptions confirmed this statistical finding. Extremely wet

periods were concentrated in September, October, November, December and January.

- More extreme wet periods are likely to be experienced in the near future (2021-2040) as compared to 2041-2050 while more droughts are likely to be experienced during 2031-2050 as compared to 2021-2030.

Question 3: Which sociodemographic characteristics influence household capacity to prepare, recover and adapt when faced with prolonged droughts and erratic rainfall events?

- Household ability to meet its daily expenditure needs, household size and networks with relatives and NGOs had significant effects on resilience capacities to prepare, recover and adapt to prolonged droughts and erratic rainfall events.
- Even the lowest income households are substantially more likely to prepare for and recover from prolonged droughts or erratic rainfall events if they can meet their daily expenditure needs.

Question 4: What priority components are perceived to enhance community resilience in Mbale municipality?

- Access to education, health care, employment and peace and security were perceived to be the most important components of resilience to climate change shocks and stresses in Mbale municipality.

Question 5: What are the most achieved and least achieved resilience components in Mbale municipality?

- The most achieved resilience components include: access to credit, building productive farms, contributing with hard work and sustaining peace and security, while the least achieved include: diverse income generating activities, access to insurance, food security, employment and health care.

Question 6: What constitutes the MRI proposed in this study in the context of Mbale municipality?

- The MRI consists of 46 variables explaining the physical, social, economic and institutional dimensions.

Question 7: What is the resilience index of Mbale municipality and what is the contribution of the dimensions of MRI

- Mbale Municipality has a low resilience index of 0.2.

- The physical dimension contributed more than the other dimensions towards the resilience index of Mbale municipality. This is followed by the economic and the institutional dimensions. The least scoring dimension was the social dimension.
- Most variables in the four dimensions of the MRI show a low factor loading.

5.3 Conclusion

- Knowledge that even the lowest income households are substantially more likely to prepare for and recover from climate change shocks and stresses if the household can meet its daily expenditure is valuable particularly for the poorest population who are generally most vulnerable to hazards.
- Future studies need to continue utilizing a multidimensional approach in understanding the overall aspects that influence household or community resilience to climate related shocks and stresses.
- To understand municipality resilience in Uganda, a study covering all the municipalities in the country is necessary.

5.4 Recommendations

- The study recommends that policy makers and practitioners need to encourage small household size and household activities that can boost their ability to meet daily expenditure needs to increase resilience capacities. Furthermore, the importance of social networks implies that disaster risk reduction policies and practitioners may need to promote social networks that shape household resilience to enhance preparedness, recovery and adaptation.
- The proposed MRI constituting of 46 variables and 4 dimensions can be applied in any municipality in developing countries with similar climate related challenges and with limited availability of robust socio-economic and bio-physical data.
- Government needs to continue focusing on redirecting more efforts and resources on providing quality education and health care, creating more employment opportunities and sustaining peace and security in order to build the resilience capacities of communities for preparedness, recovery and adaptation to climate related shocks and stresses.

- There is also a need for researchers to focus more on assessing location-specific dynamics of the determinants of urban resilience to climate related shocks and stresses in secondary cities of SSA, given the growing role that secondary cities will play in the strong urban growth trajectories projected over the next decades. This can facilitate the achievement of household resilience strategies in particular urban areas.

References

Abdrabo, M.A., & Hassaan, M.A. (2015). An integrated framework for urban resilience to climate change-case study: sea level rise impacts on the Nile delta coastal urban areas. *Urban Climate*, *14*(2015), 554–565. ttp://doi.org/10.1016/j.uclim.2015.09.005

ACCRA. (2013). *Uganda Climate Change Vulnerability Assessment*. Kampala.

ADB. (2014). *Urban Climate change Resilience: A* Synopsis. *ADB: Asian Development Bank*. http://doi.org/10.1038/479267b

Albrecht, F. (2018). Natural hazard events and social capital: the social impact of natural disasters. *Disasters*, *42*(2), 336–360. http://doi.org/10.1111/disa.12246

Aldrich P.D., and Meyer, M. (2014). Social capital and community resilience. *American Behavioral Science*, (February 2015), 1–6. ttp://doi.org/10.1177/0002764214550299

Aldunce, P., Beilin, R., Handmer, J., & Howden, M. (2016). Stakeholder participation in building resilience to disasters in a changing climate. *Environmental Hazards*, *15*(1), 58–73. http://doi.org/10.1080/17477891.2015.1134427

Aldunce, P., Beilin, R., Howden, M., & Handmer, J. (2015). Resilience for disaster risk management in a changing climate: practitioners' frames and practices. *Global Environmental Change*, *30*(2015), 1–11. http://doi.org/10.1016/j.gloenvcha.2014.10.010

Arora, V., Scinocca, J., Boer, G., Christian, J., Denman, K., Flato, G., Kharin, V., Lee, W., and Merryfield, W.J. (2011). Carbon emission limits required to satisfy future representative concentration pathways of greenhouse gases. *Geophysical Research Letters, 38(*2011), *38*, 1-6.

Awange, J.L., Aluoch, J., Ogallo, L.A., Omulo, M., & Omondi, P. (2007). Frequency and severity of drought in the LakeVictoria region (Kenya) and its effects on food security, *33(2007)*, 135–142.

Ayyoob, S. (2016). A critical review of selected tools for assessing community resilience. *Ecological Indicators*, *69*(2016), 629–647. http://doi.org/10.1016/j.ecolind.2016.05.023

Baharen, K., Abbaspour, K.C., Lehmann, A., Wehrli, B., and Yang, H. (2018). Spatial assessment of maize physical drought vulnerability in sub-Saharan Africa: Linking drought exposure with crop failure. *Environmental Research Letter*.

Batica, J. & Gourbesville, P. (2016). Resilience in flood risk management - A new communication tool. *Procedia Engineering*, *154*(2016), 811–817. http://doi.org/10.1016/j.proeng.2016.07.411

Bennett, S., & Iiyanagec, W.M. (1988). Simplified general method for cluster sample surveys. *World Health*, *44*(1991), 98–106.

Bizikova, L., Tyler, S., Moench, M., Keller, M., & Echeverria, D. (2016). Climate resilience and food security in Central America: a practical framework. *Climate and Development*, *8*(5), 397–412. http://doi.org/10.1080/17565529.2015.1064806

Bob, H. (2011). *Reducing risk of disaster in our communities*. (H. Gaw, Ed.) (Second Edi). Teddington, England: Tearfund.

Boyd, E., & Juhola, S. (2014). Adaptive climate change governance for urban resilience. *Urban Studies*, *52*(7), 1234–1264. http://doi.org/10.1177/0042098014527483

Bozza, A., Asprone, D., & Manfredi, G. (2015). Developing an integrated framework to quantify resilience of urban systems against disasters. *Natural Hazards*, *78*(3), 1729–1748. http://doi.org/10.1007/s11069-015-1798-3

Braun V., and Clerk. V. (2006). Thematic analysis. *Qualitative Research in Psychology*, *3*(2), 77–101. http://doi.org/10.1191/1478088706qp063oa

Cavestro, L. (2003). *PRA-Participatory Rural Appraisal Concepts Methodologies and Techniques*. Retrieved from http://www.agraria.unipd.it/agraria/ master/02-03/participatory rural appraisal.pdf

Conway, G., and Chambers, R. (1991). *Sustainable Rural Livelihoods: practical concepts for the 21st century* (Agriculture and rural problems; food security; environment No. 296). http://doi.org/ISBN 0903715589

Chun, H., Chi, S., & Hwang, B.G. (2017). A Spatial disaster assessment model of social resilience based on geographically weighted regression. *Sustainability*, *9*(12), 2222–2238. http://doi.org/10.3390/su9122222

Climate change department. (2014). *Uganda Second National Communication to the United Nations Framework Convention on Climate Change*. Kampala.

Cooper, S.J., & Wheeler, T. (2015). Adaptive governance: Livelihood innovation for climate resilience in Uganda. *Geoforum*, *65*, (2014), 96–107. http://doi.org/10.1016/j.geoforum.2015.07.015

D'Errico, M., & Di Giuseppe, S. (2018). Resilience mobility in Uganda: a dynamic analysis. *World Development*, *104*, (2018), 78–96. http://doi.org/10.1016/j.worlddev.2017.11.020

Dai, A. (2011). Drought under global warming: a review. *Wiley Interdisciplinary Reviews: Climate Change*, *2*(1), 45–65. http://doi.org/10.1002/wcc.81

David, F., Fikret, B., Bonnie, J., McCay, M. A. (1990). The tragedy of the commons: twenty-two years later. *Human Ecology*, *18*(1), 189. http://doi.org/10.1093/nq/s2-VI.140.189-c

Davis, C. L., Hoffman, M. T., & Roberts, W. (2016). Recent trends in the climate of Namaqualand, a megadiverse arid region of South Africa. *South African Journal of Science*, *112*(3), 1–9. http://doi.org/10.17159/sajs.2016/20150217

Department for International Development. (2011). Defining disaster resilience. *A DFID Approach Paper*, 1–20. http://doi.org/https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/186874/ 10

Dhar, T. K., & Khirfan, L. (2017). A multi-scale and multi-dimensional framework for enhancing the resilience of urban form to climate change. *Urban Climate*, *19*, (2017), 72–91. http://doi.org/10.1016/j.uclim.2016.12.004

Di Baldassarre, G., Elshamy, M., van Griensven, A., Soliman, E., Kigobe, M., Ndomba, P.,… Uhlenbrook, S. (2011). Future hydrology and climate in the River Nile basin: a review. *Hydrological Sciences Journal*, *56*(2), 199–211. http://doi.org/10.1080/02626667.2011.557378

Dobson, S. (2017). Community-driven pathways for implementation of global urban resilience goals in Africa. *International Journal of Disaster Risk Reduction*, *26*(2017), 78–84. http://doi.org/10.1016/j.ijdrr.2017.09.028

Dobson, S., Nyamweru, H., & Dodman, D. (2015). Local and participatory approaches to building resilience in informal settlements in Uganda. *Environment and Urbanization*, *27*(2), 605–620. http://doi.org/10.1177/0956247815598520

Edwads, B., Cole, J., Tesh, J., Cameron, H., Albrito, P., Newnham, C … Kailiponi, P. (2013). Measuring the resilience of Cities: The Role of Big Data. In S. P. Cole (Ed.), *Proceedings of the Conference Measuring the Resilience of Cities: The Role of Big Data, 25 October 2013* (pp. 1–143). London, UK: Royal united services institute for defence and security studies, Whitehall. Retrieved from www.stfc.ac.uk, www.rusi.org

Egeru, A. (2016). Climate risk management information, sources and responses in a pastoral region in East Africa. *Climate Risk Management*, *11*(2016), 1–14. http://doi.org/10.1016/j.crm.2015.12.001

Elena, C., Mariella, D.F., & Fabio, F. (2017). Energy resilience of historical urban districts: a state of art review towards a new approach. In *Energy Procedia*, *111* (2017), 426–434). Elsevier B.V. http://doi.org/10.1016/j.egypro.2017.03.204

Elinor, O. (1992). Governing the commons: the evolution of institutions for collective action. *Natural Resource Journal*, *32*(4159, 414–417. http://doi.org/10.2307/3146384

Epule, T. E., Ford, J. D., Lwasa, S., & Lepage, L. (2017). Vulnerability of maize yields to droughts in Uganda. *Water (Switzerland)*, *9*(3), 1–17. http://doi.org/10.3390/w9030181

Eriksen, S. H., & O'Brien, K. (2007). Vulnerability, poverty and the need for sustainable adaptation measures. *Climate Policy*, *7*(4), 337–352. http://doi.org/10.1080/14693062.2007.9685660

FAO-UNICEF-WFP. (2014). *Household Resilience in Dolow, Somalia*.

Few, R., Satyal, P., McGahey, D., Leavy, J., Budds, J., Assen, M… Bewket, W. (2015). *Vulnerability and Adaptation to Climate Change in the Semi-Arid Regions of East Africa* (ASSAR Working Pape No. 3). *International Development Research Centre*. South Africa, 111 pp.

Floater, G., Rode, P., Alexis, R., Chris, K., Hoornweg, D., and Slavcheva, R. (2014). *Cities and the New Climate Economy: the transformative role of global urban growth*. Retrieved from www.newclimateeconomy.net 1

Forino, G., MacKee, J., & von Meding, J. (2016a). A proposed assessment index for climate change-related risk for cultural heritage protection in Newcastle (Australia).

International Journal of Disaster Risk Reduction, *19*(2016), 235–248. http://doi.org/10.1016/j.ijdrr.2016.09.003

Forino, G., MacKee, J., & von Meding, J. (2016b). A proposed assessment index for climate change-related risk for cultural heritage protection in Newcastle (Australia). *International Journal of Disaster Risk Reduction*, *19*(2016), 235–248. http://doi.org/10.1016/j.ijdrr.2016.09.003

Freudenberg, M. (2003). *Composite indicators of country performance: a critical assessment*. *OECD Science, Technology and Industry Working Papers Vol.16*. http://doi.org/10.1787/405566708255

Frey, J.H., & Fontana, A. (1991). The group interview in social research. *The Social Science Journal*, *28*(2), 175–187.

Giglioni, M. (2015). *Hydrological drought prediction through a stochastic model*. Rome.

Gonzales, P., & Ajami, N.K. (2017). An integrative regional resilience framework for the changing urban water paradigm. *Sustainable Cities and Society*, *30*(2017), 128–138. http://doi.org/10.1016/j.scs.2017.01.012

Greenwalt, J., & Raasakka, N. (2018). *Building Urban Resilience to Address Urbanization and Climate Change*. (N. R. and K. A. Julie Greenwalt1, Ed.), *Resilience*. Elsevier Inc. http://doi.org/10.1016/B978-0-12-811891-7.00012-8

Habitat III. (2016). New Urban Agenda. In *Habitat III Conference*. Quito. Retrieved from http://www.eukn.eu/news/detail/agreed-final-draft-of-the-new-urban-agenda-is-now-available/

Hayes, M.J., & Svoboda, M.D. (2000). Monitoring drought using the standardized precipitation index. In Donald A. Wilhite (Ed.), *Drought Mitigation Center Faculty Publications*, 70, (2000), 168–180. London Routledge.

Hepworth, N. D. (2010). *Climate Change Vulnerability and Adaptation Preparedness in Uganda*. Nairobi. Retrieved from www.ltsi.co.uk

Holling, C.S. (1973). Resilience and stability of ecological systems. *Annu.Rev.Ecol.Syst.*, *4*(1973), 1–23. http://doi.org/10.1146/annurev.es.04.110173.000245

Holling, C.S. (1996). Engineering resilience versus ecological resilience. *Engineering within Ecological Constraints*, *1*(1996), 31–44. http://doi.org/10.17226/4919

Hollis, S. (2017). Localized development gaps in global governance: The case of disaster risk reduction in Oceania. *Global Governance*, *23*(1), 121–139. http://doi.org/10.5555/1075-2846.23.1.121

Hung, H.C., Yang, C.Y., Chien, C.Y., & Liu, Y.C. (2016). Building resilience: mainstreaming community participation into integrated assessment of resilience to climatic hazards in metropolitan land use management. *Land Use Policy*, *50*,(2016) 48–58. http://doi.org/10.1016/j.landusepol.2015.08.029

Ilmola, L. (2016). Approaches to measurement of urban resilience. *Springer International Publishing Switzerland, 2016*, 207–237. http://doi.org/10.1007/978-3-319-39812-9

IPCC. (2014). *Intergovernmental Panel on Climate Change Drafting Authors:* United Kingdom and New York.

IPCC. (2015). *Climate Change 2014 Synthesis Report*. Swetzerland. http://doi.org/10.1017/CBO9781107415324

Marengo, J.A., and Espinoza J.C. (2016). Extreme seasonal droughts and floods in Amazonia: causes, trends and impacts. *International Journal of Climatology*, *36*(3), 1033–1050. http://doi.org/https://doi.org/10.1002/joc.4420

Joerin, J., Shaw, R., Takeuchi, Y., & Krishnamurthy, R. (2012). Assessing community resilience to climate-related disasters. *International Journal of Disaster Risk Reduction*, *1*(2012), 44–54. http://doi.org/10.1016/j.ijdrr.2012.05.006

Joerin, J., Shaw, R., Takeuchi, Y., & Krishnamurthy, R. (2014). The adoption of a climate disaster resilience index in Chennai, India. *Disasters*, *38*(3), 540–561. http://doi.org/10.1111/disa.12058

Jones, C., Giorgi, F., Asrar, G.J.C. (2011). The coordinated regional downscaling experiment: CORDEX–an international downscaling link to CMIP5. *CLIVAR exchanges*, *16*(2016), 34-40.

Jones, L. and Samman, E. (2016) *Measuring Subjective Household Resilience*, Overseas Development Institute, London.

Jones, L. and Tanner, T. (2015) *Measuring Subjective Resilience Using People's Perceptions to Quantify Household Resilience,* Overseas Development Institute, London.

Juan-García, P., Butler, D., Comas, J., Darch, G., Sweetapple, C., Thornton, A., & Corominas, L. (2017). Resilience theory incorporated into urban wastewater systems management. State of the art. *Water Research*, *115*(2017), 149–161. http://doi.org/10.1016/j.watres.2017.02.047

Kamh, Y.Z., Khalifa, M.A., & El-Bahrawy, A.N. (2016). Comparative study of community resilience in mega coastal cities threatened by Sea level rise: the case of Alexandria and Jakarta. *Procedia - Social and Behavioural Sciences*, *216*(2015), 503–517. http://doi.org/10.1016/j.sbspro.2015.12.007

Kansiime, M.K., Wambugu, S.K., & Shisanya, C.A. (2013). Perceived and actual rainfall trends and variability in Eastern Uganda. *Journal of Natural Sciences Research*, *3*(8), 179–195.

Katsanos, D., Retalis, A., Tymvios, F., and Michaelides, S. (2018). Study of extreme wet and dry periods in Cyprus using climatic indices. *Atmospheric Research*, *1*(2018), 88–93. http://doi.org/https://doi.org/10.1016/j.atmosres.2017.09.002

Kelman, I. (2015). Geographies of resilience. *SAGE*, *39*(3), 249–267. ttp://doi.org/10.1177/0309132513518834

Kikoyo, D.A., & Nobert, J. (2016). Assessment of impact of climate change and adaptation strategies on maize production in Uganda. *Physics and Chemistry of the Earth*, *93*(2016), 37–45. http://doi.org/10.1016/j.pce.2015.09.005

Klein, R.J.T., Nicholls, R. J., & Thomalla, F. (2003). Resilience to natural hazards: How useful is this concept? *Environmental Hazards*, *5*(1), 35–45. http://doi.org/10.1016/j.hazards.2004.02.001

Kotzee, I., & Reyers, B. (2016). Piloting a social-ecological index for measuring flood resilience: A composite index approach. *Ecological Indicators*, *60*, 45–53. http://doi.org/10.1016/j.ecolind.2015.06.018

Kundzewicz, Z.W., Radziejewski, M., & Pińskwar, I. (2006). Precipitation extremes in the changing climate of Europe. *Climate Research*, *31*(1), 51–58. http://doi.org/10.3354/cr031051

Lee, E.H., & Kim, J.H. (2017). Development of resilience index based on flooding damage in urban areas. *Water (Switzerland)*, *9*(6), 1–15. http://doi.org/10.3390/w9060428

Lindsey J, Ayorekire F, Barihaihi M, Kagoro A. (2012). *Preparing for the future in Uganda: Understanding the influence of development interventions on adaptive capacity at the local level*. Kampala.

Lindsey, J., Samman, E. and Vink, P. (2018), "Subjective measures of household resilience to climate variability and change: Insights from a nationally representative survey of Tanzania", *Ecology and Society*, *23*(1), 88–99. http://doi.org/doi:10.5751/ES-09840-230109

Lwasa, S. (2010). Adapting urban areas in Africa to climate change: the case of Kampala. *Current Opinion in Environmental Sustainability-Elsevier B.V.*, *2*(3), 166–171. http://doi.org/10.1016/j.cosust.2010.06.009

Masih, I., Maskey, S., Mussá, F.E.F., & Trambauer, P. (2014). A review of droughts on the African continent: A geospatial and long-term perspective. *Hydrology and Earth System Sciences*, *18*(9), 3635–3649. http://doi.org/10.5194/hess-18-3635-2014

Mastens, A.S., Labella, M. H., & Naryan, A. J. (2016). Emotional climate in families experiencing homelessness. *Scial Development*, *25*(2), 304–321. http://doi.org/10.1111/sode.12154

Mayunga, J.S. (2007). *Understanding and Applying the Concept of Community Disaster Resilience: A capital-based approach,* USA. http://doi.org/10.1146/annurev.energy.32.051807.090348

Mbale District Local Government. (2012). *Mbale District Local Government Statistical Abstract*. Retrieved from www.ubos.org/onlinefiles/uploads/ubos/2009_HLG.../Mbale.pdf

Meerow, S., Newell, J.P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*(2016), 38–49. http://doi.org/10.1016/j.landurbplan.2015.11.011

Miguez, M.G., & Verol, A. P. (2016). A catchment scale integrated flood resilience index to support decision making in urban flood control design. *Environment and Planning Design*. *44*(5)*, 925-946,* http://doi.org/10.1177/0265813516655799

Mishra, A.K., & Singh, V.P. (2010). A review of drought concepts. *Journal of Hydrology*, *1*(11), 202–216. http://doi.org/10.1016/j.jhydrol.2010.07.012

Mugume, S.N., & Butler, D. (2017). Evaluation of functional resilience in urban drainage and flood management systems using a global analysis approach. *Urban Water Journal*, *14*(7), 727–736. http://doi.org/10.1080/1573062X.2016.1253754

Mugume, S. N., Gomez, D. E., Fu, G., Farmani, R., & Butler, D. (2015). A global analysis approach for investigating structural resilience in urban drainage systems. *Water Research*, *81*, 15–26. http://doi.org/10.1016/j.watres.2015.05.030

Nakileza, B.R., &, Mwajalolo, J.M., Abu Wandera, C.M.N. (2017). Enhancing resilience to landslide disaster risks through rehabilitation of slide scars by local communities

in Mt Elgon, Uganda. *Jàmbá: Journal of Disaster Risk Studies*, *9*(1), 390–409. http://doi.org/https://doi.org/10.4102/jamba.v9i1.390

Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A., & Giovannini, E. (2008). *"Handbook on Constructing Composite Indicators: Methodology and User Guide"* (2005 No. 3). http://doi.org/10.1787/9789264043466-en

NEMA. (2007). State of the Environment Report for Uganda 2006/2007. *Environment*, 357.

NEMA Uganda. (2010). *State of the Environment Report for Uganda 2010*, Kampala http://doi.org/10.1016/j.disopt.2009.05.002

Nicholson, S.E. (2017). Climate and climatic variability of rainfall over eastern Africa. *Reviews of Geophysics*, *55*(3), 590–635. http://doi.org/10.1002/2016RG000544

Nimusiima, A., Basalirwa, C., Majaliwa, J.G.M., Mbogga, S., Mwavu, E., Namaalwa, J., & Okello-Onen, J. (2014). Analysis of future climate scenarios over central Uganda cattle corridor. *Journal of Earth Science & Climatic Change*, *5*(10), 1-13. http://doi.org/10.4172/2157-7617.1000237

Nimusiima, A., Basalirwa, C. P. K., & Majaliwa, J. G. M. (2013). Nature and dynamics of climate variability in the Uganda cattle corridor. *African Journal of Environmental Science and Technology*, *7*(2013), 770–782. http://doi.org/10.5897/AJEST2013.1435

Nsubuga, F.W.N., Botai, O.J., Olwoch, J.M., Rautenbach, C.J.W., Bevis, Y., & Adetunji, A.O. (2014). The nature of rainfall in the main drainage sub-basins of Uganda. *Hydrological Sciences Journal*, *59*(2), 278–299. http://doi.org/10.1080/02626667.2013.804188

Nsubuga, F.W., & Rautenbach, H. (2018). Climate change and variability: a review of what is known and ought to be known for Uganda. *International Journal of Climate Change Strategies and Management*, *10*(5), 752–771. http://doi.org/10.1108/IJCCSM-04-2017-0090

OECD. (2008). *Handbook on Constructing Composite Indicators: Methodology and User Guide*. OECD Publishing. http://doi.org/10.1787/9789264043466-en

Ogallo, L.A., Kilavi, M., Awange, J.L., Njogu, A., Kululetera, V., Forootan, E., … Muchiri, P. (2013). Changes in temperature and precipitation extremes over the Greater Horn of Africa region from 1961 to 2010. *International Journal of Climatology*, *34*(4), 1262–1277. http://doi.org/10.1002/joc.3763

Ogwang, B.A., Haishan, C., & Guirong, T. (2012). Diagnosis of September - November drought and the associated circulation anomalies over Uganda. *Pakstan Journal of Meteorology*, *9*(17), 11–24.

Ongoma, V., & Chen, H. (2017). Temporal and spatial variability of temperature and precipitation over East Africa from 1951 to 2010. *Meteorology and Atmospheric Physics*, *129*(2), 131–144. http://doi.org/10.1007/s00703-016-0462-0

Oratungye, K.J., Oratungye, K.J., Oludhe, C., & Manene, M.M. (2017). A multivariate analysis approach in determining potential hotspots of seasonal rainfall change over Uganda. *International Journal of Statistics and Applied Mathematics*, *2*(1), 31–41.

OXFAM. (2017). *A climate in crisis*. Nairobi.

Palchaudhuri, M., & Biswas, S. (2013). Analysis of meteorological drought using standardized precipitation index –a case study of puruliya district, west Bengal, India. *International Journal of Environmental and Ecological Engineering*, *7*(3), 167–174. Retrieved from waset.org/Publication/9996966

Panteli, M., Sean, W., Dawson, R., & Pierluigi, M. (2017). System resilience to extreme weather: fragility Modelling, probabilistic impact assessment, and adaptation measures. *IEEE Transaction on Power Systems*, *32*(2017), 37–47. http://doi.org/10.1109/TPWRS.2016.2641463

Pharoah, R., and Ross, S. (2016). *Strengthening climate resilience in African cities*. Stellenbosch. Retrieved from http://cdkn.org/wp-content/uploads/2014/05/CDKN_ACC_WP_final_web-res.pdf

Prein, A.F., Rasmussen, R.M., Ikeda, K., Liu, C., Clark, M.P. & Holland, G.J. (2017). The future intensification of hourly precipitation extremes. *Nature Climate Change*, *7*(2017), 48–52.

Rader, J.A., and Kole, S. (2013). Measuring the resilience of cities: the role of big data. Proceedings of the conference on measuring the resilience of cities: Whitehall, London, UK, pp 1–143, 25 Oct 2013. Available at: www.stfc.ac.uk, www.rusi.org

Sadri, A.M., Ukkusuri, S.V., Lee, S., Clawson, R., Aldrich, D., Nelson, M.S., Kelly, D. (2017). The role of social capital, personal networks, and emergency responders in post-disaster recovery and resilience: a study of rural communities in Indiana. *Natural Hazards*, *90*(3), 1–30. http://doi.org/10.1007/s11069-017-3103-0

Saghir, J., & Santoro, J. (2018). *Urbanization in Sub-Saharan Africa: Meeting Challenges by Bridging Stakeholders*. Retrieved from https://en.oxforddictionaries.com/definition/sharing_economy.

Schipper E.L.F., Langston, L. (2015). *A comparative overview of resilience measurement frameworks: analysing indicators and approaches*, London. http://doi.org/10.13140/RG.2.1.2430.0882

Schöll, R., Koffi, B., Ferro, C.A.T., Frei, C., Palutikof, J., … Holt, T. (2007). Future extreme events in European climate: an exploration of regional climate model projections. *Climatic Change*, *81*(S1), 71–95. http://doi.org/10.1007/s10584-006-9226-z

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M. … Whitlock, E. (2015). Preferred reporting items for systematic review and meta-analysis protocols (prisma-p) 2015: Elaboration and explanation. *BMJ*, *349*(2015), 1–25. http://doi.org/10.1136/bmj.g7647

Sharifi, E., & Boland, J. (2017). Heat resilience in public space and its applications in healthy and low carbon Cities. *Procedia Engineering*, *180*, 944–954. http://doi.org/10.1016/j.proeng.2017.04.254

Shongwe, M.E., van Oldenborgh, G.J., van den Hurk, B., & van Aalst, M. (2011). Projected changes in mean and extreme precipitation in Africa under global warming. Part II: East Africa. *Journal of Climate*, *24*(14), 3718–3733. http://doi.org/10.1175/2010JCLI2883.1

Smith, L.C., & Frankenberger, T.R. (2018). Does resilience capacity reduce the negative impact of shocks on household food security? Evidence from the 2014 floods in

Northern Bangladesh. *World Development*, *102*, 358–376. http://doi.org/10.1016/j.worlddev.2017.07.003

Solecki, W. (2015). Hurricane sandy in New York, extreme climate events and the urbanization of climate change: perspectives in the context of sub-Saharan African cities. *Current Opinion in Environmental Sustainability*, *13*(2015), 88–94. http://doi.org/10.1016/j.cosust.2015.02.007

Solecki, W., Seto, K.C., Balk, D., Bigio, A., Boone, C.G., Creutzig, F. … Zwickel, T. (2015). A conceptual framework for an urban areas typology to integrate climate change mitigation and adaptation. *Elsevier*, *14*(2015),116–137. http://doi.org/10.1016/j.uclim.2015.07.001

Spinoni, J., vogt, J.V., Gustavo, N.P., Barbosa, A.L. (2018). Will drought events become more frequent and severein Europe? *International Journal of Climatology*, *38*(2018), 1718–1736. http://doi.org/10.1002/joc.5291

Suárez, M., Gómez-Baggethun, E., Benayas, J., & Tilbury, D. (2016). Towards an urban resilience index: a case study in 50 Spanish cities. *Sustainability*, *8*(8), 774. http://doi.org/10.3390/su8080774

Sudmeier-rieux, K.I. (2014). Resilience – an emerging paradigm of danger or of hope? *Disaster Prevention and Management*, *23*(1), 67–80. http://doi.org/10.1108/DPM-12-2012-0143

Tawodzera, G. (2012). Urban household survival and resilience to food insecurity in crisis conditions: the case of Epworth in Harare, Zimbabwe. *Journal of Hunger & Environmental Nutrition*, *7*(2012), 293–320. http://doi.org/10.1080/19320248.2012.702469

The Rockefeller Foundation/Arup. (2014). *City Resilience Index. Urban Measurement Report, 3*(May). Retrieved from http://publications.arup.com/Publications/C/City_Resilience_Framework.aspx

The Rockefeller Foundation/Arup. (2016). *Measuring City Resilience 4*(2016) New York.

Thompson, H.E., and Berrang-Ford, L. (2010). Climate change and food security in sub-Saharan Africa: a systematic literature review. *Sustainability*, *2*(8), 2719–2733. http://doi.org/10.3390/su2082719

Tippens, J.A. (2016). Urban Congolese refugees in Kenya: the contingencies of coping and resilience in a context marked by structural vulnerability, Nairobi. http://doi.org/10.1177/1049732316665348

UBOS. (2014). *National Population and Housing Census 2014*. Kampala.

UBOS. (2016). *Census 2014 Final Results _ Uganda Bureau of Statistics*. Kampala.

UNDP. (2013). *Climate profile and climate change vulnerability assessment for the Mbale region of Uganda*, Kampala.

UNDP/NEMA/UNEP. (2009). Enhancing the contribution of weather, climate and climate change to growth, employment and prosperity. *Report*, Kampala

UNDP Drylands Development Centre. (2013). *Community Based Resilience Assessment (CoBRA). Conceptual Framework and Methodology*, Dolow, Somalia

UNISDR. (2015). *Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction. International Stratergy for Disaster Reduction (ISDR)*. New York. http://doi.org/9789211320282

United Nations Development Programme. (2014). *Understanding community resilience: Findings from community-based resilience analysis (CoBRA) assessments*. Nairobi. http://doi.org/13-54467/700

UNU-CPR (United Nations University Centre for Policy Research). (2016). *Defining the Resilient City* (defining the resilient city No. 6). Stanford University, Stanford, USA and Washington D.C., USA.

Waithaka M., Gerald C. Nelson., Timothy S. T., Kyotalimye M.E. (2013). *East African agriculture and climate change: A comprehensive analysis*. Internal Food Policy Research Institute (IFRI).

Walker-Springett, K., Butler, C., & Adger, W. N. (2017). Wellbeing in the aftermath of floods. *Health and Place*, *43*(2016), 66–74. http://doi.org/10.1016/j.healthplace.2016.11.005

Warner K, De Logt V, Brouwer M, Bodegom V.J.A, Satijn B. M.P., and Galema F M. (2015). *Climate Change Profile Uganda.* Retrieved from climatehelpdesk@minbuza.nl

Wong-Parodi, G., Fischhoff, B. & Strauss, B. (2015). Resilience vs. adaptation: framing and action. *Climate Risk Management*, *10*(2015), 1–7. http://doi.org/10.1016/j.crm.2015.07.002

Yamane, T. (1967). Statistics: An Introductory Analysis. *Harper and Row*, *60*(310), 886. http://doi.org/10.2307/2282703

Appendix

Questions for the Structured Household Interviews, Group Interviews and Key Informant Interviews.

Structured Household Interviews

Dear respondent,
This questionnaire is designed to generate information for a study on urban resilience to climate variations and extremes in Mbale Municipality. It is used strictly for research purposes and the information gathered from the respondent will be kept confidential. The study is being supported by the Directorate of Research and Graduate Training, Makerere University. We request for your time to answer some questions and thank you for the cooperation

Spatial Information

Division……, Parish……,
Ward…….
4. GPS coordinates: Northing……,
Easting……
Elevation……

Section A: Household Characteristics

5. Household type

	Male headed	
	Female headed	

6. Is the household able to meet all the daily expenditure its members?

Yes	
No	

7. Household structure

Number of household members	Age	Gender	Marital status[2]	Education level[3]
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Section B: Household Resilience to Prolonged Droughts and Erratic Rainfall Events

8. If a prolonged drought and/or erratic rainfall events occurred, how likely is it that your household would be well prepared in advance?

1.	Extremely likely	
2.	Very likely	
3.	Not very likely	
4.	Not at all likely	

9. If a prolonged drought and/or erratic rainfall event occurred, how likely is it that your household could recover fully within 6 Months?

1.	Extremely likely	
2.	Very likely	
3.	Not very likely	
4.	Not at all likely	

10. If a prolonged droughts and/or erratic rainfall events became more frequent, how likely is it that your household could change its source of income and/or livelihood if needed?

1.	Extremely likely	
2.	Very likely	
3.	Not very likely	
4.	Not at all likely	

11. In the past 5 years, how serious a problem has prolonged droughts and/or erratic rainfall events been to your house hold?

1.	Extremely likely	
2.	Very likely	
3.	Not very likely	
4.	Not at all likely	

Section C. Dimensions of Household/Urban Resilience

The Physical dimension

-Water

12. Do you have access to water throughout the year? (a) Yes (b) No

13. Is the quality of water safe for drinking at all times without boiling or treatment especially during heavy precipitation events? (a) Yes (b) No

14. Do you have alternative sources of water during times of drought? (a) Yes (b) No

-Electricity

15. Do you have access to electricity? (a) Yes (b) No

16. Is electricity supply reliable and no experiences of load shading on a frequent basis? (a) Yes (b) No

17. Is there diversity in energy supply serving the city, such that alternative supplies exist should one of them fail? (a) Yes (b) No

-Sanitation

18. Which of these statements explains your household (hh) sanitation situation? (a) hh has a flash toilet (b) hh has a pit latrine (c) hh uses simple buckets (d) open defecation

19. Is your households connected to reliable sewerage network? (a) Yes (b) No

20. Does Mbale Municipality have sufficient diversity of solid waste collection and disposal methods for all types of waste generated within the Municipality, such that

a failure in one method will not result in loss of service across the Municipality? (a) Yes (b) No

-Housing

21. Do you own a house? (a) Yes (b) No

22. Describe the roof of the house you stay in? (a) Grass thatched (b) Iron sheets (c) Tiles (d) others

23. Characterize the wall of the house you stay in? (a) Bricks (b) Mud and wattle (c) Others

24. Characterize the floor of your house? (a) Concrete (b) non-concrete (c) others

25. Has the house you stay in been able to withstand storms and heavy rainfall events for the last five years? (a) Yes (b) No

-Transportation

26. Are all roads in your division accessible during heavy rainfall events? (a) Yes (b) No

27. Do the roads in your division have road side covered drains? (a) Yes (b) No

-Physical assets

28. Which of the following do you own? (a) Land (b) crops (c) Stock of adequate nutritious food (d) Livestock (f) Television (g) Radio (h) Telephone

The Social Dimension

-Education

29. What level of education did you attain (a) none (b) Primary (c) Secondary (d) Tertiary (e) University

30. Describe the quality of education that your household gets (a) the quality if good (b) the quality of education is not good.

-Health

31. Which of the following statements best describes the nature of health services to households?

	Yes	No
Quality health services are affordable		
Government programmes that control the spread of diseases (e.g., infectious, water-borne or vector-borne) exist		
Vaccination programs exist		
There are effective screening programs to monitor at risk groups e.g. cancer, sexual health, heart disease and cognitive screening,		

32. Are there existence of stockpiles for emergencies during storms and heavy rainfall events? (a) Yes (b) No
33. Does any of your household member safer from any chronical illness? (a) Yes (b) No
-Social networks
34. Which of the following are sources of help to your household during times of hardship caused by climate change shocks such as prolonged drought or heavy rainfall events?

	Yes	No
NGO's		
Friends		
Relatives		
Networks with those in position of influence in government		

Economic Dimension

-Finance
35. Which monthly income category do you fall in UGX?

	Less than 100,000	
	101,000–300,000	
	301–500,000	
	Above 500,000	

36. Do you have any alternative sources of income? (a) Yes (b) No
37. Do you have any form of savings? (a) Yes (b) No
38. Do you have access to credit? (a) Yes (b) No
39. Do you have access to remittances? (a) Yes (b) No
40. What is your occupation? (a) none (b) Farmer (c) public servant (d) Trader.
-Economic assets
41. Do you have access to pension? (a) Yes (b) No
42. Do you have access to insurance cover? (a) Yes (b) No

Section D: Resilience Governance and Disaster Preparedness Practices

43. Please indicate the degree to which the following resilience governance practices are available in your Municipality to manage variations and changes in climate.

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Good governance					
To what extent do you agree that identification of vulnerable groups exists	1	2	3	4	5
To what extent do you agree that the ecosystems such as wetlands, forests and open spaces within the municipality are protected	1	2	3	4	5
To what level do you agree that there is involvement of stakeholders in decision-making on issues related to climate change shocks and stresses in Mbale Municipality?	1	2	3	4	5
To what extent do you agree that preparedness plans against climate related shocks and stresses exist	1	2	3	4	5
To what extent do you agree that there is representation of marginalized groups in Mbale municipality?	1	2	3	4	5
To what level do you agree that Municipal authority dealing with climate change shocks and stresses exists?	1	2	3	4	5
Population awareness					
To what level do you agree that weather early warnings exist in Mbale Municipality?	1	2	3	4	5
To what extent do you agree that climate change awareness programs exist?	1	2	3	4	5
Crisis management					
To what extent do you agree that trained emergency teams dealing with climate related shocks and stresses exist in Mbale municipality?	1	2	3	4	5
To what extent do you agree that emergency facilities that can help the people to recover from the effects of climate change shocks and stresses exist?	1	2	3	4	5

Questions for the Group Interviews with Households in each of the Three Divisions

1. What are the main climate change shocks facing your division?
2. What are the characteristics of a resilient household (what does a resilient household look like)?
3. What are the three most important characteristics of household resilience ranked by importance?
4. To what extent have households achieved each of the priority characteristics during the normal period and the last significant shock in climate (i.e. prolonged drought or erratic rainfall)? Rate household progress in achieving the priority resilience characteristics on a scale of 0-10
5. Is resilience of households in your community increasing, decreasing or stable? And explain why?

6. Describe interventions/services that have helped to enhanced household level of resilience in the last five years?
7. From the interventions identified, list three current and previous interventions that had been most beneficial in building resilience and explain why?
8. What additional/future interventions would help to enhance resilience to variations and changes in climate in your household?
9. Identify household in your division that have achieved fully or partially resilience characteristics and list their common features and attributes

Questions for Key Informant Interviews with Households Perceived to be Resilient during the Group Interviews or through Discussions with Senior Local Residents

1. What factors have contributed to your household resilience to climate change shocks and stresses?
2. Why do you think your family coped better with challenges related to climate change shocks and stresses affecting the community?
3. What interventions do you think would best build wider resilience to climate change shocks and stresses in this community?

Key Informant Interview Questions for Municipal Local Government Officials

1. What elements of climate change shocks and stresses have been identified in Mbale Municipality?
2. Do you think there have any changes in rainfall in the last 10 years as compared to the previous decades? If yes, what are these changes?
3. Do you think there have been changes in dry seasons in the last 10 years as compared to the previous decades? If yes what are the changes?

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