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Original Research Article

Loss of wetland resources in Uganda: The case of lake Wamala in Mityana District

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The coastal wetland zones of Lake Wamala are experiencing a noticeable shoreline retreat leading to loss of its resources and ecological services. This henceforth, calls for sustainable wetland resource management by clearly dissecting and understanding the prime cause of such losses. The study employed community-based participatory approach to capture stakeholder perceptions and knowledge on wetland resources in six villages namely; Mityana Town, Naama, Nkonya, Buzibazi, Mpongo and Lusalira. The study sought to find out the causes of wetlands degradation, impacts and mitigation strategies, needed to avert loss of such resources. Temperature data from Mubende Meteorological Station were compared using Analysis of Covariance (ANCOVA) and the average change in temperature was determined using SAS JMP 10 Software. Variability in rainfall was determined using the coefficient of variation (CV) calculated as a ratio to the mean and expressed as a percentage. Findings attributed climate induced factors as key bottlenecks to wetland resource loss. Findings further highlight increase in human population among other human-induced factors as cause of destruction and alteration of resources in the area. Results prove the derailing nature of wetland resources around Lake Wamala significantly affected livelihoods. In order to avert this trend, prudent measures such as formulation of feasible policy framework to govern and regulate activities in the area, co-management through local community and government partnership, capacity-building programs among relevant stakeholders to enhance awareness about wetlands and its ecological benefits in our quest to improve human welfare in the face of the changing climate.

Keywords: Lake Wamala, Mityana District, climate change, perception,Uganda, livelihood.

INTRODUCTION

Wetlands contribute greatly in various ways to livelihoods of millions of people in the world. Lakes around the world have historically supported artisanal fishing constituting a significant proportion of economic and dietary resources of human populations, gathered around the lakes (Lamptey and Ofori-Danson, 2014). Benefits derived from wetlands range from food, habitats or breeding and nursery grounds to reduction in velocity of running water(plants, shrubs and trees on top wetlands reduces the speed and intensity of running water through absorption and so on), local weather conditions(wetlands regulate prevailing weather conditions through carbon sequestration and evapotranspiration thereby minimizing temperatures in such areas and its environs) local, pollution control (wetlands absorb polluted storm or running water through percolation and filtration. Water that seeps down is filtered and becomes clearer as it reaches the water table or groundwater), water quality among other benefits for numerous species (Naylor et al., 2000). Williams and Dodd Jr. (1978) asserted that many endangered plants and animal species were dependent on wetland habitats for survival due to the ecosystem functions and end-points they protrude. According to an estimation by Gu et al. (2010), the total value of wetland services in Africa amounts to 5.5 billion USD. There are increasing consensus that climatic change posed a great challenge not only to livelihoods but also to wetland resources' conservation, management and restoration (Erwin, 2009) at the local, regional and macro mega-watershed levels as well as surrounding environments (Wheeler, 2013). This has made global climate change models and projections regard anthropogenic drivers as the main threat to the removal of species, integrity and interlinks of ecosystems both marine and terrestrial ecosystems (Hulme, 2005; Sarfo et al., 2019). This is irrespective of the fact that habitat responses to different stressors vary at various levels. It's apparent that increasing temperatures for instance will affect coastal wetland biota due to changes in rainfall and sea level especially in the tropics (Day et al., 2005). Despite the existence of literature on wetland resources, ecological niches and their interdependence on climate conditions, wetland responses to climate change is still poorly understood as most climate change impact models focus on anthropogenic stressors (Clair et al., 1997).

Around Lake Wamala, the unpredictable changes in prevailing climatic conditions, manifested by precipitation shifts, floods and drought have coincided with increase in floating vegetation, decrease in fish stocks, increase in wetland fires, reduction in sea level along seasonal drying and flooding of swamp lands like in Magongolo, Nkonya and Naama villages (NEMA, 2013). Since 1990, about 80 meters of Lake Wamala's coastal waters have been lost due to progressive drying (Global Nature Fund, 2013). Despite historical perceptions about lake retreats and advances in water levels, the lake and resources therein might be lost if current climate change scenarios are not mitigated (National Wetlands Program, 2008). It's upon this background that the study will identify the impact of climate change events specifically rainfall and temperature variations on coastal wetland resources and livelihoods around lake Wamala in Mityana District of Uganda.

Information generated to bridge the knowledge gap identified will guide and serve as a benchmark for devising strategies to cope with climate change hazards along coastal areas of closed inland water bodies such as Lake Wamala. This in essence will guide local, regional, national and international policy-makers in clearly developing feasible and target-oriented strategies that would promote sustainable wetland resource management and climate change adaptation.

The main aim of the study was toexamine the impacts of climate change on wetland resources along Lake Wamala in Mityana District, Uganda. Specific objectives operationalized from the main aim sought todetermine local residents' perception about climate change and its impacts on wetland resources. The study further sought to identify the frequency and magnitude of repeated variations in weather patterns as well as establish relationships between current climate change events, livelihoods and wetland resources.

MATERIALS AND METHODS

Study Area

The current study was carried out on Lake Wamala; an inland water lake in Lake Victoria basin shared by Mityana, Mubende and Gomba districts (Uganda Wetlands Atlas, 2016). The latitudinal location of Lake Wamala is 0ˈ19' N and 31ˈ50'E with an average elevation of 1,005 m though some areas rise above 1,100 m (Sewagudde, 2009) (UBOS, 2016)(Figure 1). The lake has many tributaries with a single distributary-Kibimba, surrounded by swamp vegetation like papyrus, ambatch trees and Hippo grass with peat soils (Okaronon, 1989) which can be retrieved from a report of Lake Wamala fisheries frame survey(National Fisheries Research Institute, 2012). The lake has undergone periods of alternating water levels (GoU, 2008). In the 1960s, it covered 250 km^2 with a wetland zone of 60km^2 and a maximum depth of 4.5 meters though this area reduced to a half by 1999; partly due to climate vagaries (GoU, 2008). The lake has continuously shrunk since 1995 irrespective of the fact that there was minimum obstruction of the lake. Lake Wamala in Mityana covers two counties-Mityana municipality and Busujju; where Naama and Nkonya coastal sites are found in Busimbi Division, Mityana Town in Central Division, Buzibazi and Lusalira areas are found in Banda sub-county and Mpongo village in Maanyi Sub-County (UBOS, 2016).

The study used both quantitative and qualitative methods focusing on climate change vulnerability assessment; where existing scientific data as well as local people's experience and ideas were used to assess the vulnerability of wetland resources. Primary and secondary data were used for the study. Primary data was collected using semi structured questionnaires, field observations and key informant interviews. Hundred (100) set of questionnaires were administered to local residents in the study area. Snowball, convenient and random probabilistic sampling methodologies were used for data collection in the six coastal villages along Lake Wamala: Mityana Town, Naama, Nkonya, Buzibazi, Mpongo and Lusalira. The consent of respondents were sought for during the pilot study and data collection period. Respondents and officials willing assisted in achieving the objectives of this study.The interview guide covered local communities' views on climate change, its effects on wetland resources and livelihoods, main causes of such changes along with associated risks. The study area was selected partially due

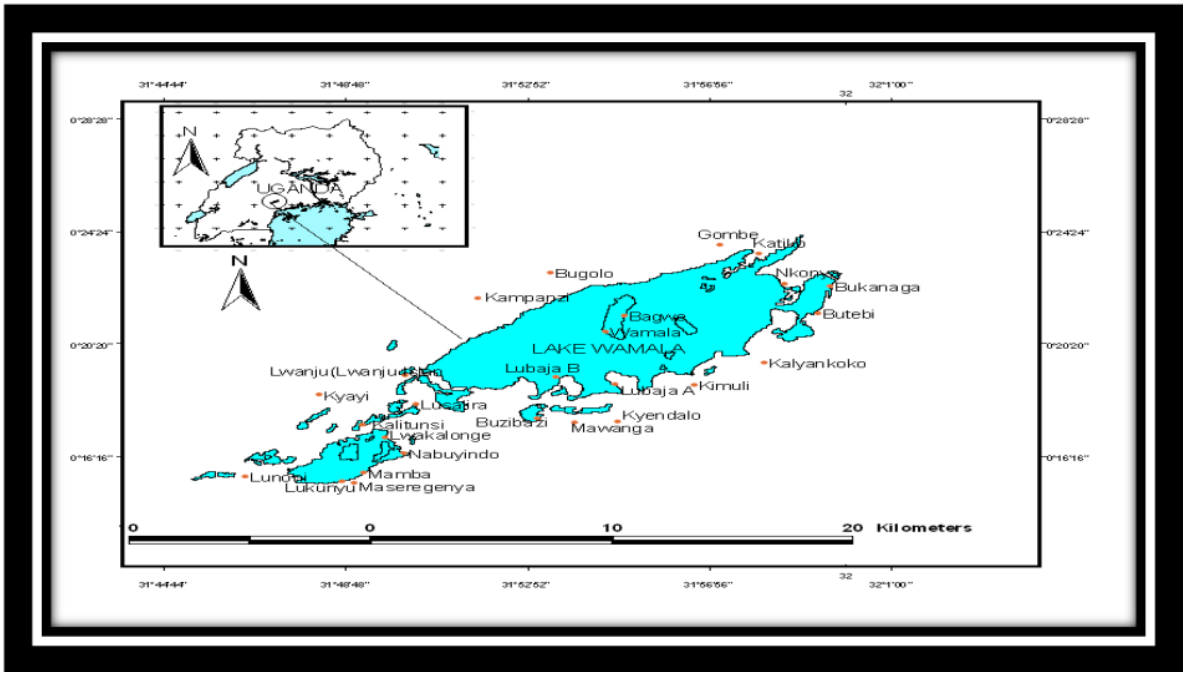

Figure 1: Spatial extent of Lake Wamala and the main villages/landing sites

Source: UBOS, 2016.

to three (3) major reasons thus; history of floods per the area's proximity to mouth of rivers such as: Nyanzi and Mpamujugu and drowned valleys/wetlands. Another major reason is partly down to growing number of livelihoods, directly or indirectly benefiting from wetland resources in the area as well as growing concerns of protecting wetlands across the globe. Secondary data covered the data on climate events and other literature not captured in the questionnaire. Data on rainfall patterns and air surface temperature were obtained from Uganda National Meteorological Mubende weather station archives and Mityana District Environmental Department; the main stations located nearest to Lake Wamala.

Data Analysis

The study employed Microsoft excel software (Excel 2016, Version 1.0 Microsoft Corporation, USA) to analyze demographic and other relevant data captured on the questionnaire. Descriptive statistics, pivot tables and charts were adopted from Mubende Meteorological Station to ease comparison and area specific analysis. They serve as a touchstone in understanding which area/s or wetland resources have been immensely or minimally affected by climate change hence helping in generating pathways in coping with and adapting to such changes. Temperature data from Mubende Meteorological Station was compared using Analysis of Covariance (ANCOVA). Variability in rainfall was determined using the coefficient of variation (CV) calculated as a ratio to the mean and expressed as a percentage.

$$\text{Coefficient of Variation (CV)} = \frac{\text{Average annual rainfall } (\mu)}{\text{Standard Deviation } (\sigma)} \times 100\%$$

Where μ connotes average annual rainfall

Σ connotes standard deviation

The inter-link between rainfall and lake depth was examined with the Pearson Product-Moment Correlation Analysis.

RESULTS

Bio-Data of respondents

This section presents results on demographic data of respondents in the six unit areas along Lake Wamala. Demographic characteristics within these areas vary. All the respondents from the sampled villages had distinct demographic characteristics based on gender, marital status, educational level and occupation (Table 1, 2 and 3).

From the distribution (Table 2) above, it could be observed that the largest proportion of marriage threshold is in Buzibuzi (10%) whilst Mityana has the largest proportion of people in celibacy. Others as outlined in table 2 were people who were engaged, separated or cohabiting.

The distribution above (Table 1) shows an almost identical gender ratio of male-female13:12 irrespective of the fact that Naama had the largest proportion of male respondents (14%) and Mityana town had the most female respondents (10%). Majority of the local people are single households with the largest proportion of married

Table 1. Demographic data of the respondents in the studied villages around Lake Wamala

Area	Mityana	Buzibazi	Naama	Mpongo	Lusalira	Nkonya
Gender						
Male	12	10	14	12	6	6
Female	10	8	5	4	7	6
Total %	**22**	**18**	**19**	**16**	**13**	**12**

Table 2. Marital status of the selected respondents in the studied villages around Lake Wamala

Marital Status	Mityana	Naama	Buzibazi	Mpongo	Lusalira	Nkonya
Single	18%	11%	6%	11%	7%	7%
Married	4%	3%	10%	4%	6%	4%
Widow	0%	3%	2%	1%	0%	1%
Others	0%	2%	0%	0%	0%	0%
Total	**22%**	**19%**	**18%**	**16%**	**13%**	**12%**

Table 3. Relative Proportion of the education level of the respondents around Lake Wamala

Level	Mityana	Naama	Buzibazi	Mpongo	Lusalira	Nkonya
University	11%	8%	5%	3%	3%	4%
Tertiary	8%	6%	5%	8%	2%	2%
Secondary	2%	4%	3%	2%	2%	5%
Primary	1%	1%	5%	3%	6%	1%
Total	22%	19%	18%	16%	13%	12%

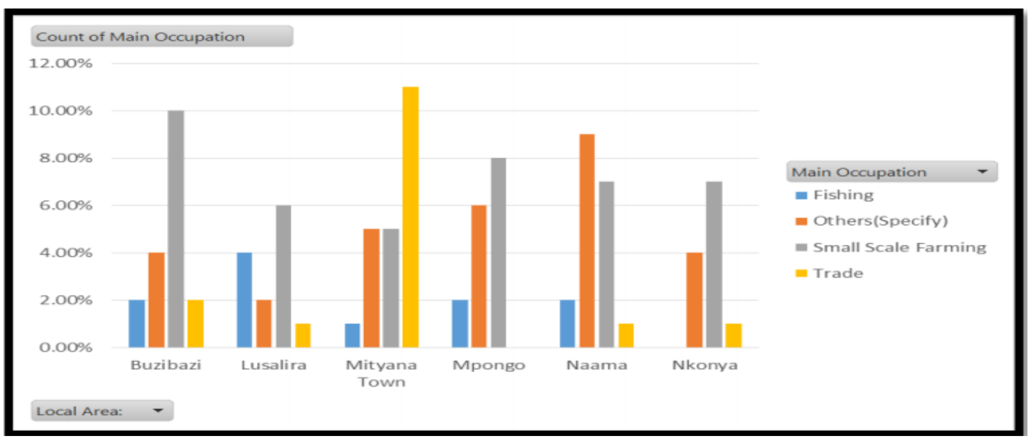

Figure 2: Primary occupation of respondents in the studied villages along Lake Wamala

households in rural areas. The largest proportion of married households (10%) was recorded in Buzibazi (Table 2). A comparatively high literacy level across all zones with 79% of respondents purported to have attained secondary school education especially in Mityana (Table 3). Virtually, all respondents are engaged in some form of income generating activity. However, continuous dominance of traditional livelihood activities such as subsistence farming despite majority of respondents asserting to engage in other alternative livelihood sources as in the case of Naama. This highlights a paradigm shift in terms of occupational status. For instance; 30% of the respondents indicated that they have diversified and engaged in other activities such as teaching, poultry, apiculture and stone quarrying as alternative livelihood sources other than fishing an activity which was their main source of livelihood. Activities like: fishing and trade were neglected in some areas like Nkonya and Mpongo respectively.

Local communities' perception on climate change

Findings show that sampled communities were alarmed by the sporadic changes in climate elements and patterns. For instance, majority of the local people (70%) (Figure 2)

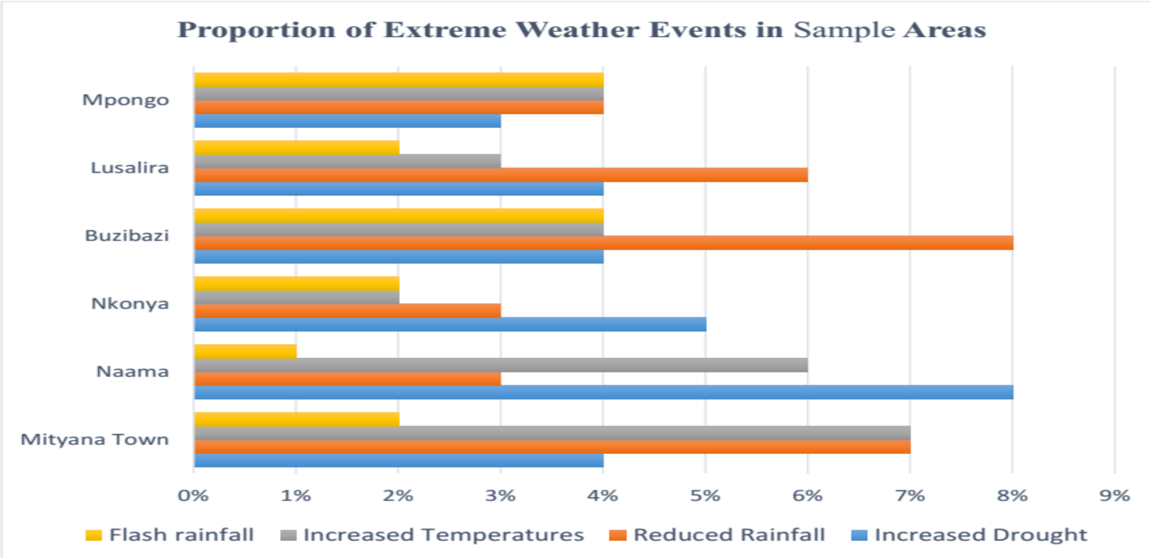

Figure 3: Relative Percentage of the perception of local communities on climate change around Lake Wamala

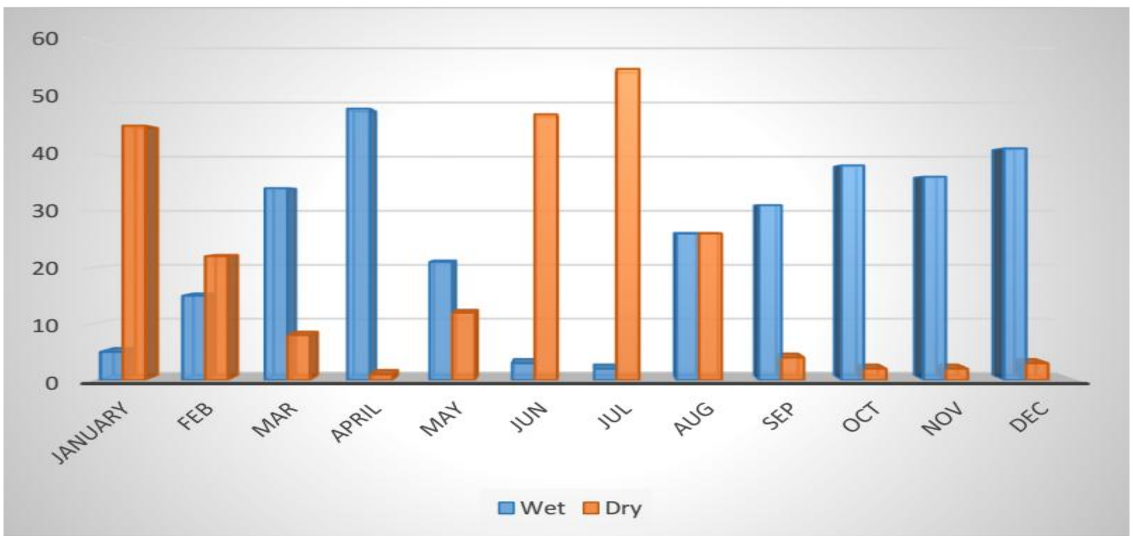

Figure 4: Frequency of Wet and Dry months along Lake Wamala between 1980 and 2012

Source: Mubende District Meteorological Archives

reported a change in the frequency and magnitude of rainfall, extended drought and extremely hot conditions have increased. Such patterns have become less predictable over the years especially in Naama and Nkonya where 5% of the households are affected by limited rainfall (see appendix 1, 2, 3 and 4).

Perception on frequency and changes of large scale climatic events are alarming especially in Naama where 4% of households reported sporadic changes synonymous (Figure 3) with data from Mubende Weather Station showing gross anomalies and unpredictable frequencies for some months (see appendix 1, 2 and 6).

Climate change alarms acknowledged by local households in Buzibazi concur with the analyses of rainfall data. It moves further to confirm that, irrespective of the fact that average rainfall were above average rainfall anomalies since 1988 by 8.03 mm, SPI values indicated high inter-annual rainfall variability (see appendix 7). In addition, the severity of drought (Figure 4) is progressively increasing since 2010 based on the probability of observed total annual rainfall.

There are variations in temperatures (see Figure 5 and appendix 5, 6 and 8) with extremes of 31°C and lows of 15°C especially in Jan-March with a mean of (22.6±0.17°C). There was a higher variation in temperature after 1990 (C.V = 1.9%) than before (C. V= 1.7%) with average

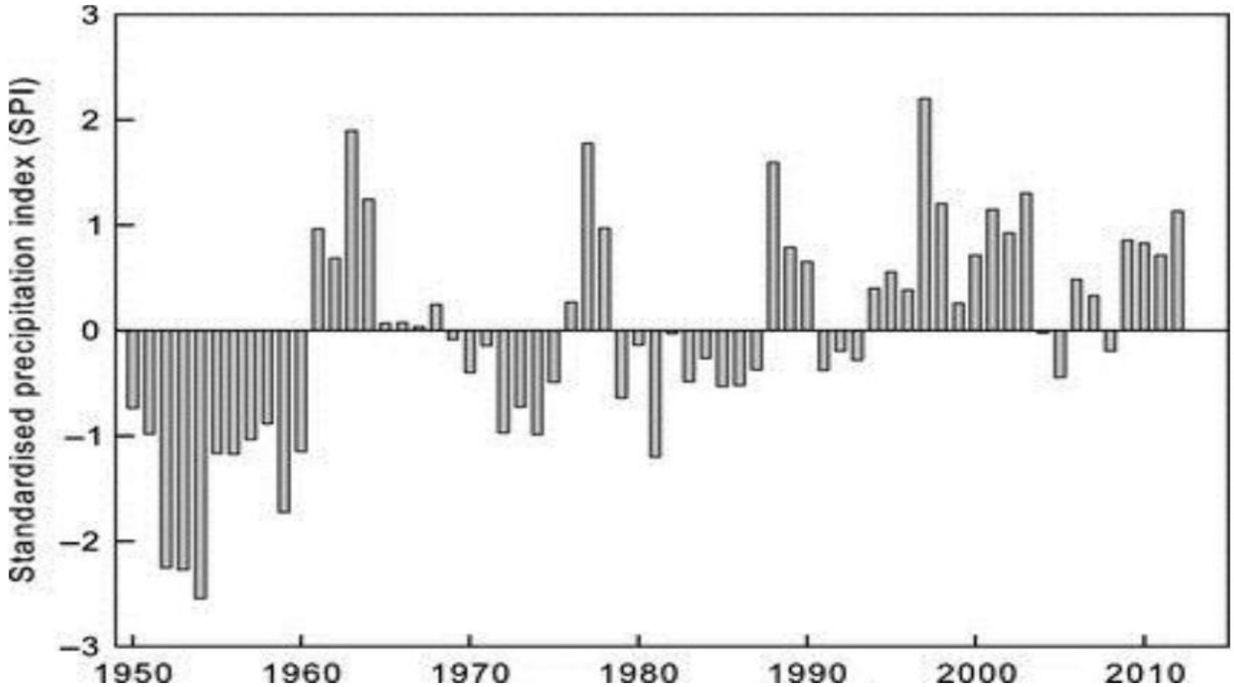

Figure 5: SPI series assessing the drought occurrence in relation to the probability of observed total annual rainfall changing from average (1980-2010)

Source: Uganda National Meteorological Authority, Entebbe.

Table 4: Annual mean minimum and mean maximum temperature anomalies (OC) time series analysis for Mubende weather station near Lake Wamala 1990-2012

Year	Mean Maximum Temperature Anomaly	Mean Minimum Temperature Anomaly
1990	-0.4495	0.4292
1991	-0.2162	0.3625
1992	0.6005	-0.4291
1993	0.4755	-0.1125
1994	0.0903	0.2909
1995	0.3234	-0.1883
1996	-0.2479	-0.1804
1997	0.1247	-0.6516
1998	-8.16E-03	-0.1865
1999	-0.5018	-0.6063
2000	-0.9793	-0.4626
2001	-0.414	-0.1255
2002	0.3951	-0.143
2003	0.2077	0.0313
2004	0.3002	-0.18
2005	1.1338	0.0292
2006	0.2255	0.2209
2007	0.3398	0.3733
2008	0.2183	-0.0282
2009	-1.0329	1.9042
2010	0.7088	0.7292
2011	0.9171	0.2875
2012	-0.2412	1.6292

temperature being 22.1±0.32°C and the average change in temperature was slightly different from the past regimes (F=30.2, p>0.05) (Table 4 and 5). Analysis of weather information indicated a linear increase in minimum

Table 5. Annual average rainfall anomalies (mm) and Standard Precipitation Indexes (SPI) for Mubende Weather Station near Lake Wamala from 1990-2012

Year	Rainfall anomaly (mm)	SPI
1990	99.016	0.5231
1991	-188.98	-0.9983
1992	-137.38	-0.7257
1993	-161.68	-0.8541
1994	28.116	-0.1485
1995	71.916	0.3799
1996	23.216	0.1226
1997	203.516	1.0751
1998	55.316	0.2922
1999	-11.284	-0.0596
2000	116.716	0.6166
2001	238.316	1.2589
2002	176.916	0.9346
2003	282.616	1.4929
2004	-89.884	-0.4748
2005	-208.27	-1.1002
2006	52.816	0.279
2007	9.516	0.0503
2008	-137.78	-0.7278
2009	157.316	0.831
2010	286.516	1.5135
2011	116.816	0.6171
2012	234.016	1.2362

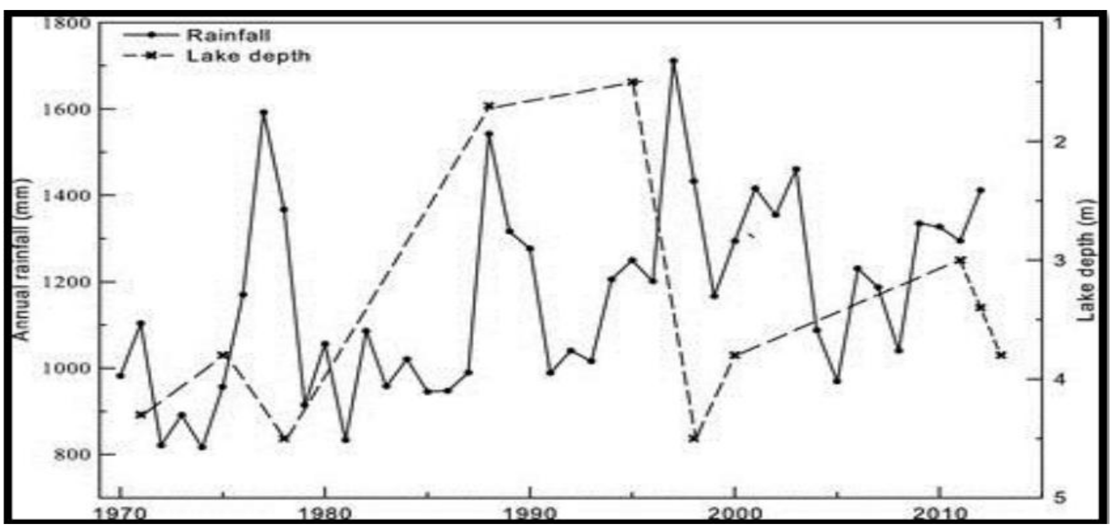

Figure 6: Relationship between Lake Depth and inter-decadal annual rainfall

Source: NaFIRRI, National Meteorological Authority, 2013

temperature (R^2=0.145), maximum (R^2=0.09) and average temperature (Rs^2=0.2).

Water Level changes

Historical data indicated a positive correlation between rainfall and lake depth till 2000s ($r=0.83$, $n=6$, $p<0.05$).

However, the Lake depth receded since 2005 with exposed water gauges (see Figure 6 and appendix 7).

Climate Variability and Livelihoods

Majority of respondents (97%) reported that continuous vagaries in climate elements have had a ripple effect on livelihoods such as small scale farming. Households in Buzibazi (18%) observed that increase in temperature has

Table 6. Relative Proportion of the Impact of Climate Change on Livelihoods

Impact	Relative Proportion
Decline in household income	23%
Reduced agricultural produce	14%
Flooding	12%
Increased cost of doing business (ICDB)	9%
Increased coldness and fog	8%
Soil degradation	7%
Reduced fish catch	7%
Increased occurrence of pests and diseases	7%
Destruction of infrastructure	6%

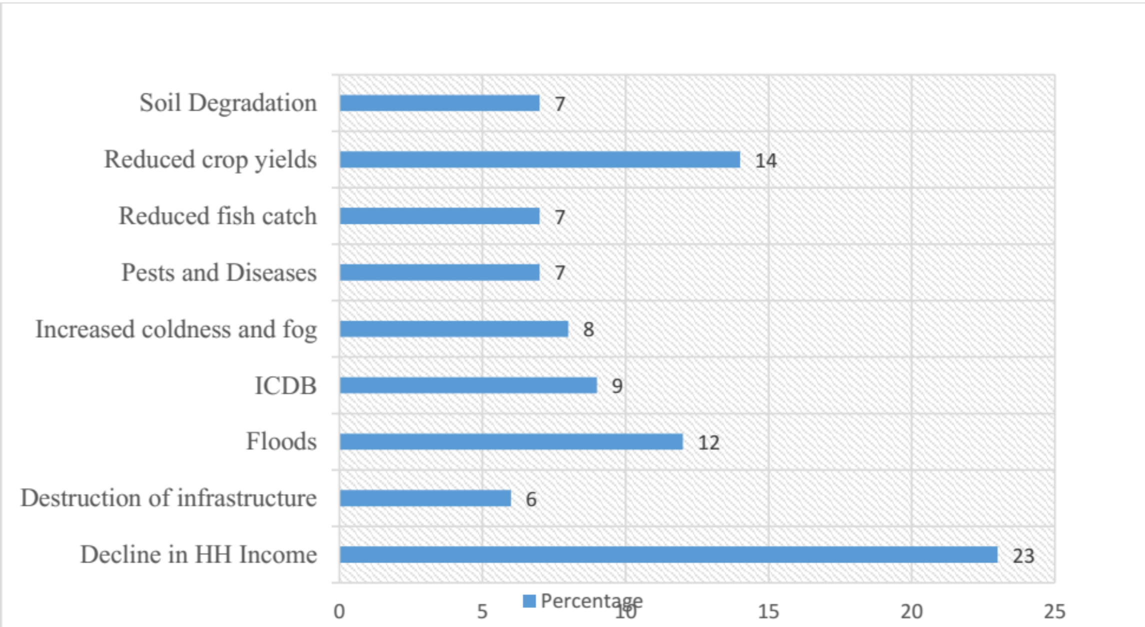

Figure 7: Impacts of Climate Change on Occupational Status of respondents

had direct impact on crop yields, catch and stocks size. Such changes have affected farm produce, increased cost of production, incidence of pests and disease infestation as well as soil degradation (Table 6) (Figure 7). For instance, 6% of respondents in Lusalira experienced a decline in household income due to climate change.

Climate Change and Wetland Resources

All households reported that climate variability has led to negative impacts on wetland resources onto which they derive their livelihood. For instance, 4% of respondents in Mpongo experienced a decline in fish stocks and catch, well as 8% of wetland soils in Nkonya have been affected (Figure 8) (Table 7). Generally, there is a direct correlation between changing climate events and wetland resources that pre-determine the source of livelihood of people therein. Small scale farming that predominates the coastlands of the lake has been directly affected by the changes in rainfall and temperature trend and associated weather events like floods and drought.

At Nkonya, 8% of the respondents reported that wetland soils have been affected (Table 7) as well as 10% of respondents in Mityana town highlighted that the main affected resource was swamp vegetation (Table 7).

Climate variability has impacted wetland resources with ripple effects on local livelihoods (Figure 7 and 8). For instance, climate impacts on wetland soils have affected small scale farming by 19% (Table 8).

General causes of wetland resource loss

There is symbiosis relationship between anthropogenic and natural factors in accounting for what causes degradation of wetland resources. However, specifically, respondents highlighted that 20% of such loss is attributed to swamp cultivation and increasing population which accounts for 16%. Natural phenomenon of drought and low rainfall

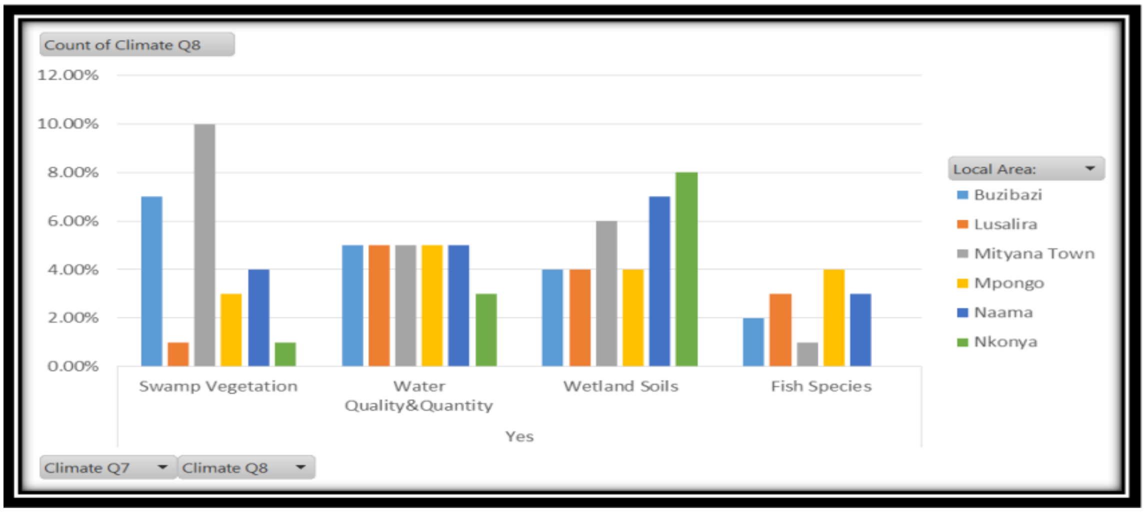

Figure 8: Effects of climate change on wetland resources

Table 7. Impacts of climate change on specific area wetland resources

Resource	Wetland Soil	Water Quality and Quantity	Swamp Vegetation	Fish Species
Mityana Town	6%	5%	10%	1%
Naama	7%	5%	4%	3%
Buzibazi	4%	5%	7%	2%
Mpongo	4%	5%	3%	4%
Lusalira	4%	5%	1%	3%
Nkonya	8%	3%	1%	0%
Total	**33%**	**28%**	**26%**	**13%**

Table 8. Relationship between wetland resource losses on livelihoods due to climate variability

Livelihood Resource	Farming	Others	Trade	Fishing	Total
Soils	19%	8%	5%	1%	**33%**
Water	13%	8%	3%	4%	**28%**
Swamp	7%	11%	6%	2%	**26%**
Fish species	4%	3%	2%	4%	**13%**

account for 15% of the total loss of wetland resources. It is also imperative to note that the causes vary from area to area (Figure 9). For instance, in Naama, poor governance accounts for 3% in causing loss to wetland resources. Respondents ranked the main causes of such losses and reported that, swamp cultivation, increased population and low rainfall and increased drought rank high in accounting for wetland resource losses.

Main risks associated with wetland resource loss

All households highlighted that increased loss of wetland resources due to both climate change and human factors have been associated with various risks both in villages and specific occupational levels. For instance, 30% of all households opined a decline in household welfare. In Naama, 26% asserted an increase in flooding (Figure 10) where 6% of the respondents had already been affected by floods. Climate variability has been associated with severe impacts on local livelihoods. Based on the ranking of respondents, 43% reported that climate change have mainly affected farming, 16% on trade, 11% on fishing whilst 30% believes climate change have had derailing impacts on other activities (Figure 11).

DISCUSSION

Climate Trend Analysis and Perception

Residents in Mityana (22%) and Buzibazi (18%) acknowledged that sporadic changes in climate have

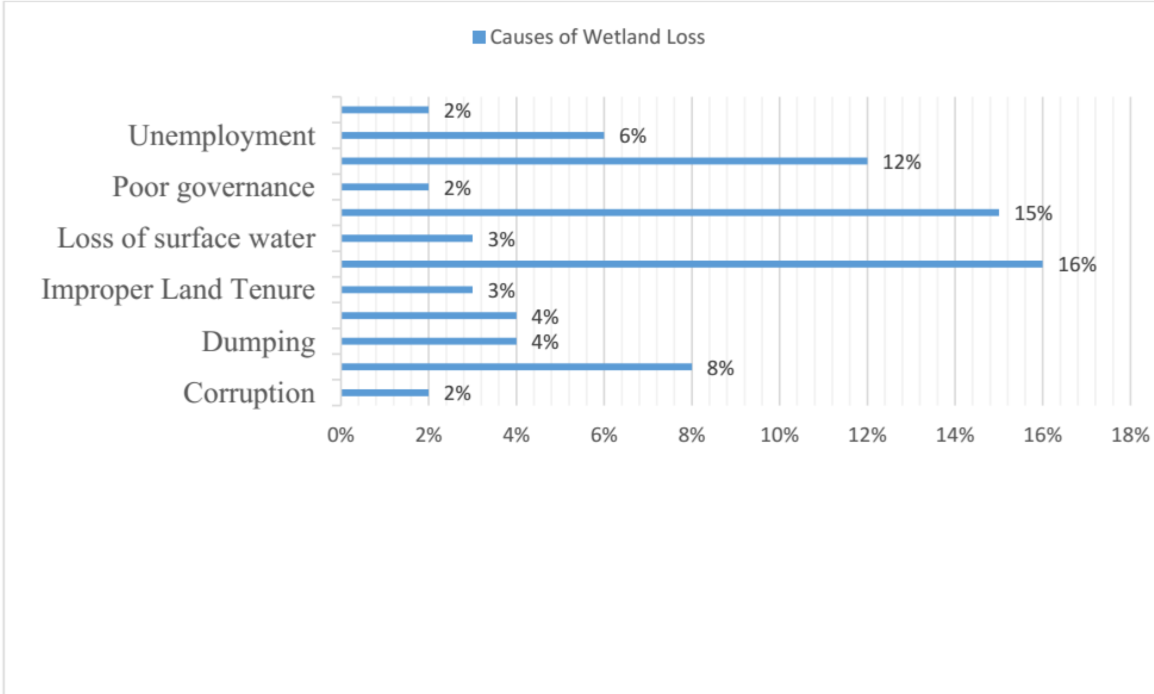

Figure 9: Causes of increased loss in wetland resources

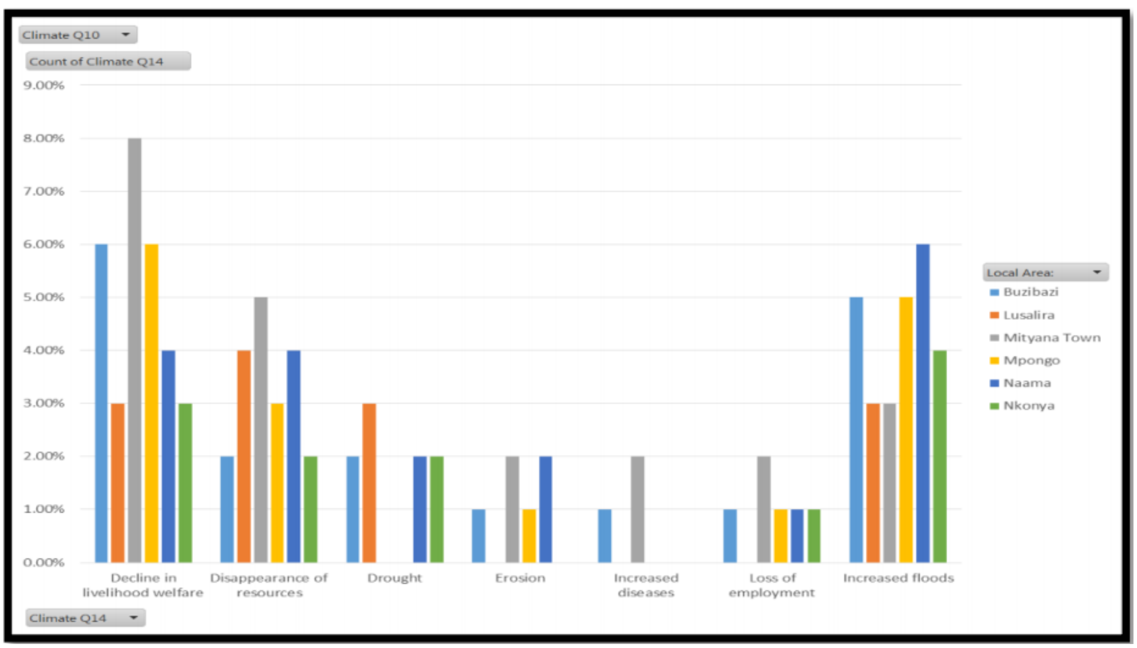

Figure 10: Risks associated with climate changes on local communities

occurred (Figure 4 and 6) and the most prime zones of effect and devastation were the ecologically sensitive areas along Lake Wamala where local people derive their livelihoods (USAID, 2014). However, the magnitude of climate change impacts are not currently understood. This is partly down to research gap in climate events and scenarios around Lake Wamala. Evidence of changes in climatic conditions are observed through increased unpredictability and frequency of climate events like erratic rainfall patterns in Naama, extreme hot temperatures, extended drought, increased frequency of winds and unexpected flooding. This perception is consistent

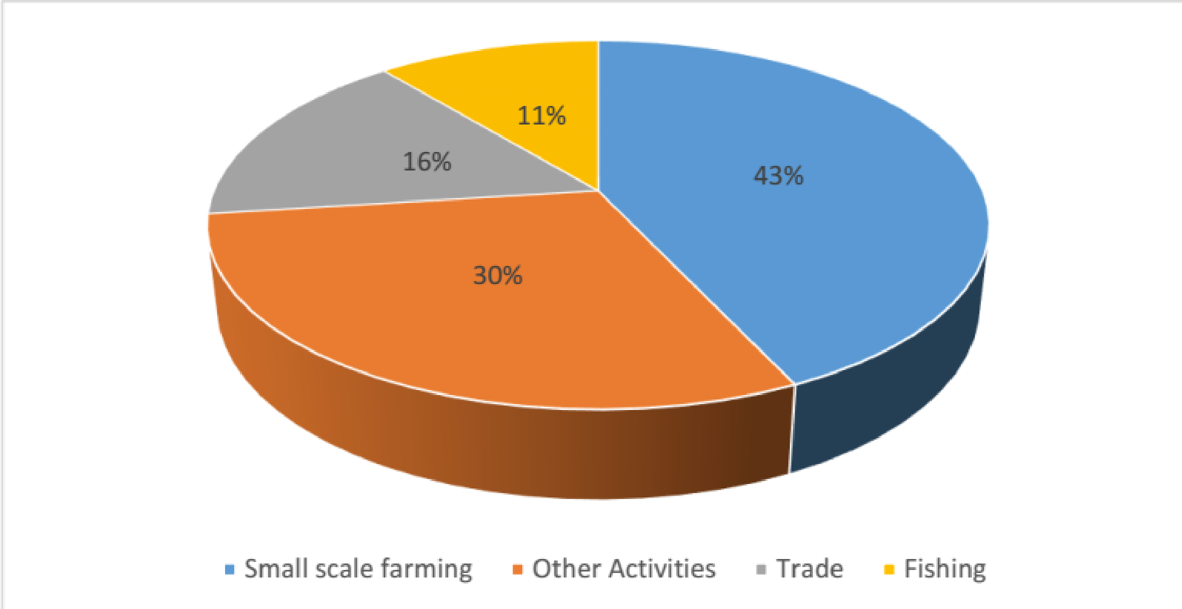

Figure 11: Impact of climate vagaries on specific occupation(s)

with recent studies and climate change trend analysis in Uganda from 1900-2009 highlighting decline in average rainfall by 8% for the 5 annual mid months making it less viable to sustain local communities' livelihoods (USAID, 2012). This amplified exposure of coastal ecological zones and resources to encroachment (Harley and Miner, 2006). In addition, local communities like; Mpongo reported sporadic changes in temperature around Lake Wamala (Figure 3 and 3.5) (see appendix 11, 12 and 13) have increased drought synonymous with the SPI values (Mubiru et al., 2009) (see appendix 7 and 14).

Impact of Climate Change on Wetland Resources

Globally, evidence of local communities' concerns on the impact of climate change on coastal ecosystems and organisms (Figure 3.5) with projected primary and secondary adverse impacts on coastal biota and functioning are highlighted in IPCC's fifth Working Group Assessment Report (IPCC, 2014). Studies in Uganda concur that the current and projected increase in temperature by an average of 2^0C or more has drastically affected agriculture (Twinomugisha, 2005; Kimbowa and Kaganga, 2011) and agro-ecological zones (Turyahabwe and Tumusiime, 2013), hence necessitates immediate and concerted efforts to cope up and pre-empt the looming consequences (WMD, 2009). However, some local people think the exact impacts of climate change appear exaggerated like in Mityana Town and are least concerned. This is partly due to ignorance among some of the local people (Figure 3.6) on current studies on climate events and poverty, shifting risk perception to current survival than long term impacts (Howe and Leiserrowitz, 2013). This partly accounts for the variation in the perception of climate and its associated impacts in sampled areas along Lake Wamala (Figure 3.6). However, generalized climate variability trends and events are in tandem with and comparable to vulnerability assessment reports in Uganda (Natugonza and Ogutu-Ohwayo, 2015). For instance, observed rainfall trends and predictions for Uganda from 2010-2039; *ceteris paribus* indicate that rainfall will decline from -150mm to -50mm (USAID, 2012). This is projected to affect open water wetland resources and threshold agro-ecological zones (Turyahabwe and Tumusiime, 2013).

Climate Variability and Livelihoods

The study demonstrated that climate vagaries have had a negative ripple effect on livelihoods especially farming, fishing and secondary activities like artisanal crafts, brick making and pottery (Figure 3.7 and 3.8). This negative impact is globally documented (Olaoye et al., 2012) irrespective of the fact that the rate and frequency of damage or effect varies at temporal scales and amongst societies (Goulden, 2006). There is growing consensus that oscillating climate trends have and will trigger negative impacts on coastal ecosystems that are vital components in sustaining threshold communities along such coastal zones (Armitage et al., 2017). The study found out that climate change will affect livelihoods by escalating floods, reducing agricultural output, destroying socio-economic infrastructure and fish stocks (Figure 6, 10 and 11). Recent studies indicate such changes are consistent with current and projected impacts of climate change on coastal livelihoods at all levels (Armitage et al., 2017). The increased frequency of droughts and floods in Uganda (see appendix 9 and 10) has inflicted severe losses to poor communities through the destruction of social-economic infrastructure, flood related diseases, increased the monetary cost of small scale farming due to increased uncertainty (Twinomugisha, 2005) and the cessation of rainfall in some periods has affected food security and household income (GoU, 2008). This has crippled activities like farming and breeding sites of fish (UNDP and UNEP, 2009). This analysis is also proved by existing literature on fish stocks, Catch per Unit Effort (CPUE) and efforts on Lake Wamala. Musinguzi et al., (2016) reports that the average stock size, weight, length, fecundity, and CPUE of Nile Tilapia in Lake Wamala have decreased despite reduction in fishing boats and efforts. Though some studies attribute such a trend to migration of fish via the Katonga and other distributaries (Kimbowa and Kaganga, 2011), such an attribute appears subjective based on field surveys and existing literature. Data from the Lake Wamala Fisheries Frame Survey (2012) proves that by 2000, most fishers had adhered to sustainable fisheries practices like limiting fishing boats and hours, seasoning, and use of the required mesh size but fish stocks continued to decline partly due to natural mortality as a result of increased drought (National Fisheries Research Institute, 2012) that led to the recession of water levels and drying of lacustrine wetlands; a habitat and spawning ground for fish (Natugonza et al., 2016). This implies that continuous drying of Lake Wamala wetlands is threatening wetland resources and livelihoods (Figure 10) which is likely to amplify food and water shortages (USAID, 2012).

Climate Variability and Wetland Resources

The study investigated and found out that climate variability has directly and indirectly affected wetland resources such as swampy plants and vegetation, water and soils through creating hard swamp beds and reducing water levels (Figure 11) (see appendix 15). This is consistent with community based studies around Lake Wamala that acknowledge that the continuous drying of Lake Wamala shores has affected the extent of lacustrine swamps (Okaronon, 1989). Though some studies on the general impacts of climate change on wetland resources are ambiguous (FAO, 1990), substantial evidence and case studies especially in Uganda validate that there is incriminating evidence at both spatial and temporal scales that climate variability has affected wetland cover and resources (Uganda Wetlands Atlas, 2016). About ¾ of the total wetland cover in Uganda is secondary as it has been degraded (Allison and Ellis, 2007). Recent research studies highlight most agro-ecological zones in Uganda such as Lake Victoria crescent have experienced losses in wetland cover due to seasonal climate variation from 1986-2011 (UBOS, 2016). The reduction in wetland cover due to climate variation is slowly but steadily offsetting a livelihood crisis as there is increasing decline in wetland resources onto which poor coastal communities enormously rely on for subsistence food, employment and household income (Armitage et al., 2017).

Causes of Loss in Wetland Resources

The study highlights a sequence of anthropogenic and natural factors complement each other in accounting for the continuous loss of wetland resources around Lake Wamala especially in Nkonya (Figure 11). This analysis is somewhat inconsistent with some of the historical global research findings; for instance, Environmental Alert (2010) summarily concludes that coastal ecosystem degradation and loss is solely due to human induced factors and activities. This subjective analysis is partly due to the fact that most pre-1990 discarded environmental determinism in influencing human activities. In addition, some climate related reports that gave subjective predictions on the magnitude and intensity of climate vagaries on coastal ecosystems despite a reversing trend today (Harley et al., 2006). Recent studies are consistent with research findings around Lake Wamala with evidence in Naama where 3% of respondents attribute drought and low rainfall as the causes of wetland loss. Armitage et al., (2017) explains that physical alterations in coastal ecosystems are environmentally and human induced. Increased temperatures for instance, have triggered natural wetland fires causing natural degradation as well as droughts reducing water availability, exposing swamp soils and affected fish and other micro-swamp organisms (Turyahabwe et al., 2013). Several research findings in Uganda concur that the main cause of wetland resource loss is increased subsistence farming. Increased subsistence farming is attributed largely to increasing population skyrocketing the demand for wetland resources (Natugonza et al., 2016).

The study highlights the main cause of loss of wetland resources in sampled areas like Mityana with 5% population explosion consistent with analysis and conclusion of most studies in developing world and Lake Wamala in particular. The Uganda Wetland Atlas (2016) indicates growing population as the main driving force accounting for wetland encroachment and loss. Local communities seek for 'free' land for settlement, small scale farming among untapped and abundant resources on wetlands such as fuel wood, papyrus, clay and sand which are essential to livelihoods in fringe communities (Goulden, 2006).

Risks Associated with Illicit Wetland Resource Degradation and Loss

Findings showed that degradation of wetland resources were associated with multiple risks at the micro level especially in Mityana with an effect of 22% (Figure 11), the environment, threshold areas and their livelihoods such as farming, fishing and related activities. This finding is consistent with existing literature on projected and real impacts of climate change on ecosystems and livelihoods. Globally, loss of coastal wetlands has increased the vulnerability of coastal ecosystems to adverse impacts of climate change. Therefore, likely to offset livelihood conflicts amongst local communities (Armitage et al., 2017). Ecosystem goods and services such as carbon sequestration and regulation, nutrient cycling, and raw materials are continuously reducing (Harley et al, 2006). On a local scale, degradation of wetlands are accelerating silting with associated adverse impacts such as declining water levels and quality (Uganda Wetland Atlas, 2016:10). This has affected fish spawning, swamp, and biodiversity where local people in the case of Nkonya derive their livelihood. This partly accounts for increased poverty amongst coastal communities in Uganda (UBOS, 2016). For instance, the recession of Lake Wamala wetlands has led to reduced fish productivity and stocks from 5,600 tons in 2010 to 4,590 tons in 2014 (Uganda Wetland Atlas, 2016). The emergence of new shorelines has accelerated natural resource and land use conflicts due to scramble for new lands for farming and grazing (UBOS, 2016).

The study points out 30% of people in local communities are at great risk of decline in livelihoods especially amongst rural communities along Lake Wamala such as Buzibazi (Figure 11). This perceived risk is within the precincts of global and national scientific and vulnerability reports. Twinomugisha (2005) explains that climate change and wetland loss have adversely impacted on people's health. The prevalence of some health hazards like malaria has increased with increasing temperatures (appendix 17) as well as a decline in natural edible resources has led to malnutrition.

CONCLUSIONS

Findings and experience from the study area reflect a paradox between wetland resources, coastal commons and state of livelihoods in the face of climate change. It can be concluded that;

The perception of local people to climate variability opens up a red-light on the status of Lake Wamala as a typical hotspot for exploring impacts of climate change on changing coastal wetlands. Increasing temperature and changes in rainfall patterns are directly affecting lake depth, soils and water levels hence disrupting the hydrological pattern of the lake. Moreover, the derailing natures of wetland resources have had detrimental impacts on livelihoods. This trend could sprawl coastal communities' land use and natural resource conflicts. The study also availed data showing both anthropogenic factors through increasing population and demand for wetland resources as well as natural factors account for loss in wetland resources. This trend has increased vulnerability of local people through reduction of resources that sustain their livelihoods. Based on research findings, the study wish to propose prudent measures such as formulation of feasible and target-oriented policy framework, aimed at governing and regulating activities in the area. Other measures like co-management through stakeholder involvement and participation, capacity-building programs among relevant stakeholders to enhance awareness about wetlands and its ecological benefits. Going forward, subsequent studies could delve into cost benefit analysis on conservation of wetland resources in the area and other development parameters.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

REFERENCES

Allison E, Ellis F, (2007). Enhancing the resilience of inland fisheries and aquaculture systems to climate change. J. of Semi-Arid Trop. Agricu. Res, 4(1): 10–14.

Armitage D, Charles A, Berkes F (2017). Governing the Coastal Commons: Communities, Resilience and Transformation. Community Conser. Res. Net. Earthscan from Routledge1:15–50. Retrieved from http://www.routledge.com/governing-the-coastal-commons-communities-resilience-and-transformation/Armitage-Charles-Berkes/p/book/9781138918436. Crossref

Clair TA, Warner BG, Roberts R, Murkin H (1997). Impacts of climate change to inland wetlands: a Canadian *perspective.*University of Waterloo, Waterloo, Ontario 7 (1): 1-645

Day JW, Narra, J, Kemp, GP, Ko, JY, (2005). Implications of Global Climatic Change and energy cost and availability for the restoration of the Mississippi Delta. Ecol Eng, 24: 253–265.Crossref

Environmental Alert. (2010). Climate Change in Uganda: Insights for Long Term Adaptation and Building Community Resilience. Kampala, Uganda.

Erwin LK (2009). Wetlands and Global Climate Change: the role of wetland restoration in a changing world. Wetlands Eco. and Manag, 17: 71–84.Crossref

FAO, (1990). The Mismanagement of Lake Wamala's Fish Resources. Rome, Italy.

Global Nature Fund. (2013). Living Lakes, National Networks, Wamala; Business and Biodiversity Campaign. Network E. Af: 2–4.

GoU (2008). Climate Change: Uganda National Adaptation Program for Action (NAPA). http://unfccc.int/resource/docs/napa/uga01.pdf. Accessed on 20th May, 2018.

Goulden M (2006). Livelihood diversification, social capital and resilience to climate variability among natural resource dependent societies in Uganda. Univ. of East Anglia, UK.

Gu LX, Wu, CN, Pu HM, Nan N, Wu JL, Guo R (2010). Ecosystem Services value of wetland in Suzhou, Taihu Lake. Eco. Econ., 6 (1): 349- 355.

Harley GDC, Miner GKM (2006). The impacts of climate change in coastal marine systems. Ecol. Lett, 9: 228–241.Crossref

Howe P, Leiserrowitz A (2013). Who remembers a hot summer or a cold winter? The assymetric effect of beliefs about global warming on perceptions of local climate conditions in the US. Global Env. Ch, 10(105): 23–26.Crossref

Hulme PE (2005). Adapting to climate change: is there scope for ecological management in the face of a global threat? Appl Ecol, 42: 784–794.Crossref

IPCC, (2014). Summary for Policy Makers; Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. New York, USA.

Kimbowa R, Kaganga J (2011). Adaptation through local institutions: A Case study of local initiatives around Lake Wamala basin (Uganda). International Course on Climate Change Adaptation (CCA) in Agriculture and Natural Resources Management. Agricultural Edu. Cen., Makerere Uni.

Lamptey MA, Ofori-Danson PK (2014).The status of fish diversity and fisheries of the Keta lagoon, Ghana, West Africa._Ghana J . Agric. Sci. 54(1): 3-18.

Mubiru D, Agona A, Komutunga E (2009). Microlevel analysis of seasonal trends, farmer's perception of climate change and adaptation strategies in Eastern Uganda. Seasonality revisited. Institute of Dev. Stds 8: 25.

Musinguzi L, Efitre J, Odongkara K, Ogutu-Ohwayo RMF (2016). Fishers' Perceptions of Climate Change Impacts on their Livelihood and Adaptation strategies in environmental change hotspots: A Case of Lake Wamala. Environment, Dev. and Sust, 18(4): 1255–1273.Crossref

NaFIRRI/NARO, (2016). Final Report of the Fisheries catch assessment survey conducted in December 2015 and December 2013 on the Ugandan waters of Lake Victoria. National F. Res.Ins. 2: 1-30

National Fisheries Research Institute, (2012). Report of Lake Wamala Fisheries Frame Survey. Fish Stock Assessment Team, Jinja, Uganda: 1-21. Retrieved from: http://aquaticcommons.org/20447/1/Lake%20Wamala%20Frame%20survey%20Report%202012.pdf

National Wetlands Program. (2008). The status of wetlands in Mubende district. Kampala, Uganda. Retrieved fromhttps://www.mwe.go.ug/sites/default/files/Uganda%20Wetlands%20Atlas%20Volume%20II_Popular%20Version.pdf. Accessed on October 14th, 2018

Natugonza V, Ogutu-Ohwayo REJ (2015). The responses of Nile Tilapia (Linnaeus, 1758) in Lake Wamala (Uganda) to changing climatic conditions. Lakes and Reservoirs: Res. and Manag., 20(10): 101–119. Crossref

Naylor RL, Goldburg RJ, Primavera, JH, Kautsky N, Beveridge MC, Clay J, Troell M (2000). Effect of aquaculture on world fish supplies. Springer Nature, 405(6790): 1017 - 1024.Crossref

NEMA, (2013). State of the Environment Report: Draft guidelines for solid waste. Kampala, Uganda.

Okaronon J (1989). Development and management of fisheries in small water bodies in Uganda with particular reference to Lake Wamala. FAO Fis. Report. 425: 175–190.

Olaoye OJ, Idowu AA, Omoyinmi GAK, Akintayo IA, Odebiyi OC, Fasina AO (2012). Socio-Economic Analysis of Artisanal Fisher Folks in Ogun Water-Side Local Government Areas of Ogun State, Nigeria. Global J. of Sci.Front.Res. Agricul.and Biol, 12(2): 4–10.

Sarfo I, Yiadom MB, Dontoh JI, (2019). Concept of Climate Vulnerability: Key Determinants, Responses and Constraints to Climate Change Adaptation. Advances in Soc. Sci. Res. J. 6(2):232-253. Crossref

Sewagudde S (2009). Lake Victoria's water budget and potential effects of climate change in the 21st Century. African J. Trop. Hydro Fis.12: 22–30.Crossref

Turyahabwe N, Tumusiime DM, KW, (2013). Wetland Use/Cover Changes and Local Perceptions in Uganda. Sustainable Agric. Res., *2*(4): 95–105. Crossref

Twinomugisha B (2005). A Content Analysis Report on Climate Change, Vulnerability and Adaptation in Uganda. Kampala, Uganda.

UBOS, (2016). Integrating Gender into National Agricultural Surveys: 6th Global Forum on Gender Statistics measuring women's engagement in Agriculture. Kampala, Uganda. Retrieved from http://www.ubos.org17.

Uganda Wetlands Atlas. (2016). UN Uganda Wetland Atlas; Popular Version 2.0: 1-48

UNDP, UNEP, (2009). Enhancing Wetlands' Contribution to Growth, Employment and Prosperity: Env. and Nat. Res. Report Series. Kampala, Uganda.

USAID, (2012). A Climate Trend Analysis of Uganda: Famine Early Warning Systems Network-Informing Climate Change Adaptation Series.

USAID, (2014). Uganda Climate Change Vulnerability Assessment Report. Pennsylvania Av, Washington DC. Washington DC.

Wheeler SA, Bjornlund H (2013). Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. Global Enviro. Chan, 23: 537–547. Crossref

Williams JD, Dodd Jr CK, (1978).Importance of wetlands to endangered and threatened species. Wetland Functions and Values: The State of Our Understanding. American W. Res. Assoc: 565-575.

WMD, (2009). Mapping a better future: How spatial analysis can benefit Wetlands and reduce poverty in

Uganda. Wetlands Management Department, Min. of Wat. and Env, Kampala, Uganda.

Appendix 1. Annual minimum and maximum Temperatures (^0C) extracted from Mubende Station, data from 1990-2012

Year	Maximum Temperature	Minimum Temperature	Average Temperature
1990	27.8	16.4	22.1
1991	28.0	16.3	22.1
1992	28.8	15.5	22.2
1993	28.7	15.8	22.3
1994	28.3	16.2	22.3
1995	28.5	15.7	22.1
1996	28.0	15.8	21.9
1997	28.3	15.3	21.8
1998	28.2	15.8	22.0
1999	27.7	15.3	21.6
2000	27.7	15.5	21.7
2001	27.8	15.8	21.8
2002	28.6	15.8	22.2
2003	28.4	16.0	22.2
2004	28.5	15.8	22.1
2005	29.3	16.0	22.7
2006	28.5	16.2	22.3
2007	28.5	16.3	22.4
2008	28.4	15.9	22.2
2009	28.0	17.8	22.5
2010	29.0	16.6	22.8
2011	29.1	16.1	22.6
2012	28.5	17.6	22.8

Appendix 2. Annual Rainfall pattern (mm) recorded at Mubende Weather Station around Lake Wamala, 1990-2011

Year	Rainfall Amount	Year	Rainfall Amount
1990	1276.7	2001	1416
1991	988.7	2002	1354.6
1992	1040.3	2003	1460.3
1993	1016	2004	1087.8
1994	1205.8	2005	969.41
1995	1249.6	2006	1230.5
1996	1200.9	2007	1187.2
1997	1711.6	2008	1039.9
1998	1433.1	2009	1335
1999	1166.4	2010	1326.9
2000	1294.4	2011	1294.5

Source: Uganda National Meteorological Authority, Entebbe, Uganda

Appendix 3. Monthly Average Rainfall (mm) for Mubende Weather Station near Lake Wamala, 1990-2012

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average Rainfall	51.76	52.91	122.6	130.2	146.6	54.82	54.1	88.9	117.9	145.1	145.7	85.8

Appendix 4. Decadal average temperature (OC) from Mubende Station around Lake Wamala, 1990-2012

1990-1999	2000-2012
22.1125	21.40174
22.19583	21.85292
22.20833	22.24871
22.30417	22.24217
22.31326	22.18275
22.1902	22.70417
21.90849	22.32273
21.85923	22.47926
22.02537	22.21777
21.56863	22.55833

Appendix 5. Historical Monthly Temperature (OC) variations for Mityana District

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average	21.7	21.8	21.8	21.4	21.2	20.6	20.1	20.5	20.9	21.3	21.4	21.5
Minimum	15.4	15.6	16.1	16.3	16.2	15.3	14.6	14.9	15.2	15.8	15.9	15.8
Maximum	28	28.1	27.6	26.6	26.2	26	25.7	26.1	26.6	26.8	26.9	27.1

Source: Uganda Meteorological Authority; Mityana District Historical Precipitation Data (2006-2016)

Appendix 6. Annual mean minimum and mean maximum temperature anomalies (OC) time series analysis for Mubende weather station near Lake Wamala 1990-2012

Year	Mean Maximum Temperature Anomaly	Mean Minimum Temperature Anomaly
1990	-0.4495	0.4292
1991	-0.2162	0.3625
1992	0.6005	-0.4291
1993	0.4755	-0.1125
1994	0.0903	0.2909
1995	0.3234	-0.1883
1996	-0.2479	-0.1804
1997	0.1247	-0.6516
1998	-8.16E-03	-0.1865
1999	-0.5018	-0.6063
2000	-0.9793	-0.4626
2001	-0.414	-0.1255
2002	0.3951	-0.143
2003	0.2077	0.0313
2004	0.3002	-0.18
2005	1.1338	0.0292
2006	0.2255	0.2209
2007	0.3398	0.3733
2008	0.2183	-0.0282
2009	-1.0329	1.9042
2010	0.7088	0.7292
2011	0.9171	0.2875
2012	-0.2412	1.6292

Appendix 7. Annual average rainfall anomalies (mm) and Standard Precipitation Indexes (SPI) for Mubende Weather Station near Lake Wamala from 1990-2012

Year	Rainfall anomaly (mm)	SPI
1990	99.016	0.5231
1991	-188.98	-0.9983
1992	-137.38	-0.7257
1993	-161.68	-0.8541
1994	28.116	-0.1485
1995	71.916	0.3799
1996	23.216	0.1226
1997	203.516	1.0751
1998	55.316	0.2922
1999	-11.284	-0.0596
2000	116.716	0.6166
2001	238.316	1.2589
2002	176.916	0.9346
2003	282.616	1.4929
2004	-89.884	-0.4748
2005	-208.27	-1.1002
2006	52.816	0.279
2007	9.516	0.0503
2008	-137.78	-0.7278
2009	157.316	0.831
2010	286.516	1.5135
2011	116.816	0.6171
2012	234.016	1.2362

Appendix 8. Annual minimum and maximum Temperatures (^{0}C) extracted from Mubende Station, data from 1990-2012

Year	Maximum Temperature	Minimum Temperature	Average Temperature
1990	27.8	16.4	22.1
1991	28.0	16.3	22.1
1992	28.8	15.5	22.2
1993	28.7	15.8	22.3
1994	28.3	16.2	22.3
1995	28.5	15.7	22.1
1996	28.0	15.8	21.9
1997	28.3	15.3	21.8
1998	28.2	15.8	22.0
1999	27.7	15.3	21.6
2000	27.7	15.5	21.7
2001	27.8	15.8	21.8
2002	28.6	15.8	22.2
2003	28.4	16.0	22.2
2004	28.5	15.8	22.1
2005	29.3	16.0	22.7
2006	28.5	16.2	22.3
2007	28.5	16.3	22.4
2008	28.4	15.9	22.2
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1996	1200.9	2007	1187.2
1997	1711.6	2008	1039.9
1998	1433.1	2009	1335
1999	1166.4	2010	1326.9
2000	1294.4	2011	1294.5

Source: Uganda National Meteorological Authority, Entebbe, Uganda

Appendix 10. Monthly Average Rainfall (mm) for Mubende Weather Station near Lake Wamala, 1990-2012

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average Rainfall	51.76	52.91	122.6	130.2	146.6	54.82	54.1	88.9	117.9	145.1	145.7	85.8

Appendix 11. Decadal average temperature (OC) from Mubende Station around Lake Wamala, 1990-2012

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22.1902	22.70417
21.90849	22.32273
21.85923	22.47926
22.02537	22.21777
21.56863	22.55833

Appendix 12. Historical Monthly Temperature (OC) variations for Mityana District

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average	21.7	21.8	21.8	21.4	21.2	20.6	20.1	20.5	20.9	21.3	21.4	21.5
Minimum	15.4	15.6	16.1	16.3	16.2	15.3	14.6	14.9	15.2	15.8	15.9	15.8
Maximum	28	28.1	27.6	26.6	26.2	26	25.7	26.1	26.6	26.8	26.9	27.1

Source: Uganda Meteorological Authority; Mityana District Historical Precipitation Data (2006-2016)

Appendix 13. Annual mean minimum and mean maximum temperature anomalies (OC) time series analysis for Mubende weather station near Lake Wamala 1990-2012

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1995	0.3234	-0.1883
1996	-0.2479	-0.1804
1997	0.1247	-0.6516
1998	-8.16E-03	-0.1865
1999	-0.5018	-0.6063
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2001	-0.414	-0.1255
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2005	1.1338	0.0292
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2010	0.7088	0.7292
2011	0.9171	0.2875
2012	-0.2412	1.6292

Appendix 14. Annual average rainfall anomalies (mm) and Standard Precipitation Indexes (SPI) for Mubende Weather Station near Lake Wamala from 1990-2012

Year	Rainfall anomaly (mm)	SPI
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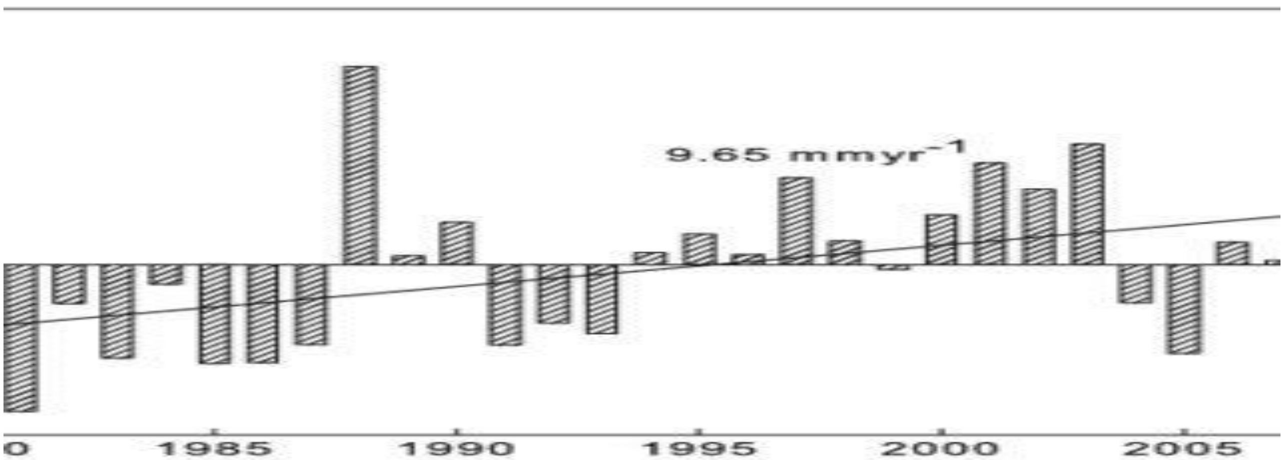
1995	71.916	0.3799
1996	23.216	0.1226
1997	203.516	1.0751
1998	55.316	0.2922
1999	-11.284	-0.0596
2000	116.716	0.6166
2001	238.316	1.2589
2002	176.916	0.9346
2003	282.616	1.4929
2004	-89.884	-0.4748
2005	-208.27	-1.1002
2006	52.816	0.279
2007	9.516	0.0503
2008	-137.78	-0.7278
2009	157.316	0.831
2010	286.516	1.5135
2011	116.816	0.6171
2012	234.016	1.2362

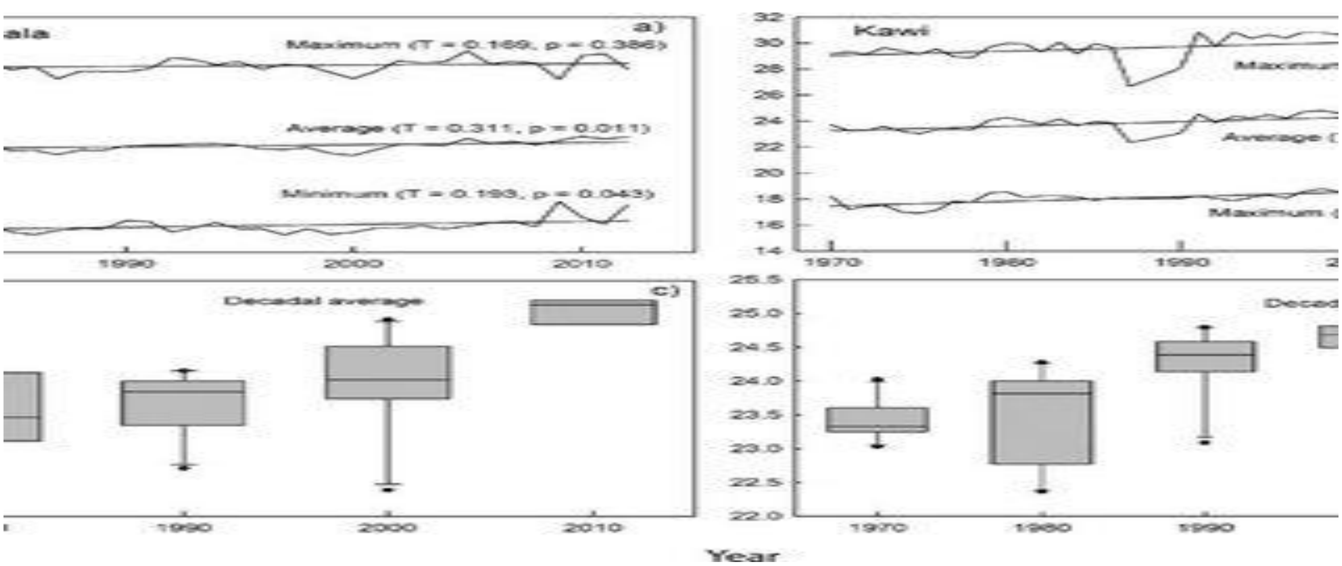
Appendix 15. Climate variability on wetland resources (Negative impact on wetland resources)

Resource	Proportion of impact (%)
Swamp plants and fruits	36%
Water	25%
Fertile soils	17%
Wetland birds	12%
Sand	10%
Total	100%

Appendix 16. Annual Rainfall Trends and Anomalies around Lake Wamala



Appendix 17. Inter-decadal variations in temperature around Lake Wamala



Source: National Meteorological Station, Mubende