

Full Length Research Paper

A community perspective of flood occurrence and weather forecasting over Kampala City

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Weather and climate issues have become increasingly recognized among the global challenges especially in the era of climate change. Kampala city has faced a number of flooding events in the past that have led to serious damages in many low lying areas of the city. A study was conducted in one of the flood prone areas in Kampala city to understand the community perspectives on flood occurrence and weather forecasting in the area. The main objective was to understand community perceptions on flood occurrence as well as use of weather information for early warning. Data was collected from 400 respondents using a structured questionnaire as well as focused group discussions. Results from the survey revealed that 99.8% of the respondents reported rainfall intensities to have increased in the last 5 years and as a result, 96% of these respondents stated floods as the main climate risk in the area. The most common impacts of floods in the community included loss of property, lack of safe and clean water and disease outbreaks among others. In response to floods, the community identified use of raised tables or stands and use of stones in the compound as the main coping mechanisms employed in the community. In terms of weather alerts, only 22% of respondents reported receiving the weather alerts issued by the Uganda National Meteorological Authority (UNMA). Of those who receive the alerts, 91% hear the information mainly on television. Therefore, the study proposes strengthening of collaboration between UNMA and the local leaders through the Kampala Capital City Authority (KCCA) for provision of earlier weather forecasts that help reduce the negative flood impacts among communities.

Key words: Weather alerts, flood forecasting, changing climate and community perspectives.

INTRODUCTION

Weather and climate are key environmental challenges especially in the developing countries that depend on

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natural resources for most of their economic activities (Noack et al., 2019; Foster and Brozovic, 2018). For example, Uganda is dependent on agriculture that is mainly rain fed contributing 22% to the total GDP and employs 78% of the total population (UBOS, 2019). With the increasing irregularity and unpredictability of seasonal rainfall, rural communities that depend on rain fed agriculture are vulnerable to climatic hazards such as droughts and floods (Noack et al., 2019; Ogwang et al., 2016). These normally lead to crop failures and thus exacerbating food insecurity and famine. Therefore availability of timely climate information for communities to make better farming decisions is pivotal in insulating them from climatic vagaries.

Meteorological information, especially weather and climate forecasts, is essential in planning not only agricultural production activities but also business related activities especially for city dwellers (Jordan, 2020; Osuret et al., 2016). For instance, the following decisions should not be made without knowing climatic conditions: land use and management, selecting plants and breeds of animals and crop production practices such as irrigation, pest and disease control and crop-weather relationships (Elias et al., 2019). The success and failure of agricultural farming is generally related to the prevailing weather conditions. Weather plays an important role in crop production from germination of a seed to the maturity of the crop (Foster and Brozovic, 2018). The timing of sowing of a given seed of a particular crop, transplanting, scheduling of irrigation water application, timing of fertilizer application, using of pesticides to control the diseases and pests of the crops should all be pegged on weather conditions of the area to maximize agricultural production (Guo et al., 2020; Foster and Brozovic, 2018).

The cities especially in the developing countries are equally affected by changes in weather and climate because their activities like sports, business and travel also depend on weather conditions (Ogwang et al., 2016; Jordan, 2020; Lu et al., 2020; Akampumuza and Matsuda, 2017). The weather changes are exacerbated by the planning challenges mainly due to poor drainage channels that normally induce flood during the rainy seasons (Kwiringira et al., 2016; Isunju et al., 2016). Over Kampala city, flooding events have been reported to be on an increase affecting the city dwellers (Twinomuhangi et al., 2021; Kiyengo et al., 2020; Sliuzas et al., 2017). Heavy rainfall events in the city usually led to increased traffic jams in the different parts of the city due to flooding on the major roads.

One of the critical factors in managing flooding is improved weather prediction. However, accurate quantitative rainfall prediction is often a challenge to national hydro meteorological services (Mugume et al.,

2016). So, for managing floods especially in Kampala city, improving the prediction of heavy rainfall is very important for the communities living in the city. This enables them to have sufficient early warning messages and be in position to implement early actions especially in the flood prone areas. The purpose of this study was mainly to understand the impacts of heavy rainfall that normally causes flooding in a flood prone area of Kampala city as well as understanding the dissemination of weather and climate information in the same community.

MATERIALS AND METHODS

Study area

Kampala city, located in the central region is the capital and largest city of Uganda. It is located on latitude 0.35°N and longitude 32.58°E. The city occupies an estimated area of 189 km² of which 176 km² is land area and 13 km² is water. The city is divided into five divisions; Makindye, Kawempe, Nakawa, Central and Rubaga (Figure 1). Generally, Kampala city has a bimodal rainfall regime with two major rainfall seasons of March to May (MAM) and September to November (SON). However, the city being closer to Lake Victoria receives rainfall in almost all months of the year due to land and Lake Breeze effects.

The study was conducted in the areas of Kyebando-Nsoba, Bwaise and Makerere III wards in Kawempe division, one of the flood prone divisions in Kampala City under the Kampala Capital City Authority (KCCA). The division was chosen because of the recurrent flooding events that have been observed in the area. In addition, the study areas are among the slums in Kampala City.

Selection of respondents

Household surveys (HHS)

The respondents were purposively selected from communities along the Kyebando-Lubigi channel because of their high vulnerability to floods in the division compared to other areas. A total of 400 respondents were sampled from four wards (100 households from each Ward) along the channel following guidance from the Environmental officer of Kawempe Division, Kampala Capital City Authority (KCCA) and local council chairpersons. Only residents who had been in the area for more than 5 years qualified to be interviewed.

Data collection

Both primary and secondary data were used in this study to understand community perspectives on floods and weather forecasting in the flood prone area of Kampala city.

Primary data

A questionnaire was designed to capture the community perceptions in relation to heavy rainfall (storms) and its impacts on their livelihoods. The questionnaire was pre-tested among 20

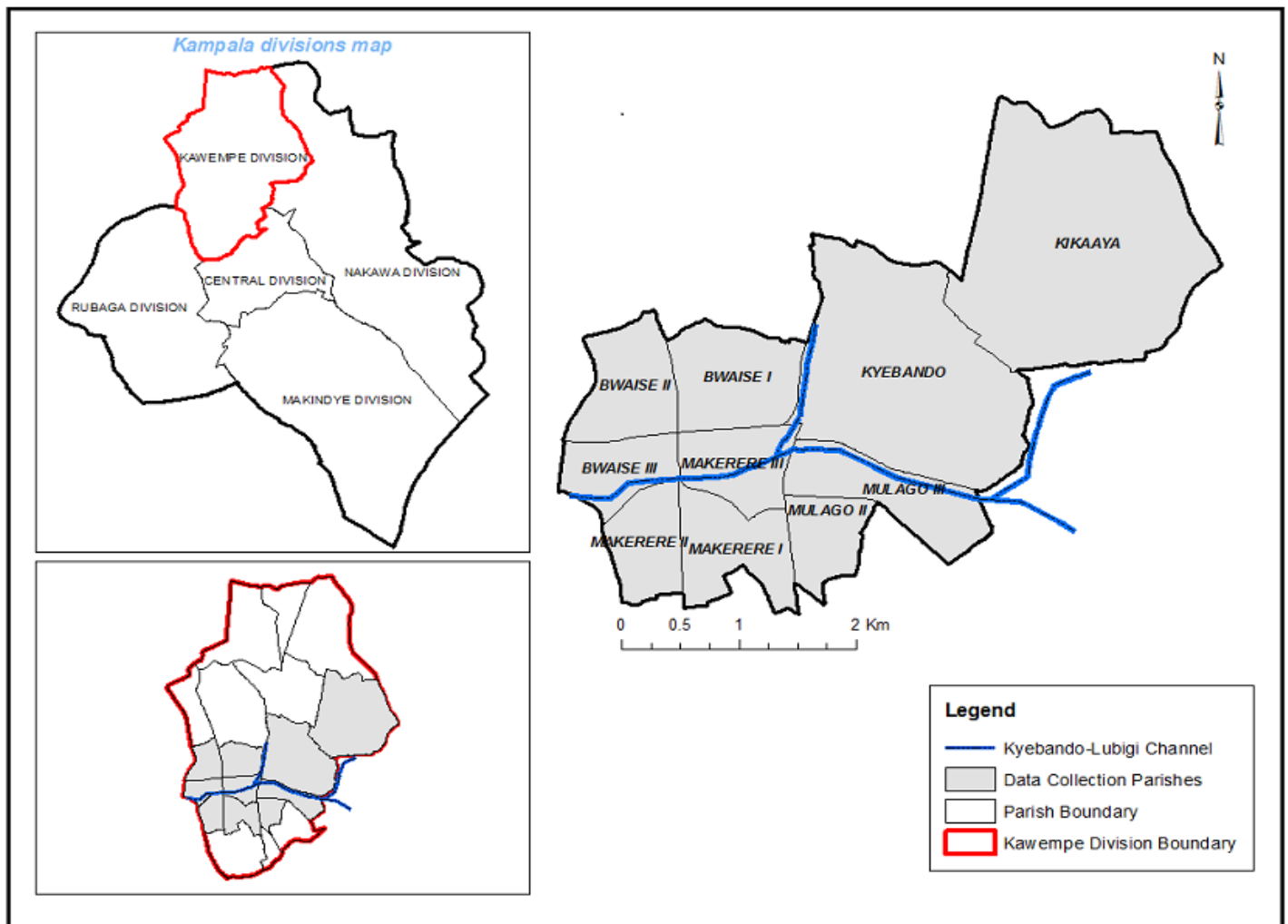


Figure 1. Study area map showing Kawempe division and the Kyebando – Lubigi Channel.

residents in Makerere III ward to confirm its reliability and validity before it was administered to the communities. In addition, four focus group discussions were conducted from both males and females in the same area to further understand the nature of the problem and also to explain the missing links from the household survey. Two focus groups consisted of mixed men and women while the other two consisted of males and females only respectively. The groups were chosen following the guidance of the local council chairpersons of people who had lived in the area for a period of at least five years.

Secondary data

This consisted of historical data mainly on rainfall from 1981 to 2019. Kampala synoptic weather station was selected mainly to understand the trends of extreme rainfall events at both seasonal and annual scales. This data was obtained from the Uganda

National Meteorological Authority in the Ministry of Water and Environment.

Data analysis

Primary data

The questionnaires from the Household Survey (HHS) were coded and results entered using epi-data software which was later exported to SPSS for further analysis. Graphs, and tables and cross tabulations of variables of specific interest are then presented for discussion.

Secondary data

The data was checked and quality controlled using WMO (1983)

Table 1. The respondent's characteristics.

| Variable | Frequency (n=400) | % |
|------------------------|-------------------|------|
| Gender | | |
| Male | 177 | 44.2 |
| Female | 223 | 55.8 |
| Age | | |
| 18-25 | 5 | 1.3 |
| 26-35 | 179 | 44.8 |
| 36-50 | 193 | 48.3 |
| Above 50 | 23 | 5.8 |
| Education level | | |
| None | 4 | 1.0 |
| Primary | 24 | 6.0 |
| Secondary | 339 | 84.8 |
| Tertiary | 33 | 8.3 |
| Marital status | | |
| Single | 59 | 14.8 |
| Married | 285 | 71.3 |
| Divorced | 28 | 7.0 |
| Widowed | 28 | 7.0 |

guidelines. Trend analysis on seasonal and annual extreme rainfall trends in the study area was then performed. Extreme rainfall considered here was daily rainfall greater than 20 mm (R20 mm) (ECTCD).

RESULTS

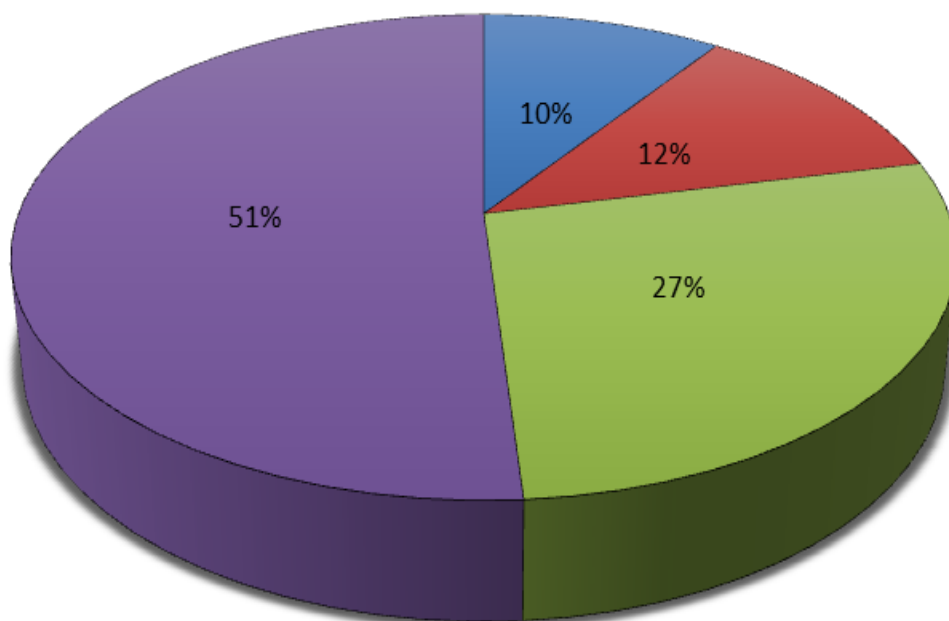
Bio data of the respondents

Table 1 shows the characteristics of the sampled respondents in terms of gender, age, education level and marital status. This is key to understanding their responses and how they adapt in various situations. From the survey, 55.8% were females and 44.2% were males. Whilst this may be attributed to the nature of the occupation of the residents in the area where males are always working outside their residences during the day to support their families, the study supports the narrative that women and children are more vulnerable to floods and storms. Over 98% of respondents were greater than 26 years who are expected to understand the impacts of floods in their communities since 2010 (ACPF, September 2013). 84% of the respondents completed secondary education which meant that they could easily respond to the given questions. However those who did

not understand English were interviewed through interpreters who were recruited from the communities. The education level is not surprising because this is a peri-urban and most people who come to live there have some formal education training compared to a rural setting (UBOS, 2017). Of the respondents, 71.3% were married compared to 14.7% that were single, 7% widowed and 7% divorced.

Length of stay in the area

Figure 2 shows the duration the respondents had resided in the area. It can be seen that 27% of the respondents interviewed have stayed in the area for more than 5 years (between 6 and 10 years) while 51% of the respondents had stayed in the area for more than 10 years. This serves to provide good information from the two categories of respondents whose length of stay in the area is long enough and very important in relation to information sharing pertaining to the impacts of floods and storms along the selected areas. It was considered that respondents who have stayed in the area for more than 5 years, that is, 78% (51% for over 10 years and



■ Less than 1 year ■ Between 1 and 5 Years ■ Between 6 and 10 Years ■ More than 10 years

Figure 2. Respondents' length of stay in the area.

27% for over 5 years) have a richer experience with the environment.

Changes in the rainfall amounts and intensity in the area over the last 10 years

From Figure 3, it is clearly seen that about 99.8% of the respondents interviewed agreed that they have observed changes in the rainfall amounts and intensity and only 0.2% of the respondents have not observed changes in rainfall amounts and intensity in the study areas for the last 10 years. The changes in rainfall amounts and intensities are attributed to changes in flood incidences that are occurring in Kawempe division since there are no proper channels that have been constructed to accommodate the flood waters. This was further confirmed in focus group discussions that captured the actual facts from the communities as reported by some members.

In the last years (before 2010), the rains were moderately received but for long hours compared to 2019 where it was heavily received for short hours. In 2017, there was more sunshine than rains contrary to 2019 where rain

has been too much. Also, rains of those days could prepare (okubindabinda), that is to say you would see the rainy clouds forming in the sky giving people notice and time to prepare, unlike these days where rains come abruptly.

Times of the day when they normally receive heavy rainfall events

From Figure 4, the areas usually receive heavy rainfall events in the afternoon (48%), the evening takes (34%), and night time (10%) and rarely in the early morning (8%). The biggest percentage of time, the day goes to afternoon since this is the time of the day when there is convective rainfall events that usually result in flooding events. It can be argued that these results, especially the timing, are expected as these areas experience the convective effects of Lake Victoria.

Rates of occurrence of floods within the seasons in the last 10 years (2010-2019)

From Figure 5, it is observed that floods occur mostly in

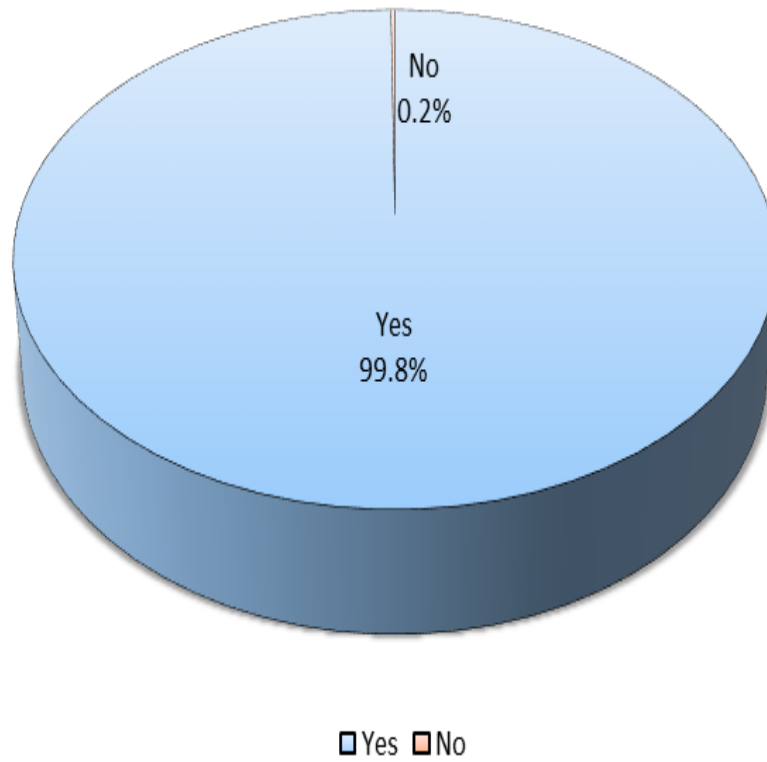


Figure 3. Perceptions on rainfall amounts and intensity.

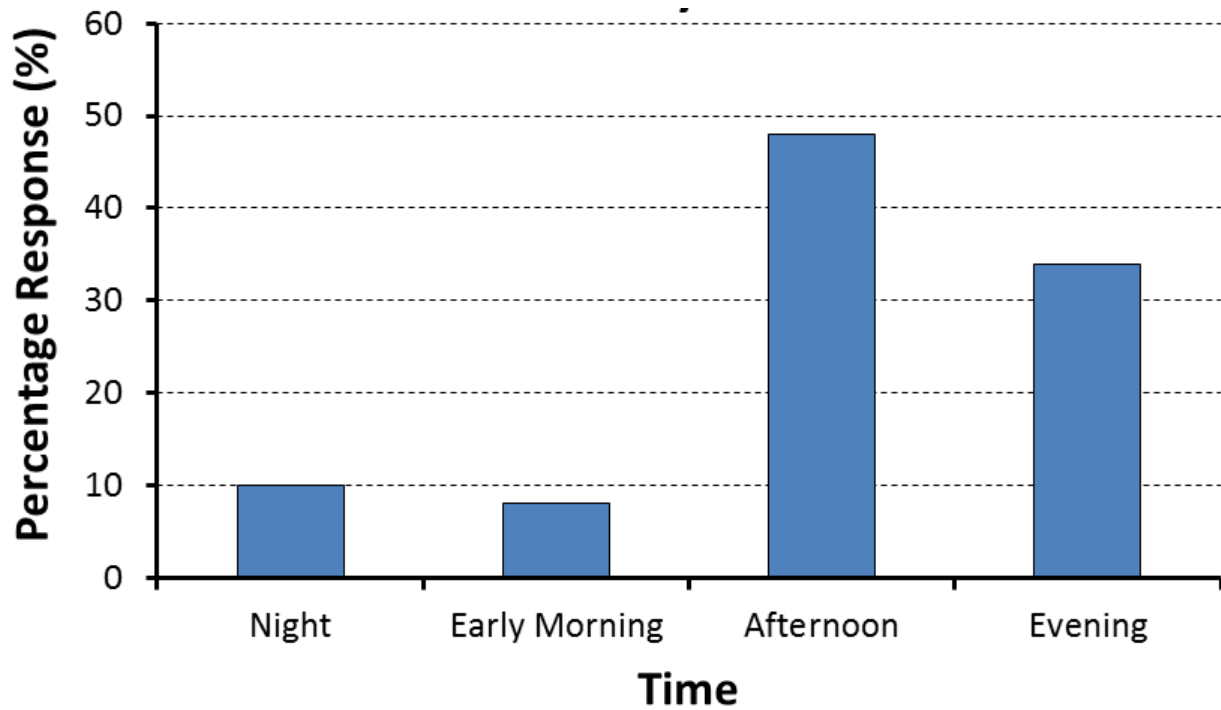


Figure 4. Time when heavy rainfall events are received.

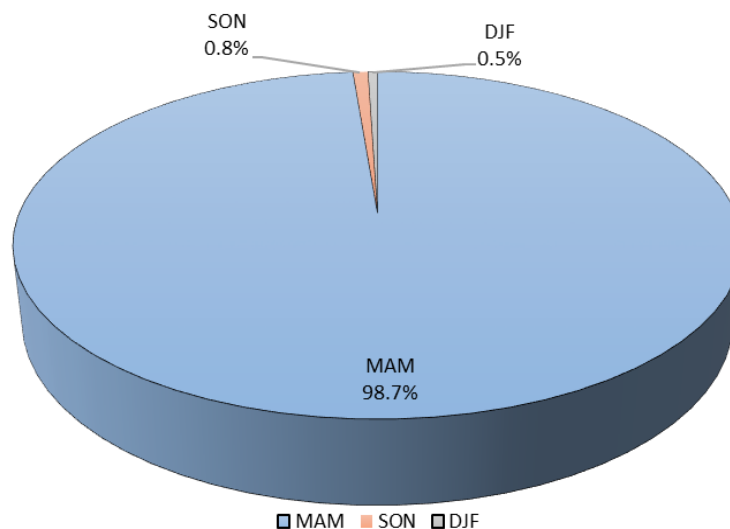


Figure 5. Seasonality occurrence of floods.

the MAM season (98.7%), followed by SON season (0.8%) and lastly in the DJF season (0.5%). Flood occurrence in the MAM season is attributed to the fact that it is long rainfall season experienced in the area. Analysis of secondary data from seasonal rainfall of Kampala weather station show that extreme rainfall (daily rainfall greater than 20 mm) has been increasing especially in the MAM season (Figure 6).

Climate risk event that has/have affected people most

The climatic risk events that affect the residents in the chosen study area are drought, floods and water related human diseases (Figure 7). With these climatic risk events, floods are ranked as number one with a percentage effect of 96%, followed by water related human disease and drought with the same ranking (2%). Floods are ranked number one as this is attributed to the heavy rainfall intensities received in the area and the informal settlement patterns of the local people who usually block the existing drainage channels of the flowing waters leading to enormous cases of floods.

Effects of floods on the community

From the Figure 8, loss of property (23.4%), lack of clean and safe water (22.1%) and disease outbreaks (17.6%) take the biggest percentage of the effects of floods, followed by, blockage of drainage systems (14.7%), loss

of lives (10.3%), children missing school (5.9%), increased traffic jam (4.4%) and others that mainly included reduced customers and increased crime activities. The high effects associated with floods are majorly attributed to the poor informal settings, heavy rainfalls and poor drainage systems in the area.

Coping strategies used by the local people

Table 2 shows the common coping mechanisms/strategies employed by the communities in the study area during heavy rainfall or flooding events.

Results from the coping strategies used by local community indicate that raised tables/stands takes the biggest percentage of about (32%), followed by use of stones in the compounds and use of soil bags (16%) while the least mechanism was scooping out water using basins (1%). Figure 9 shows these mechanisms have proved not to be sustainable during heavy floods, since they cannot withstand the strength of the flood waters; some have been reported to be expensive while others are time consuming and labour intensive, requiring a lot of energy like scooping out water from houses using basins. The communities were asked the challenges they face in trying to cope with the floods and mentioned the high cost of materials used for controlling floods as a major challenge since their level of incomes are very low to afford the purchase of the required materials. They also reported lack of modern technologies to control such floods and also having no alternative places to live in.

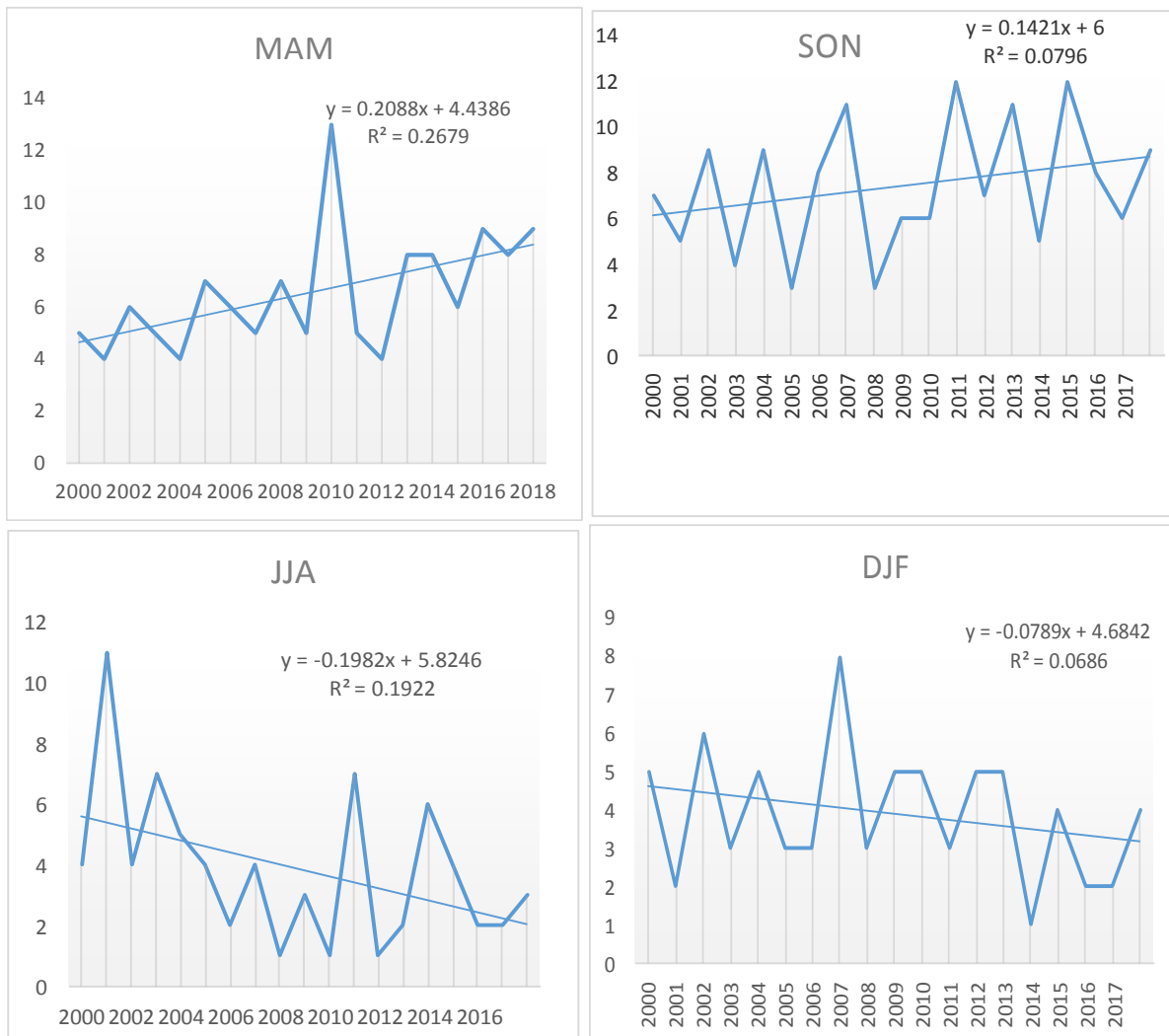


Figure 6. Trends in extreme rainfall over Kampala from 2000 to 2017 for the four seasons.

Reception of weather alerts

Respondents were also asked about receiving weather alerts regarding the forecasted heavy rainfall events that normally cause flooding. About 78% of the respondents interviewed have not been receiving weather alerts and forecasts in the last ten years while only 22% of the respondents have been receiving weather alerts and forecasts (Figure 10). This increases the vulnerability of the communities since they cannot plan based on the weather alerts. Of those who receive the alerts, 91% reported getting the messages through television, 5% normally through radio while others receive it from friends as well as social media (Figure 11). However, television

being the biggest source of weather information is not sustainable since it involves monthly subscription charges, monthly electricity bills, poor signal strength coupled with poor arrangement of programs where weather forecasts are usually given at the end of the news forcing some people to miss out on weather alerts and forecasts.

Challenges associated with weather alerts and forecasts

Survey results show that the biggest challenge associated with weather alerts and forecasts is that 63%

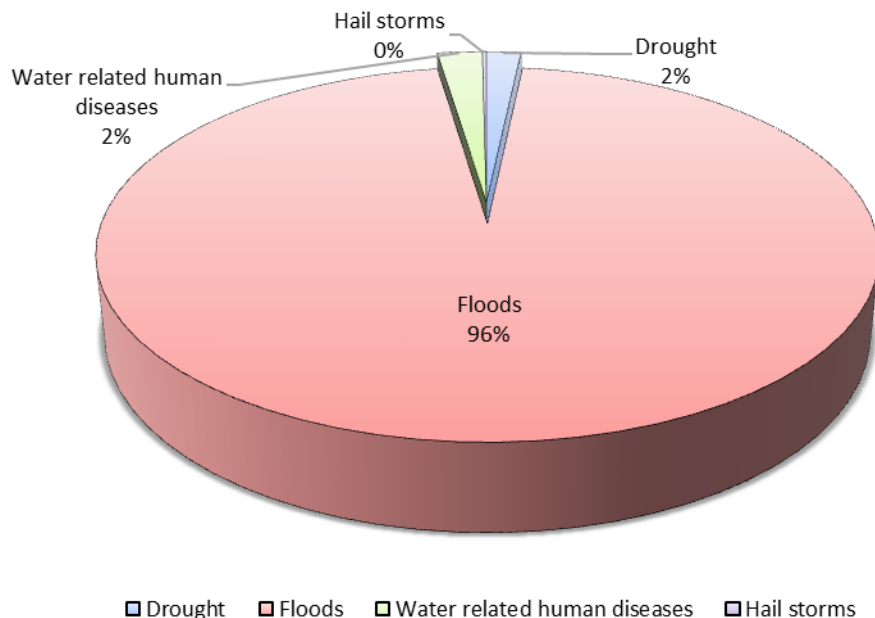


Figure 7. Climate risk event that affect the people.

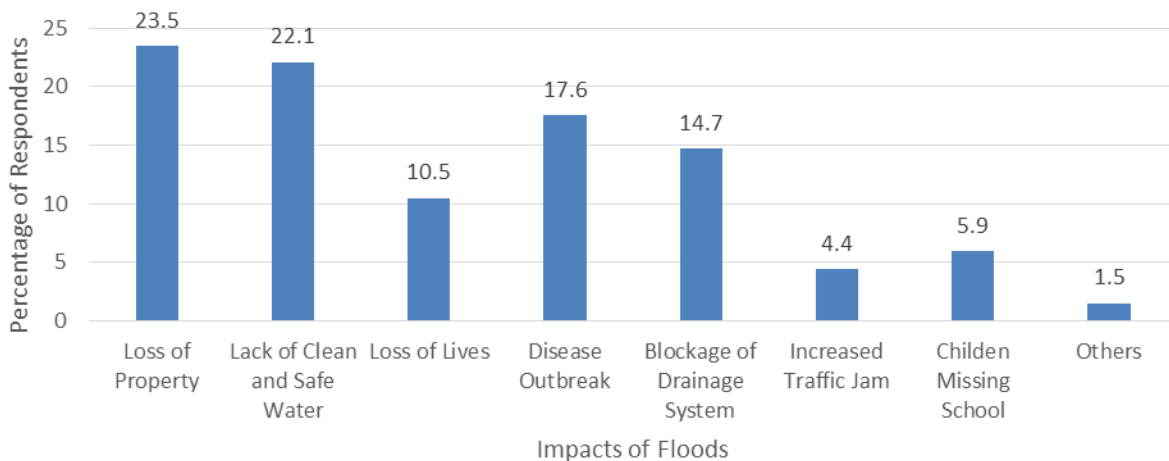


Figure 8. Effects of floods to surrounding communities.

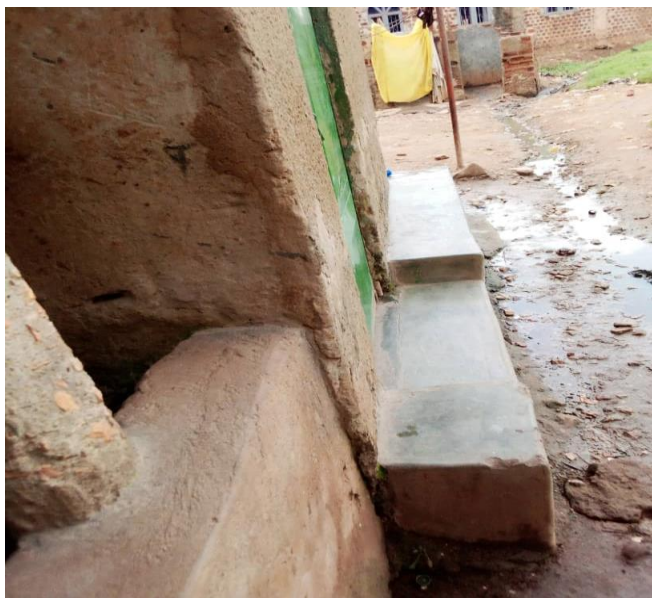
do not reach the communities in the study area, 17% are not broadcasted in time, 11% are not accurate and 9% are as a result of language barrier (Figure 12). This information obtained from the survey study portrays the level at which the people are missing out on weather alerts and forecasts. They reported that the most of these forecasts are always broadcasted in English which some of them do not comprehend easily and therefore they normally loose interest even when they know the

importance of such information.

Among the suggestions given by the community to improve access and use of weather information was to involve local leaders in the process of disseminating weather alerts and forecasts (37%), the use of local radio stations (26%), translating the alerts and forecasts in local languages (16%), use of social media (11%) and lastly that alerts should be disseminated in time (Table 3). Involving local leaders emerged the best alternative as

Table 2. Major coping strategies to flooding employed by the communities.

| Coping Strategy | Percentage of Respondents |
|---|----------------------------------|
| Using raised tables/ Stands at house entrance | 32 |
| Use of stones in the compound | 16 |
| Use of soil bags | 16 |
| Seek financial help | 11 |
| Building raised verandas | 7 |
| Leaving houses for some time | 4 |
| Unblocking trenches around the home | 2 |
| Rely on business | 2 |



(a)



(b)



(c)

Figure 9. Some of the coping strategies employed by the communities including (a) Raised stands at house entrance, (b) Raised veranda and (c) Use of soil bags.

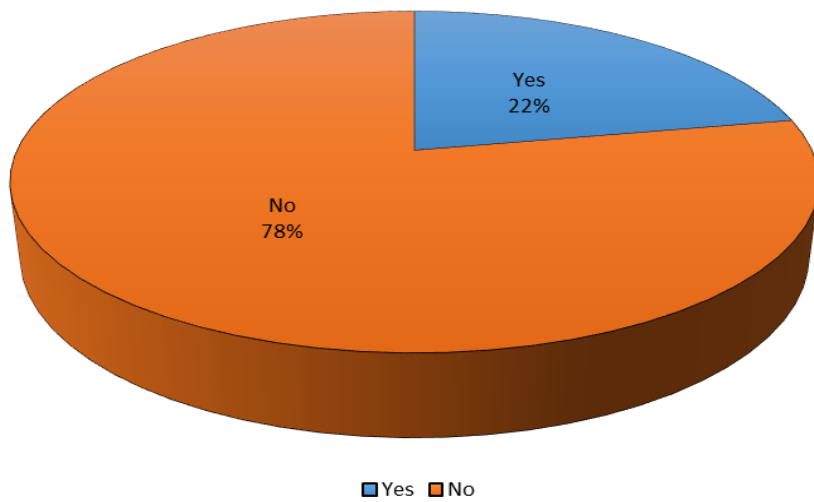


Figure 10. Reception of weather alerts.

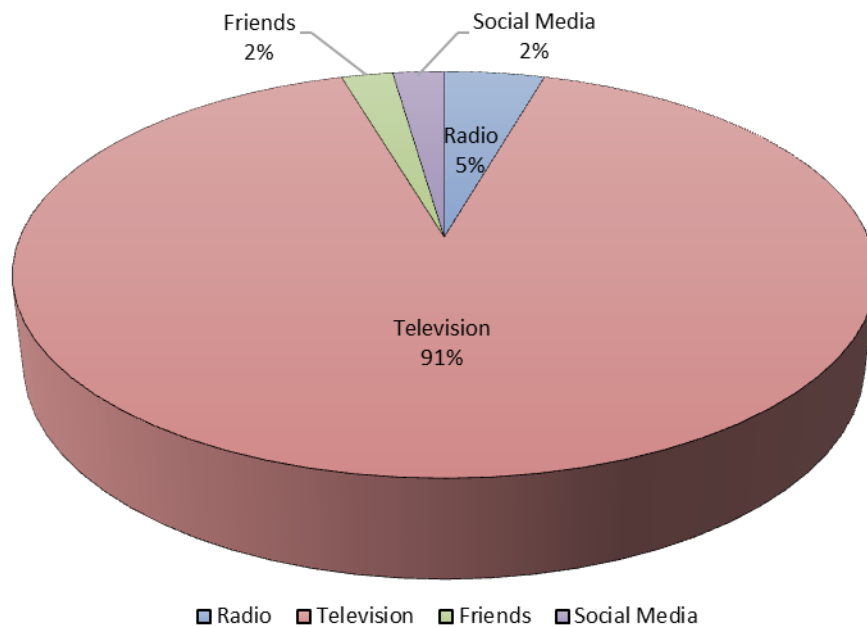


Figure 11. Sources of weather alerts and forecasts.

people think that these local leaders can easily and directly talk to them any time of the day and they are always with them.

DISCUSSION

Table 4 shows the perception of the various variables in

relation to the social demographic characteristics.

The perceptions to changes in rainfall (amount and intensity) were significantly associated to the respondent's level of education ($p = 0.011$) and membership ($p = 0.015$) (Table 4). For instance, the majority of the respondents who were aware of changes in rainfall had attained secondary and tertiary education (85 and 8.0%, respectively) and were members in the

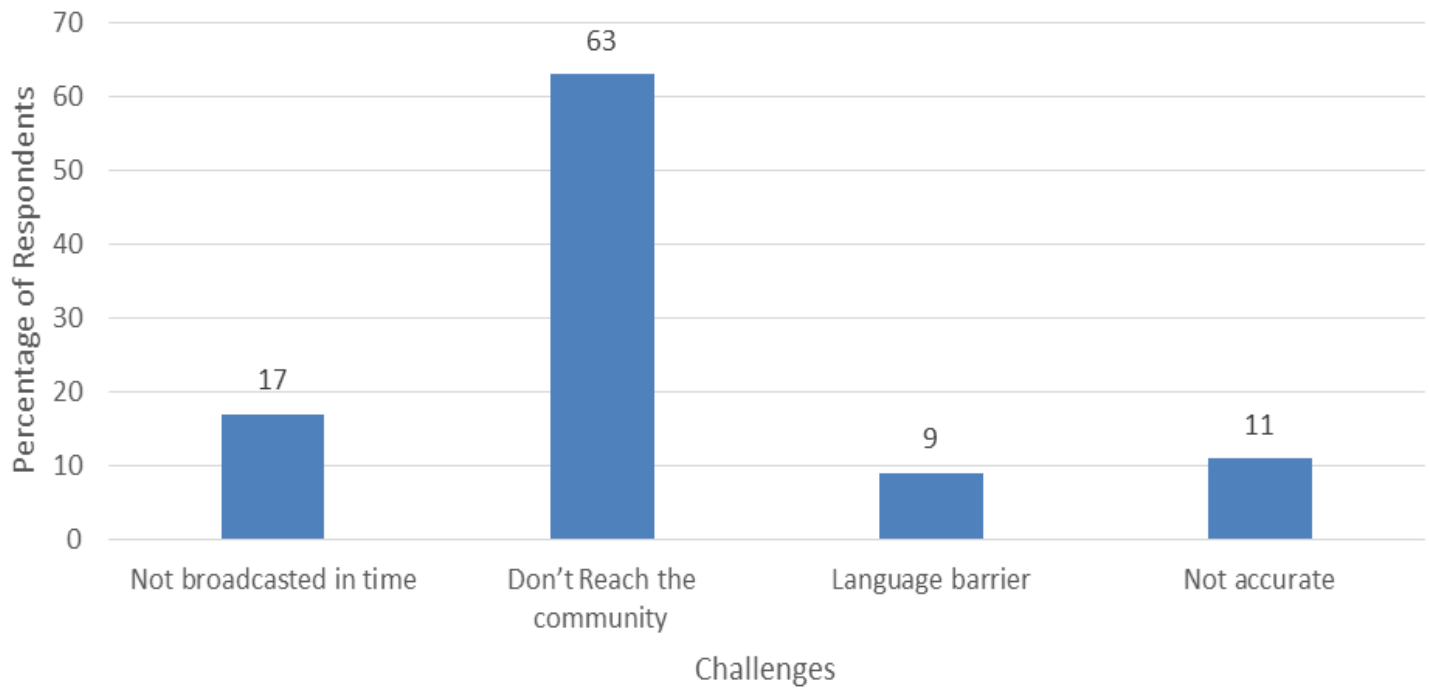


Figure 12. Challenges associated with weather alerts and forecast.

Table 3. Suggestions to improving the dissemination of weather forecasts and alerts.

| Suggestion | Percentage of respondents |
|------------------------------|---------------------------|
| Involving local leaders | 37 |
| Use of local radio stations | 26 |
| Translated in local language | 16 |
| Use of social media | 11 |
| Alerts given in time | 10 |

Table 4. Perceptions of flood occurrences in Kawempe division.

| Socio-demographic characteristics | Perceptions | | | | | | | | | | | |
|-----------------------------------|---|-----|--------|----------------------|-----|--------|-------------------|-----|--------|---|-----|--------|
| | Change in rainfall (amount and intensity) | | | Occurrence of floods | | | Effects of floods | | | Reception of weather forecasts and alerts | | |
| | X ² | df. | Sig. | X ² | df. | Sig. | X ² | df. | Sig. | X ² | df. | Sig. |
| Sex | 1.263 | 1 | 0.261 | 0.796 | 1 | 0.372 | 0.006 | 1 | 0.940 | 2.568 | 2 | 0.277 |
| Marital status | 0.405 | 3 | 0.939 | 0.405 | 3 | 0.939 | 2.299 | 3 | 0.513 | 6.675 | 6 | 0.352 |
| Age of respondent | 1.075 | 3 | 0.783 | 79.198 | 3 | 0.000* | 1.709 | 3 | 0.635 | 30.665 | 6 | 0.000* |
| Education level | 11.149 | 3 | 0.011* | 15.706 | 3 | 0.001* | 11.482 | 3 | 0.009* | 10.780 | 6 | 0.095 |
| House ownership | 0.474 | 3 | 0.925 | 0.474 | 3 | 0.925 | 0.546 | 3 | 0.909 | 4.610 | 6 | 0.595 |
| Membership | 5.962 | 1 | 0.015* | 0.169 | 1 | 0.681 | 4.685 | 1 | 0.030* | 1.051 | 2 | 0.591 |
| Length of stay in area | 7.508 | 3 | 0.057 | 7.508 | 3 | 0.057 | 2.891 | 3 | 0.409 | 93.374 | 6 | 0.000* |

*Significant at 95%.

different groups (14.2%). The perceptions on occurrence of floods were significantly associated to the respondent's age ($p = 0.000$) and level of education ($p = 0.001$). It should be noted that majority of the respondents who were aware of occurrence of floods fall in age group categories (36-50 and 26-35) (48.4 and 44.9%, respectively).

Effects of floods were significantly associated to respondent's level of education ($X^2=11.485$, d.f. =3, $p = 0.009$) and membership ($X^2= 4.685$, d.f. = 1, $p = 0.030$). Insights on the reception of weather forecasts and alerts were significantly associated to the respondent's age ($X^2=30.665$, d.f. =6, $p = 0.000$) and length of stay in an area ($X^2=93.374$, d.f. =6, $p = 0.000$). Results indicated that respondents who receive weather forecasts and alerts fall in age group categories (36-50 and 26-35 years) (56.5 and 40%, respectively) and while for the length of stay in an area, majority of the respondents had stayed in the area (more than ten years and less than one year) (48.2 and 30.6%) respectively.

Like many cities in sub-Saharan Africa, this study findings are in agreement with several studies indicating that Kampala city experiences recurrent floods that have occurred over years (Kiyengo et al., 2020; Osuret et al., 2016; Pérez-Molina et al., 2015). Coupled with population projections, climate change is also likely to worsen Kampala's flooding problems (Isunju et al., 2016; Sliuzas et al., 2017).

The study area is low lying and has a high water table, making it vulnerable as observed by Dimanin (2012) that floods are common in low lying areas mainly occupied by the urban poor and distracting their livelihoods (Shatkin, 2019). According to Isunju et al. (2016), occupation of flood-prone areas happens in dry seasons, among population that are always on the move hence the vulnerability. Empirical evidence similar to study findings suggest that extreme/intense rainfalls during the high peak MAM season result in high flooding (Jacobs et al., 2016). As such, the effects of floods reportedly include destruction of property, damage to houses, blockage of drainage channels, disease outbreaks and pollution of water sources. This is also in line with other previous studies which points out that floods have a negative impact on human health and livelihoods (Isunju et al., 2016).

In relation to coping strategies, similar ones have been adopted elsewhere; elevating the ground level before the construction of their houses, barriers in front of doors or small dyke around the house and small levee around drainage channels (Habonimana, 2014); filling the flooded parts of their houses with soil, building raised houses and clearing the drainage channels of soil and rubbish (Bagonza, 2014); use of indigenous knowledge in weather forecasting and preparedness (Osuret et al.,

2016). This is achieved partly because most of the community members in the area have attained at least a secondary level education (84.8%) which enables them to understand and apply the indigenous knowledge. Despite the above improvised strategies adopted, the communities are still vulnerable to flood events due to their income status and less capacity to cope more especially for the women who are the majority (55.8%) and are mainly engaged in informal livelihood strategies that are prone to flood events.

A study by Asfaw and Maggio (2018) suggest that weather shocks tend to negatively impact both husbands and wives though more on female headed households due to lack of access to productive resources and opportunities including land and credit (Akampumuza and Matsuda, 2017).

On the other hand, Bagonza (2014) argues that the coping capacity of the women and children is somehow enhanced by the agencies in charge of management of the flood hazard, in this case, Kampala Capital City Council Authority.

Conclusion

Floods were ranked as the highest climate risk events in the study area. This has been attributed to changes in rainfall amounts and intensity (extreme rainfall) and underlying human activities that affect the water channels. The heavy rainfalls mainly occur in the afternoon and evening especially in the MAM season. Consequentially, loss of property, lack of clean and safe water and disease outbreak are common impacts affecting the vulnerabilities of the poor urban men and women in the study. Whilst the communities have devised coping strategies, strengthening capabilities of these efforts is required. Since a small percentage of the respondents receive weather alerts, there is need for local leaders to be actively involved in dissemination of weather information as well as the use of local vernacular radio stations with translated weather information in their local language. The linkages between UNMA (producers of weather information) and KCCA staff that interact with communities at the grass roots should be strengthened for better use and uptake of weather information.

ABBREVIATIONS

DJF, December, January, February season; **ECTCD**, Expert Team on Climate Change Detection; **GDP**, Gross domestic product; **HHS**, Household survey; **JJA**, June, July, August season; **KCCA**, Kampala Capital City Authority; **MAM**, March, April, May season; **UBOS**,

Uganda Bureau of Statistics; **UNMA**, Uganda National Meteorology Authority; **WMO**, World Meteorological Organisation.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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