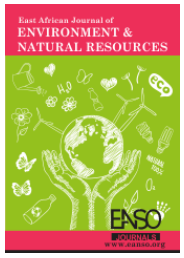
Article DOI: https://doi.org/10.37284/eajenr.5.1.605



East African Journal of Environment and Natural Resources
eajenr.eanso.org
Volume 5, Issue 1, 2022
Print ISSN: 2707-4234 | Online ISSN: 2707-4242
Title DOI: https://doi.org/10.37284/2707-4242

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Review of the Past, Current, and the Future Trend of the Climate Change and its Impact in Uganda.

Upton Nuwagira[1*] *& Igga Yasin*[1]

[1] Mbarara University of Science and Technology, P. O Box 1410, Mbarara, Uganda.
* Correspondence ORCID ID: https://orcid.org/0000-0001-6200-522; email: unuwagira@must.ac.ug.

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

Date Published: *09 April 2022*

Keywords: *Climate Change, NASA, GIS, SD.*

ABSTRACT

Climate change is a big problem in Sub-Saharan Africa because it brings about prolonged droughts and heavy rainfall that destroys crops. Further, heavy rainfall amounts throughout the entire region have caused flooding and landslides, thus leaving many houses destroyed and people and animals dead. However, the past, current, and future trends of climate change and its impact in Uganda remain unachieved. In this paper, we: 1) analyse the past, current, and future climate change in Uganda; 2) determine the relationship between climate variables; and 3) review the impact of climate change in Uganda. Our study employed the use of secondary data from authentic sources such as the National Aeronautics and Space Administration, journal articles, and books. We used Inverse Distance Weighing interpolation to show the trend of climate change in Uganda. We employed the PCA to show the variation between climate variables in different regions in Uganda. Our data shows that the mean ± SD of temperature (25.24±3.85), rainfall (1252.5±476.9), relative humidity (63.45±7.11), and solar (19.831±1.46) from 1982 to 2019. One Way ANOVA showed a significant difference between temperature ($p = 0.003$), relative humidity ($p = 0.00$), and solar radiation ($p = 0.00$), while rainfall did not vary between regions ($p = 0.239$). Our study evidences that the current climate change impacts in Uganda include prolonged drought, which causes water stress and increases crop loss, floods, landslides, invasion of locusts, rises in lake water levels, and floating islands on Lake Victoria.

APA CITATION
Nuwagira, U. & Yasin, I. (2022). Review of the Past, Current, and the Future Trend of the Climate Change and its Impact in Uganda. *East African Journal of Environment and Natural Resources*, *5*(1), 115-126. https://doi.org/10.37284/eajenr .5.1.605.

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

CHICAGO CITATION

Nuwagira, Upton & Igga Yasin. 2022. "Review of the Past, Current, and the Future Trend of the Climate Change and its Impact in Uganda". *East African Journal of Environment and Natural Resources* 5 (1), 115-126. https://doi.org/10.37284/eajenr .5.1.605.

HARVARD CITATION

Nuwagira, U & Yasin, I. (2022) "Review of the Past, Current, and the Future Trend of the Climate Change and its Impact in Uganda", *East African Journal of Environment and Natural Resources*, 5(1), pp. 115-126. doi: 10.37284/eajenr.5.1.605.

IEEE CITATION

U. Nuwagira & I. Yasin, "Review of the Past, Current, and the Future Trend of the Climate Change and its Impact in Uganda", *EAJENR*, vol. 5, no. 1, pp. 115-126, Apr 2022.

MLA CITATION

Nuwagira, Upton & Igga Yasin. "Review of the Past, Current, and the Future Trend of the Climate Change and its Impact in Uganda". *East African Journal of Environment and Natural Resources*, Vol. 5, no. 1, Apr 2022, pp. 115-126, doi:10.37284/eajenr.5.1.605.

INTRODUCTION

Climate change is a big problem in Sub-Saharan Africa (Desanker, 2002; International Monetary Fund, Africa Dept., 2020). Mainly, climate change causes rising sea-level changes, high rainfall intensities, and high temperatures (World Meteorological Organization (WMO), 2021). According to a study by Masters and Norgrove (2010), Africa was predicted to experience increased water stress and several countries experienced a 50% decrease in agricultural productivity.

Human activities and natural hazards are seen as major causes of climate change at a global level (UNFCCC, 2011). Humans have been noticed as major influencers of climate change globally through deforestation, burning of fossil fuels, and livestock rearing, which add enormous greenhouse gases into the air, increasing the greenhouse effect and hence causing global warming that affects crop productivity (European-Union, 2020).

In addition, climate change has increased the level of drought, which has a great effect on lowering animal growth and productivity (IPCC, 2019). For instance, food insecurities and reduced food production in the Sub-Saharan African region are attributed to climate change effects (Misselhorn, 2005; Ruwoldt, 2013).

Since Uganda is dependent on agriculture and rain-fed crop growing, the low levels of rainfall and high temperatures have resulted in low crop productivity (Raworth & Oxfam, 2008). Moreover, low crop productivity in Uganda is attributed to prolonged drought (Mworozi et al., 2012; McGuire et al., 2015). This is because prolonged drought leads to increased water stress and crop failure (Elhadi et al., 2015; Sabiiti et al., 2018).

Based on the sedimentary and archaeological records of the past 6000 years, it was noted that the climatic variability has affected the livelihoods of approximately millions of people in the East African area (Marchant, 2021). In Uganda, it was shown that between 1960 and 2002, the mean annual temperature increased in the southeast (~0.02 °C/year) and the northwest (~0.03 °C/year), which was between March and May. For instance, the average hot and cool days increased by 74 (24%) and 136 (37%) respectively between 1990 and 2009 (UNDP, 2012). In addition, the temperature rose by 22.3 degrees (CCKP, 2015).

According to (CCKP, 2015), the average annual precipitation was 1160 mm with a 150 mm peak in April. The country also has a short-wet season between October to December and a long-wet season ranging from March to May, with an average of 3.4 mm and a 6 mm decrease in precipitation (UNDP, 2012). However, the data on drought is scanty, with the drier periods experienced in La Nina years (UNDP, 2012). Prolonged drought was evidenced in the southwestern region of Uganda, especially in the Isingiro district (Kushaba, 2016; NBS, 2016; Newvision, 2017; Twongyirwe et al., 2019). The areas that faced prolonged drought include Mbale, Kashumba, and Rugaaga sub-counties in Bukanga County. Evidence from the research also shows that agricultural diversification and production are interfered with by the prolonged

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

drought experienced in the Isingiro district (Desai, 2010).

Furthermore, Uganda is located in a tropical region in Africa, which means it experiences weather and climate anomalies. This includes erratic rainfall that triggers landslides, especially in the Eastern Region of Uganda, such as the mountainous Elgon Region area, which has left many dead (Masiga, 2012).

More recent, extreme climate anomalies that have been noted in Uganda include floods and melting of ice on top of Mount Rwenzori in Kasese district, moving islands in Lake Victoria, landslides in Eastern Uganda, and prolonged drought in north-eastern Uganda, especially in the Karamoja region (World-Bank, 2019). The floating islands on Lake Victoria led to the interference of national power due to the failure of the turbines to work properly (BBC, 2020).

The current extreme weather events, for example, prolonged drought in 24 districts in the regions of Karamoja, Teso, Acholi, Lango, and Busigu, have led to the invasion of desert locusts, which have caused great harm to vegetation as well as destroyed food crops like maize, hence causing food insecurity (FAO, 2021). More so, the rising water levels on Lake Kyoga led to flooding in the Amolatar district in northern Uganda, which left numerous people homeless, along with crops, and roads (NTV, 2021). Efforts have been made to determine the impact of climate change (Babel & Turyatunga, 2015; Lwasa, 2018). However, there are limited studies reviewing the past, current, and future climate change impacts as well as presenting the trend of climatic information using the Geographic Information System. Even where efforts have been made, the information is scanty and too generalized. More so, the maps that have been developed are not realistic. Adequate arrangement and decision-making in the management of climatic disasters through the help of early warning systems needs proper and well-detailed information to come up with a standard early warning system that can yield real-time data (Twongyirwe et al., 2019).

This study aims to provide detailed review information on climate change in Uganda and aims to answer the subsequent queries: 1) What has been, is being, and will be the past, current, and projected climate change in Uganda (temperature, rainfall, humidity, relative humidity, and solar)?2) What is the relationship between climate variables? 3) What is the impact of climate change on Uganda?

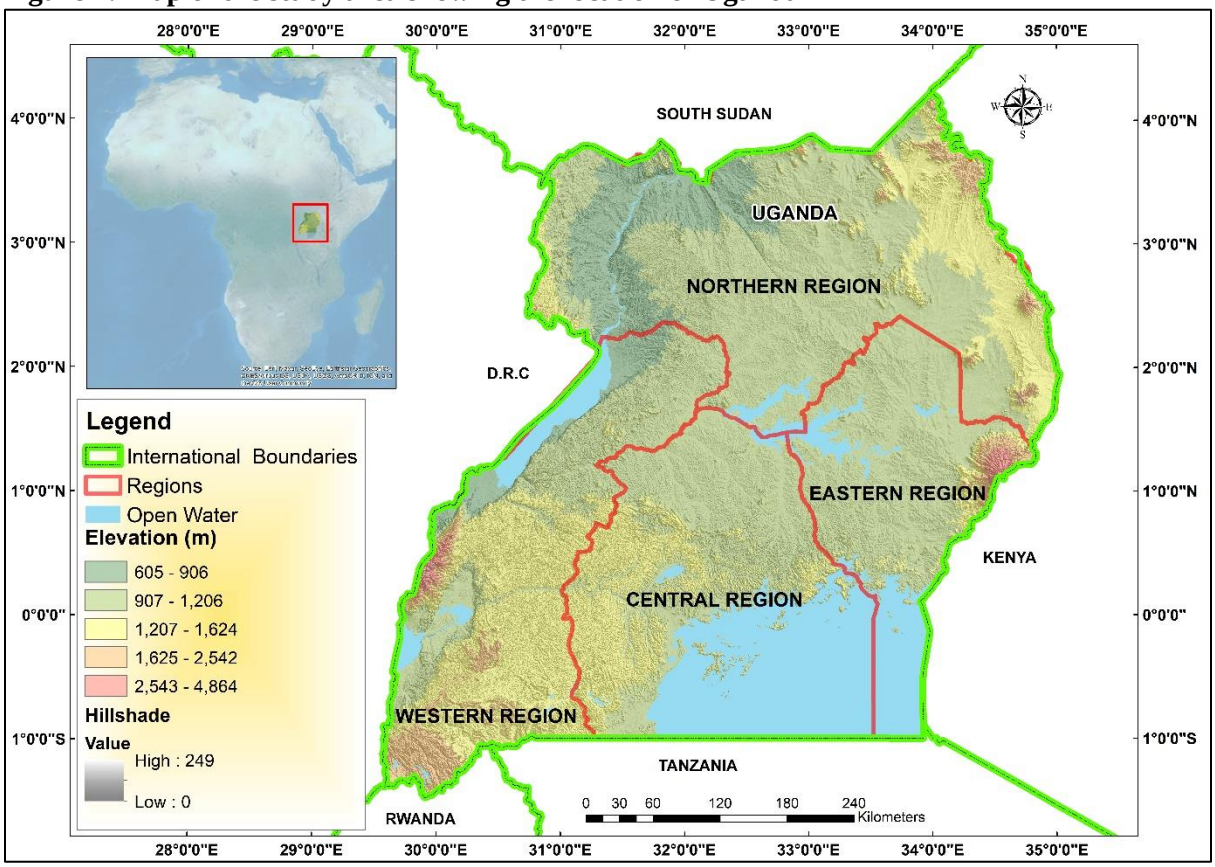
MATERIALS AND METHODS

Study Area

Uganda is located in Eastern Africa. The country is landlocked, surrounded by South Sudan to the north, Kenya to the east, the Democratic Republic of Congo to the west, Rwanda to the south-east, and Tanzania to the south (see *Figure 1*). The majority of Uganda is located on a plateau with a gentle sloping area of about 1,500 m a.s.l. in the south and 3000 m a.s.l. in the north. The dominant soil types in the country are ferrisols, which are productive, followed by ferruginous that are scattered throughout the whole country. Uganda is dependent on agriculture as a major source of income as well as being classified as the backbone of the country (CEPA, 2019). The vegetation in Uganda is mostly tropical, with tropical shrubs, trees, and savannah grass. The climate in Uganda is dominated by wet and dry seasons. Rainfall ranges from 500 m to 2000 m from March to May and October to November, with temperatures ranging from 20 °C to 25 °C from November to March (Kiwanuka et al., 2021).

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

Figure 1: Map of the study area showing the location of Uganda



Our study employed the use of secondary data from different authentic sources like websites and published journal articles and books. Data on climate such as rainfall, temperature, relative humidity, and solar radiation was obtained from the NASA website (https://www.nasa.gov/) and the World Bank Climate Change Knowledge Portal (https://climateknowledgeportal.worldbank.org/). The other literature on the current impact of climate change was also obtained from the media stories, most especially those concerning challenges caused by climate change (NBS, 2016; NTV, 2021).

The data on climate (rainfall, temperature, relative humidity, and solar) was interpolated using IDW in ArcGIS Software version 10.5 (Figures 2 and 3). Interpolation using the Inverse Distance-Weighted (IDW) has been widely used to model climate data and has yielded very good results (Chen & Liu, 2012; Yang et al., 2020). It is, therefore, very reliable in modelling climate data. The Inverse Distance-Weighted involves estimating unknown values using a set of known control points (Baddeley et al., 2015; Maleika, 2020). The choice of the study area was grounded on our expert knowledge and information about the study area.

Data Analysis

We used three data analysis methods. Each research query had a data analysis method. For the first research question, we used descriptive statistics (Mean ± SD) of the climate variables (rainfall, temperature, relative humidity, and solar), as well as an interpolation method, to show the trend and projection of climate change as from 1981 to 2019. Arc GIS version 10.7 was employed to map the spatial and temporal trends of the climatic variables in the study area.

The Principal Component Analysis was used on the second objective to determine the relationship between different variables such as rainfall, temperature, relative humidity, and solar radiation within the regions of Uganda (*Figure 2*). Furthermore, One-Way Anova was also employed to determine the difference between different groups. All the statistical analysis was carried out at

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

a 95% confidence interval and a 5% level of significance using Minitab version 19.0.

The third objective used secondary data sources such as journal articles, reports, media websites, and climate websites to get information concerning climate change impacts in Uganda (*Figure 3*).

RESULTS AND DISCUSSIONS

Trend of Weather and Climatic Variables in Uganda

Table 1: Mean of weather and climatic variables (Mean ± SD) from 1981 to 2019

Variable	Mean ± SD	Minimum	Maximum
Temperature (^{0}C)	25.24±3.85	18.74	27.85
Rainfall (mm)	1252.5±476.9	282.01	3794.06
Relative humidity	63.448±7.11	50.18	76.21
Solar	19.831±1.46	16.13	23.89

The results in *Table 1* show that between the years 1981 to 2019 in Uganda, the most recorded weather and climatic variables were temperature (25.24±3.85), rainfall (1252.05±476.09), relative humidity (63.45±7.12) and solar (19.831±1.46). The statistics on minimum and maximum temperatures (18.74 and 27.85), rainfall (282.01, 3794.06), relative humidity (50.18, 76.21) and solar (16.13, 23.89) respectively were recorded for the period from (1981 to 2019).

Figure 2: Climate projections for Uganda from 1981 to 2019

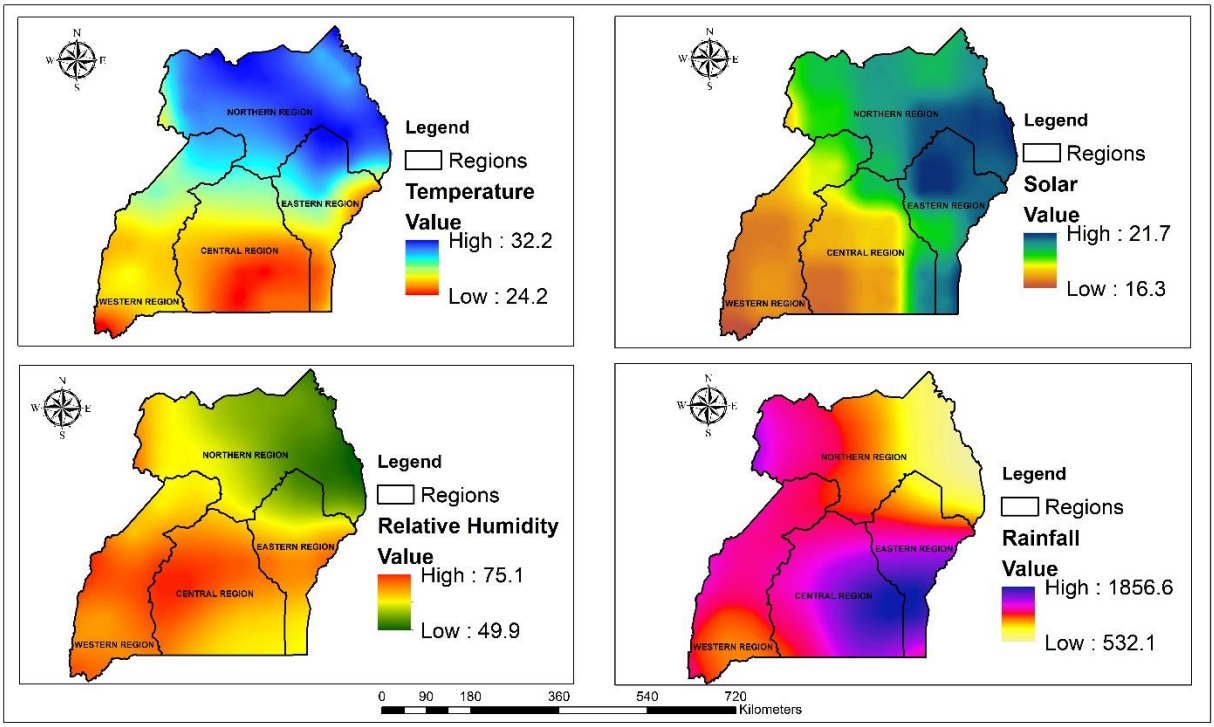


Figure 2 shows the climate projections for Uganda from 1981 to 2019 very high in the northern region, moderate in the northern central and eastern regions, and very low in the south-western region and central region. Solar is very high in the north-eastern and south-eastern regions, moderate in the central and north western regions with green colour, and very low in the western, central, and small parts of north-western Uganda. The relative humidity in Uganda is very high in the western,

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

central, and eastern regions; very low in some parts of the north-western and northern Uganda; rainfall is very high in the central region; moderate in the northern parts of Uganda; and very low in north-eastern Uganda.

Figure 3: Uganda's projected climate (rainfall and temperature) from 2020 to 2100

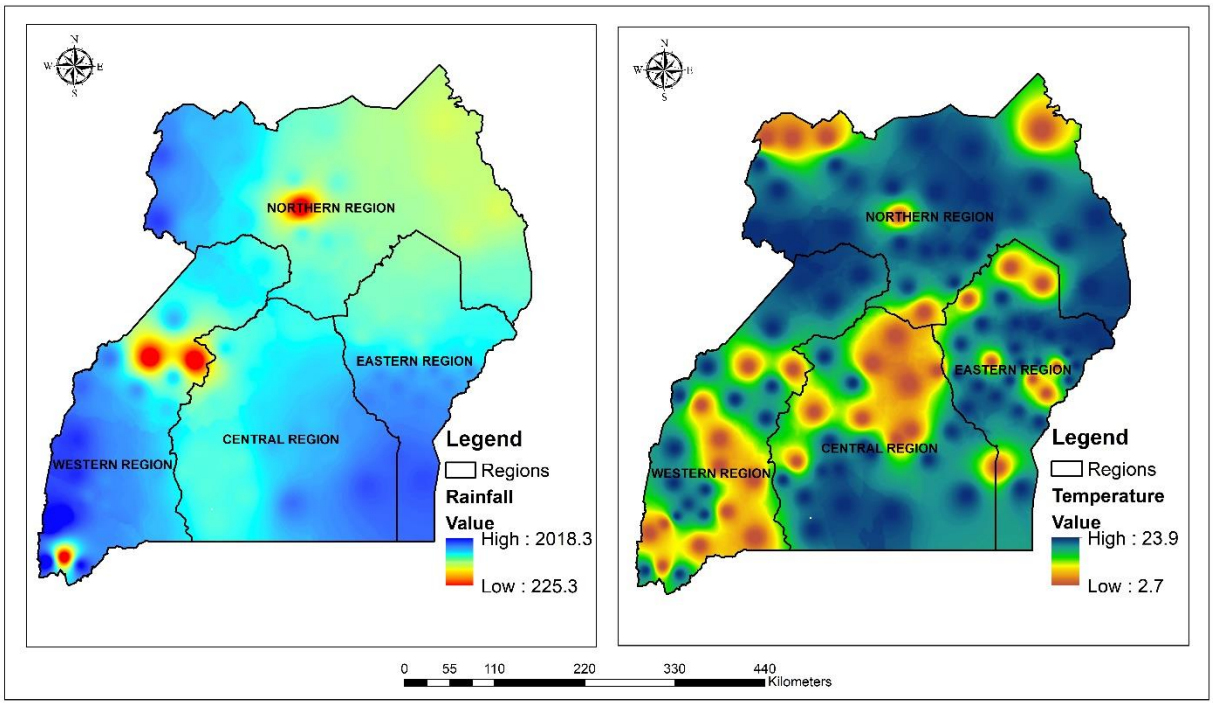
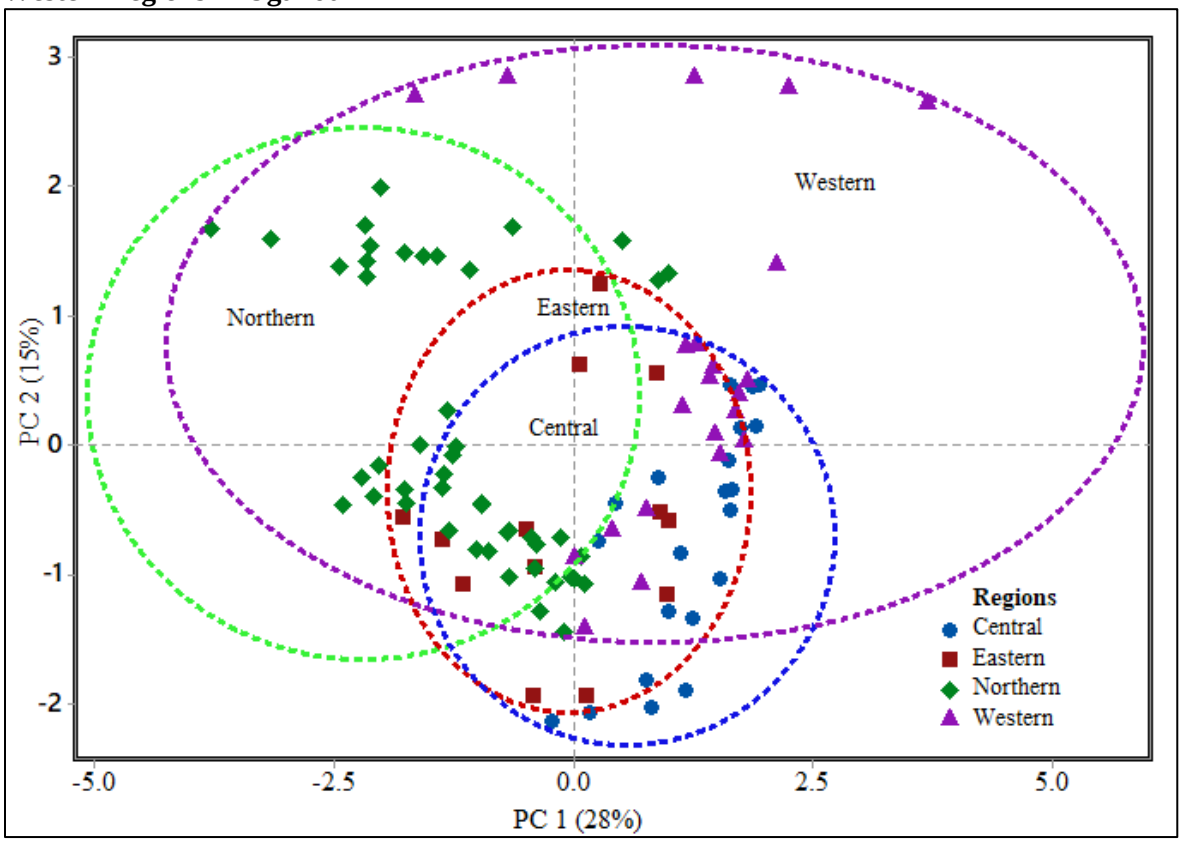


Figure 3 shows Uganda's projected climate (rainfall and temperature) from 2020 to 2100. Rainfall was projected to be high and moderate in the central, western, north-western, and some parts of the eastern region, and very low in some spots in south-western Uganda, western Uganda, and some small areas in northern and north-eastern Uganda. The reason for making only rainfall and temperature data is that we lacked data on solar and relative humidity. The mean ± SD rainfall (1406.8 ± 202.07) and temperature (18.79 ± 9.62) were also determined for the period between 2020 and 2100, respectively. The minimum and maximum projected temperatures and rainfall are as follows: maximum temperature (2.7±23.96).

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

Relationship between Climatic Variables

Figure 4: Principal Component Analysis of the climate variables for Central, Eastern, Northern and Western regions in Uganda



The One-Way Anova was also used to determine whether there was a significant difference between the climate variables. Our data showed that there was variation in temperature ($p = 0.003$), relative humidity ($p = 0.00$) and solar (0.00) in the regions of Uganda, while rainfall did not vary in all regions (0.239).

5.3 Impact of Climate Change in Uganda

Figure 5: Climate Change's Impact in Uganda) landslide in Bududa, eastern Uganda

(a)

(b)

Source: https://www.watchdoguganda.com/news/20200210/87193/l

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

Source: https://blogs.agu.org/landslideblog/2018/10/12/bududa-1/

(c)

Source: Office of the Prime Minister, May 10, 2020

ocust-invasion-locals-in-karamoja-stone-locusts-in-a-bid-to-scare-them-off.html

(d)

Source: NTV Uganda, Oct 31, 2016

(d)

Source: Uganda Radio Network

Figure 5 shows Climate Change's Impact in Uganda) landslide in Bududa, eastern Uganda, which left homesteads stranded; b) locust invasion in north-eastern Uganda (Karamoja), which destroyed many crops; c) flooding in River Nyamwambwa, which destroyed the Kasese-Kirembe road; d) drought in Isingiro district, which caused food scarcity and thus the death of people; and e) floating island on Lake Victoria, which hinders electricity power generation.

DISCUSSION

Trend of Weather and Climatic Variables in Uganda

There has been a trend in weather and climate variables like temperature, solar radiation, relative humidity, and rainfall. Evidence from this study, however, shows that the weather and climate variables keep on changing as time goes on changing. According to Mangheni et al. (2012), Uganda as a country has experienced several

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

changes in climate and weather events in the last 30 years, like an increase in temperature, frequent floods, and severe winds, especially in the eastern region. A study by Nimusiima et al., (2013), also explains that between 1961 and 2010, it was observed that there was a gradual increase in temperature in Uganda. The causes of climate change are attributed to deforestation, bush burning, continuous agricultural activities, overgrazing, wetland degradation, and industrial pollution (Nimusiima et al., 2013; Nagasha et al., 2019; Twinomuhangi et al., 2021). The recent changes in rainfall patterns around Lake Kyoga have caused a rise in lake water levels (Obubu et al., 2021). This also demonstrates that Uganda has experienced weather and climate change.

Relationship between Climatic Variables

The Principal Component Analysis of the climate variables (temperature, relative humidity, and solar radiation) for the Central, Eastern, Northern, and Western regions varied significantly, hence having different characteristics. The differences in temperature, relative humidity, and solar radiation in all the regions could be due to differences in the agro-ecological zones of Uganda.

Further, the variations in climate variables in regions of Uganda could also be due to the existence of tropical high forests. These include Kalinzu central forest reserve, Budongo central forest reserve, Bugoma central forest reserve, Bwindi Impenetrable National Park and Katsyoha-Kitomi central forest reserve, which play a lot in moderating the climate, thus bringing more variations.

The tropical rain forests are dominated by tropical climates with two rainfall patterns (Wangalwa et al., 2021), thus causing the variation in the climatic conditions between the regions of Uganda. One-Way Anova also determined whether there was a significant difference between the climate variables. Our data showed that temperature ($p = 0.003$), relative humidity ($p = 0.00$) and solar (0.00) varied greatly in the regions of Uganda while rainfall did not vary in all regions (0.239), meaning that the rainfall is at least uniformly distributed throughout the entire country, though little rainfall was noticed in the north-eastern region of Uganda, especially in the Karamoja area.

In addition, Uganda is located along the equator and areas around the equator receive two rainfall seasons throughout the year, hence making rainfall uniformly distributed throughout the country (USAID, 2013).

Impact of Climate Change in Uganda

Climate change in Uganda has led to the death of human and animal life and the destruction of crops due to drought and landslides in Isingiro and Mbale districts. The destruction of toilets has been noted due to the flooding of rivers and lakes such as the Nyamwamba, Lake Kyoga, and Lake Victoria, as well as the destruction of crops due to the invasion of desert locusts in northern Uganda. It has been noted that the failure in crop productivity and yield in Uganda is attributed to prolonged drought and little rainfall received (Zziwa et al., 2015; Mubiru et al., 2018). In addition, the prolonged drought experienced in south-western Uganda has caused destruction of crops and the death of animals, which has caused food insecurity and a reduction in people's sources of livelihood (Twongyirwe et al., 2019). Furthermore, projections in crop productivity have been shown to be higher in the wet season as compared to the dry season for the majority of crops, which are needed for food security in the entire country (Sridharan et al., 2019). The impact of climate change is also felt, especially due to prolonged drought periods that cause water stress, hence leading to wilting of crops (Lobell & Gourdji, 2012; Teixeira et al., 2013).

CONCLUSIONS

This paper analyses the past, current, and future climate change and the relationship between climate variables and the impact of climate change in Uganda. Rainfall did not vary in regions of Uganda. Current climate change impacts noted in this study include prolonged drought, landslides, floods, locust invasion, and an increase in water volume on Lakes George, Albert, and Kyoga, as well as moving islands on Lake Victoria.

This study also noted that the decline in crop productivity and yields is due to climate change, most especially the prolonged drought, the decrease

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

in rainfall amounts, and the shift in rainfall periods in the entire country. The study also noted that the temperature, relative humidity, and solar radiation varied in the regions of Uganda and rainfall did not vary.

RECOMMENDATIONS

We recommend the following for the better management of climate change impact in Uganda;

We recommend that Uganda National Meteorological Authority should provide timely, annual and decadal climate change information in order to make people be aware of climate change hazards and catastrophes.

We recommend that Uganda National Meteorological Authority should broadly study the interplay between climate and weather variables in order to better predict or forecast accurately which can help most especially people who deal in rainfed agriculture.

We further recommend that Uganda should do more research and be able to discover other strategies and models to better deal with climate change impacts once it happens.

REFERENCES

Babel, M. S., & Turyatunga, E. (2015). Evaluation of climate change impacts and adaptation measures for maize cultivation in the western Uganda agro-ecological zone. *Theoretical and Applied Climatology*, *119*(1), 239–254.

Baddeley, A., Rubak, E., & Turner, R. (2015). *Spatial point patterns: methodology and applications with R*. CRC press.

BBC. (2020). *Ugandan floating island causes national power cut*. https://www.bbc.com/news /world-africa-52286296

CCKP. (2015). *Climate Change Knowledge Portal (CCKP)*. https://climateknowledgeportal.worldb ank.org/

CEPA. (2019). *Agriculture as a backbone of Uganda*. https://cepa.or.ug/agriculture-ugandas-key-to-sustainable-growth-and-development/

Chen, F.-W., & Liu, C.-W. (2012). Estimation of the spatial rainfall distribution using inverse distance weighting (IDW) in the middle of Taiwan. *Paddy and Water Environment*, *10*(3), 209–222.

Desai, M. (2010). Problems Facing Small Scale Farmers in Isingiro District , Uganda : Focus on Bananas Banana Production in Isingiro District, 1–8.

Desanker, P. (2002). Impact of Climate Change on Life in Africa. *WWF Climate Change Program*, 1–6.

Elhadi, Y. A., Nyariki, D. M., & Wasonga, O. V. (2015). Role of camel milk in pastoral livelihoods in Kenya: contribution to household diet and income. *Pastoralism*, *5*(1), 1–8.

European-Union. (2020). *Causes of climate change*. https://ec.europa.eu/clima/climate- change/caus es-climate-change_en

FAO. (2021). *Desert Locusts: Uganda prepares for the second wave of invasion*. https://www.fao.org/uganda/news/detail- events /en/c/1380922/

International Monetary Fund. Africa Dept. (2020). Adapting to Climate Change in Sub-Saharan Africa. *International Monetary Fund*, *April*, 1–18.

IPCC. (2019). Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.

Kiwanuka, M. Semakula M. , Kokole, . Omari H. , Ingham, . Kenneth and Lyons, . Maryinez. (2021). *Uganda. Encyclopedia Britannica* (pp. 1–5). https://www.britannica.com/place/Uganda

Kushaba, A. (2016). *Prolonged Drought: Livestock Farmers Count Loses*. https://ugandaradionetw ork.net/story/isingiro-livestock-farmers-count-loses-following-prolonged-dry-spell-

Lobell, D. B., & Gourdji, S. M. (2012). The influence of climate change on global crop

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

productivity. *Plant Physiology*, *160*(4), 1686–1697.

Lwasa, S. (2018). Drought and flood risk, impacts and adaptation options for resilience in rural communities of Uganda. *International Journal of Applied Geospatial Research (IJAGR)*, *9*(1), 36–50.

Maleika, W. (2020). Inverse distance weighting method optimization in the process of digital terrain model creation based on data collected from a multibeam echosounder. *Applied Geomatics*, *12*(4), 397–407.

Mangheni, M. N., Sseguya, H., Bashaasha, B., & Studies, I. (2012). Evaluation naturelle de l'impact de Beauveria bassiana : Champignon enthomopathogène dans la dynamique de population de Hypothenemus hampei , scolyte de baies des cerises de Coffea canefora. *Evaluation Naturelle de l'impact de Beauveria Bassiana : Champignon Enthomopathogène Dans La Dynamique de Population de Hypothenemus Hampei , Scolyte de Baies Des Cerises de Coffea Canefora*, *20*(2), 443–451. https://doi.org/10.4314/acsj.v20i2

Marchant, R. (2021). *Climate Change in Eastern Africa*. https://doi.org/10.1093/acrefore/9780190277734.013.1004

Masiga, M. (2012). Analysis of Adaptation and Mitigation Options; Territorial Approach to Climate Change. May, 100.

Masters, G., & Norgrove, L. (2010). Climate Change and Invasive Alien Species. *CABI Working Paper 1*, *1*(November), 30. http://prod.sgk.cabiorg.cab.semcs.net/Uploads/File/CABi worldwide/Invasive alien species working paper.pdf

McGuire, S. F. A. O., FAO, I., IFAD, & WFP. (2015). The state of food insecurity in the world 2015: meeting the 2015 international hunger targets: taking stock of uneven progress. *Rome: FAO*, 623-624.

Misselhorn, A. A. (2005). What drives food insecurity in southern Africa? A meta-analysis of household economy studies. *Global Environmental Change*, *15*(1), 33–43.

Mubiru, D. N., Radeny, M., Kyazze, F. B., Zziwa, A., Lwasa, J., Kinyangi, J., & Mungai, C. (2018). Climate trends, risks and coping strategies in smallholder farming systems in Uganda. *Climate Risk Management*, *22*, 4–21. https://doi.org/10.1016/j.crm.2018.08.004

Mworozi, E., Gebru, B., & Kibaya, P. (2012). Enhancing the adaptive capacity of communities to climate change induced water challenges using ICT in Uganda: project design and anticipated policy implications. *Policy Brief/Climate Change Adaptation and ICT (CHAI); No. 1*.

Nagasha, J. I., Ocaido, M., & Kaase-Bwanga, E. (2019). Attitudes, practices and knowledge of communities towards climate change around Lake Mburo National Park Uganda: A Gender Centered Analysis. *African Social Science Review*, *10*(1), 3.

NBS. (2016). *Famine hits Isingiro*. https://nbs.ug/2016/10/famine-hits-isingiro/

Newvision. (2017). *ReliefNewvision, Drought: Isingiro people get food*. https://www.newvision.co.ug/news/1444809/drought-isingiro-people-food-relief

Nimusiima, A., Basalirwa, Majaliwa, J. G. M., Otim Nape, Okello Onen, J., Rubaire Akiiki, C., Konde Lule, J., & Ogwal Byenek, S. (2013). Nature and dynamics of climate variability in the uganda cattle corridor. *African Journal of Environmental Science and Technology*, *7*(8), 770– 782. https://doi.org/10.5897/ajest2013.1435

NTV. (2021). *Residents lose homes and gardens to rising water levels along Lake Kyoga*. https://www.ntv.co.ug/ug/news/national/residents-lose-homes-and-gardens-to-rising-water-levels-along-lake-kyoga-3479854

Obubu, J. P., Mengistou, S., Fetahi, T., Alamirew, T., Odong, R., & Ekwacu, S. (2021). Recent Climate Change in the Lake Kyoga Basin, Uganda: An Analysis Using Short-Term and

Article DOI: https://doi.org/10.37284/eajenr.5.1.605

Long-Term Data with Standardized Precipitation and Anomaly Indexes. *Climate*, *9*(12), 179.

Raworth, K., & Oxfam, G. B. (2008). Gender and climate adaptation. *Briefing Paper, February, Oxfam GB*.

Ruwoldt, G. (2013). Food insecurity and climate change. *American Journal of Public Health*, *103*(1), E1.

Sabiiti, G., Ininda, J. M., Ogallo, L. A., Ouma, J., Artan, G., Basalirwa, C., Opijah, F., Nimusiima, A., Ddumba, S. D., & Mwesigwa, J. B. (2018). Adapting agriculture to climate change: suitability of banana crop production to future climate change over Uganda. In *Limits to Climate Change Adaptation* (pp. 175–190). Springer.

Sridharan, V., Ramos, E. P., Zepeda, E., Boehlert, B., Shivakumar, A., Taliotis, C., & Howells, M. (2019). The Impact of Climate Change on Crop Production in Water and Energy Implications. *Water*, *2019*, 24. https://res.mdpi.com/d_attachment/water/water-11-01805/article_deploy/water-11-0

Teixeira, E. I., Fischer, G., Van Velthuizen, H., Walter, C., & Ewert, F. (2013). Global hot-spots of heat stress on agricultural crops due to climate change. *Agricultural and Forest Meteorology*, *170*, 206–215.

Twinomuhangi, R., Sseviiri, H., Mulinde, C., Mukwaya, P. I., Nimusiima, A., & Kato, A. M. (2021). Perceptions and vulnerability to climate change among the urban poor in Kampala City, Uganda. *Regional Environmental Change*, *21*(2). https://doi.org/10.1007/s10113-021-01771-5

Twongyirwe, R., Mfitumukiza, D., Barasa, B., Naggayi, B. R., Odongo, H., Nyakato, V., & Mutoni, G. (2019). Perceived effects of drought on household food security in South-western Uganda: Coping responses and determinants. *Weather and Climate Extremes*, *24*(January), 100201. https://doi.org/10.1016/j.wace.2019.100201

UNDP. (2012). *United Nations Development Programme (UNDP)Climate Change Country Profiles: Uganda*. https://www.google.com/search?q=Climate+Change+Information+Fact+Sheet+UGANDA&oq=Climate+Change+Information+Fact+Sheet+UGANDA&aqs=chrome..69i57.858j0j7&sourceid=chrome&ie=UTF-8

UNFCCC. (2011). Climate Change Science - The Status of Climate Change Science Today. United Nations Framework Convention on Climate Change. https://unfccc.int/files/press/backgrounders/application/pdf/press_factsh_science.pdf

USAID. (2013). Uganda climate change vulnerability assessment. USAID African and Latin American Resilience to Climate Change (ARCC). 0–77.

Wangalwa, R., Olet, E. A., Kagoro-Rugunda, G., Tolo, C. U., Ogwang, P. E., & Barasa, B. (2021). Occurrence of Citropsis articulata in tropical forests in Uganda: implication for ex situ conservation. *International Journal of Forestry Research*, *2021*.

World Bank. (2019). *Ugandan Government Steps Up Efforts to Mitigate and Adapt to Climate Change*. https://www.worldbank.org/en/news/feature/2019/05/31/ugandan-government-steps-up-efforts-to-mitigate-and-adapt-to-climate-change

World Meteorological Organization (WMO). (2021). *State of the Climate in Africa 2020* (Issue 1275). https://library.wmo.int/doc_num.php?explnum_id=10914

Yang, W., Zhao, Y., Wang, D., Wu, H., Lin, A., & He, L. (2020). Using principal components analysis and IDW interpolation to determine spatial and temporal changes of surface water quality of Xin'anjiang river in Huangshan, China. *International Journal of Environmental Research and Public Health*, *17*(8), 2942.

Zziwa, E., Mpairwe, D., Mugasi, S. K., & Laswai, G. H. (2015). Beef production practices and responses to climate change in the rangelands of Lake Victoria basin in Uganda. *International Journal of Agriculture and Forestry*, *5*(2), 121–130.

