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A Review of the Potential Negative Impact on Vulnerable Communities in East Africa Arising from Climate Change - Uganda as A Case Study

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Received: 2 June 2024 Accepted: 28 July 2024 Published: 10 July 2024

Abstract: Climate change has significantly impacted the lives of millions of people. Compared to the global north, the global south emits less carbon dioxide while suffering more from the impacts of climate change. This climate injustice makes it more difficult for vulnerable communities living in poor countries. Uganda is one of the world's poorest countries located in East Africa, with 42% of its population living on less than $2.15 per day in 2017, and an agricultural sector that accounts for 23% of its annual GDP, affecting the income and quality of life of more than 69% of its population. It is important to understand how climate change affects this country and look for solutions. This paper was conducted by a desk-based narrative literature review method collected from research publications, organisational reports, and expert opinions. As a result of the findings, vulnerable communities such as smallholder farmers, fishermen, and women are disproportionately affected by climate change. This paper recommends encouraging climate-smart agriculture projects and promoting climate prediction as a short-term solution to climate change problems. By analysing Uganda`s pathway to combat climate change, it can provide practical lessons to increase climate resilience globally.

Keywords: Climate Impact; East Africa; vulnerable communities; Uganda; Climate Solutions

1. Introduction

Climate change is a global phenomenon that affects all countries and communities in various ways. However, some communities are more vulnerable than others to the impacts of climate change. East Africa is one of the most vulnerable regions in the world to the impacts of climate change (Mugeere et al., 2021). Because it is located in a region that is prone to natural disasters, such as droughts and floods, which are exacerbated by climate change. The region is also home to a number of active volcanoes and fault lines, which can lead to devastating earthquakes and volcanic eruptions (Natural and Human-Induced Hazards and Disasters in Africa, 2016). Together socio-economic conditions, including poverty,

poor infrastructure, and inadequate access to health care and education, make them more vulnerable to the effects of climate change (Phillip, 2017). It is well known that humanity lives in a common destiny and that negative climate feedback will affect the global (Zhang, 2018). As such, the international community needs to provide support and resources to help the region adapt and mitigate the effects of climate change.

Uganda, located in east-central Africa, is one of the seven biogeographic regions of Africa and is a country with a high level of biodiversity (UN, 2018). However, the country is also one of the most vulnerable to climate change in the region. Because of its geographical location, which features high temperatures, high humidity, and severe rainfall, it is particularly vulnerable to extreme weather occurrences such as floods and droughts. (World Bank Climate Change Knowledge Portal, 2021.). Moreover, its economy is highly dependent on agriculture, which accounts for 23% of its annual GDP(FAO,2022). Also, its socioeconomic position is precarious. Uganda has one of the world's youngest populations, with 41% of its people living in poverty (U-report, 2015), (Data for Uganda, Low Income, 2022). Therefore, this paper seeks to identify the climate challenges in Uganda and ways to address the problem.

Specifically, it aimed to resolve 3 questions: I- How has climate change disproportionately impacted Uganda, and what evidence exists to support this claim? II- Who and what subjects are suffering from the disproportionate climate change? III-Based on the results of the narrative literature review, what policy and practice recommendations can be made to address the impacts of climate change in Uganda and mitigate its effects on vulnerable populations.

2. Methodology and Ethical Issues

2.1 Literature Review

This paper used a narrative literature review method that helps to analyse climate change and its disproportionate impact in Uganda (Hart, 2018). Specifically, it plans to review the documents using clearly formulated questions (Table 1) and select relevant studies with systematic and clear criteria (Mugeere et al., 2021). The paper reports its search and inclusion/exclusion criteria to ensure a systematic approach in analysing the findings of the collected studies. This approach is effective in synthesising the evidence and providing insights to inform policy and practice (Snyder, 2019).

Table 1 Research Question

I- How has climate change disproportionately impacted Uganda, and what evidence exists to support this claim?
II- Who and what subjects are suffering disproportionately from climate change?

III-Based on the results of the narrative literature review, what policy and practice recommendations can be made to address the impacts of climate change in Uganda and mitigate its effects on vulnerable populations.

Table 2 Search Terms and Criteria

Research Terms	**Inclusion Criteria**	**Exclusion Criteria**
"Climate change" "Disproportionately impact" "Uganda" "Resilience" "Vulnerable" "East Africa"	• Written in English • Published between 2015-2022 • Includes a measure of, or report on climate resilience, disproportionately and vulnerable • Includes a measure of, or report on gender, farmers, fishers, • Includes a measure of, or report on solutions, productivity, sustainability	•Theoretical studies with no empirical findings •

Table 2 states the details of conducting the review. After initial literature searches yield many articles, 42 articles are finally adopted. Specifically, the review process draws on the impact of climate change on vulnerable communities in East Africa. Following that, the focus then shifted to how to improve Uganda's climate resilience in the short and long term. Regarding the data resources, it mainly came from the Google Scholar database, as well as reports from NGOs, such as the United Nations, FAO, WHO, and the World Bank. By using the literature analysis framework from Author Snyder, an excel form was generated that includes descriptive information about the data, such as authors, topics, or results consistent with the research questions and objectives (Snyder, 2019).

In the following sections, this paper presents an overview of how the climate is predicted to change in Uganda from now to 2100. Following, it is going to evaluate who, and which subjects will be influenced by climate change disproportionately. Next, it provides practical solutions for Uganda`s policymakers in the short term. Finally, this paper presents the findings and ends with a conclusion.

3. Climate Change Impact Assessment in Uganda

Uganda is a continental African nation with a land area of approximately 241 thousand km², thus it ranks as the 27th smallest country in the world (Uganda, 2023). Its population is 47 million, of which

women account for 49.3% (World Data, 2022). More than 69% of Uganda's population is employed in agriculture, 89% of whom are smallholder (FAO,2022). Data shows agriculture accounts for 23% of its annual GDP, and more than half of farmers` income is generated on the farm, of which maize and beans are the most grown crops (FAO,2022). Moreover, female dominance in smallholder households is less than 1/3, with an education level of around 5 years in Uganda (FAO,2022). More than half of Uganda's population is under the age of 15(Learn Facts about Uganda, Poverty, and Development, 2022.). In addition, 27% of smallholder farmers live below the national poverty line because of their high reliance on rain-fed agriculture and lack of financial support for access to improved seeds and fertilisers (FAO,2022). Only 0.7 percent of the average household's farmland is irrigated, resulting in its agriculture's high reliance on rain-fed (FAO,2022).

With an increase in the average temperature of 0.28 degrees per decade since 1960 and an upward trend in the number of hot days, Uganda`s average monthly rainfall has decreased by 6.0 mm per decade, and droughts are more frequent and last longer (World Bank Climate Change Knowledge Portal, 2021) It has experienced a statistically significant decrease in both annual and seasonal rainfall. For example, the overall rainfall in the south ranges from 600 to 2200mm and in the north from 400 to 1600mm, with Karamoja having the lowest rainfall of around 400 mm and Lake Victoria having the highest at approximately 2200mm (World Bank Climate Change Knowledge Portal, 2021). The World Bank also estimates that this shift toward warmer and drier temperatures, humidity, and rainfall patterns caused by human activities will become more noticeable over the next decade or more in Uganda.

The Coupled Model Intercomparison Project (CMIPs) is created to develop different scenarios to visualise current and future climate (World Bank Climate Change Knowledge Portal, 2021.). It is supported by the World Climate Research Program, scientific cooperation, and partnerships. In the high emission scenario (business-as-usual scenario), it estimates that global average temperature increases by approximately 5-6ºC by 2100, relative to pre-industrial temperature levels, with a maximum temperature of 35.82 degrees and a minimum temperature of 20.22 degrees, with an average temperature of 27.55 degrees and a sea-level rise of about 1 metre in Uganda (World Bank Climate Change Knowledge Portal 2021). Extreme weather will become more frequent, with anomalous rainfall intervals of (-26.0 to +63.1) mm by 2080 to 2099 (World Bank Climate Change Knowledge Portal 2021). Additionally, rainfall amounts will decrease marginally (Twinomuhangi et al., 2021). Lake Victoria, Uganda's largest lake, is anticipated to get 20% less rainfall than ordinary (Twinomuhangi et al., 2021). Therefore, smallholders in Uganda have to suffer disproportionately from climate impacts.

Most importantly, our planet doesn't exist in isolation. The linkages of the carbon cycle across global systems are clear. For example, positive climate feedback accelerates the rise in temperature and sea-level rise. When the ice melts, the vegetation beneath it is exposed, absorbing higher levels of energy, and causing the Earth to continually warm up (Positive climate feedback - Energy Education, 2022.). Therefore, if the world moves towards a more sustainable path, People who live in climate-disproportionately affected places can therefore have a higher quality of life.

4. Impact of Climate on Vulnerable Communities

As discussed before, agriculture plays an important role in Uganda, and it is highly dependent on the climate (FAO,2022) (Atube, 2021). If the climate continues to heat up, it will not only hurt Uganda's economy but also disproportionately affect vulnerable communities. Taking smallholders as an example, the yields of maize are expected to decrease by more than 4.7 in areas of rapid warming and low rainfall, such as Kasese city (Kikoyo & Nobert, 2016). Influence also exists in export products, such as Robusta coffee. It has a high tolerance to temperature, with an optimum temperature below 20.5°C considering yield and precipitation temperature (Kath et al., 2020). If temperatures are above 24.1°C, each 1°C increase corresponds to a 14% decrease in yield or 350-460 kg/ha (95% credible interval) (Kath et al., 2020). So, the increasing temperature will reduce farmers' income and Uganda`s foreign exchange reserves. Further, a drop in the production of key plant species will also hurt Uganda's main food security.

Regarding the blue economy, Lake Victoria is the second-largest freshwater lake in the world and the largest freshwater lake in Africa and Uganda accounts for 45% of it compared to Kenya, Tanzania, Rwanda, and Burundi (Yunana et al., 2017). Thus, Lake Victoria plays an important role in Uganda's economy. Generally, seasonal rainfall is 80% of Lake Victoria's water source (Olaka et al., 2019). Future river discharges are predicted to range from 5 to 267%, which will increase the frequency of extreme weather events. (Olaka et al., 2019). In the business-as-usual scenario (PRC8.5), Lake Victoria's temperature is predicted to climb by 4°C, which will increase water evaporation and decrease the lake's capacity to store water(Olaka et al., 2019) According to Yunnan, Trends in future climate change will result in a 50% reduction in fish production, which severely reduces the main source of income for locals(Yunana et al., 2017). Even worse, climate-related livestock will also decline by 2% per year, leading to hardship for people living near the Lake Victoria Basin in Uganda (Yunana et al., 2017). Climate change will not only affect small farmers, but it will also be a disaster for the blue economy.

Gender equality issues become more significant as a result of climate change. Because more women than men (70% vs. 58%) are engaged in agricultural activities, and more than 50% of them are unpaid for their agricultural activities (Bamanyaki and Aogon, 2020). Even in the same agricultural activities, employed women are paid less than men in Uganda (Bamanyaki and Aogon, 2020). Also, climate change-induced changes in agriculture, such as a decline in agricultural yields, could lead to more women not having access to adequate food and could result in fewer opportunities for women to obtain paid work. Additionally, the widespread cultural norms in Uganda prioritise women's responsibility for household food production and management, meaning that women have to access the same sources of food as they do in a context of less access to productive resources, such as finance, information, and technology. These increase women's labour time and lead to an increase in female hunger because the priority of food consumption is given to male household members and children (Bamanyaki and Aogon, 2020). For those reasons, feminism is being undermined by climate warming.

In short, vulnerable populations, such as small farmers, the blue economy, and feminism, suffer disproportionately from the effects of climate change. They are currently dealing with the worst climate injustice ever. As a result, there are even more people living in poverty. For example, the poverty population in Kampala increased from 10% to 15% between 1991 and 2014 (Twinomuhangi et al., 2021). To achieve Sustainable Development Goal 1 No Poverty, Goal 5 Gender Equality, and SDG 14 life below water, numerous tasks need to be completed, necessarily, helping vulnerable communities recover from the risks of climate change and disadvantaged groups become more equal in society, offering equal access & opportunities for a better life.

5. The Sustainable Solution in Short-Term Strategy

5.1 Encourage the Climate-Smart Agriculture (CSA) Program

The concept of climate-smart agriculture (CSA) was first described at the 2010 Hague Conference on Agriculture, Food Security, and Climate Change (Fao Success Stories on Climate-Smart Agriculture, 2010) It is a concept for restructuring, and reorienting agricultural production systems and food value chains to achieve environmental sustainability and food security in the context of climate change (Fao Success Stories on Climate-Smart Agriculture, 2010). It is an improved agricultural approach that utilises ecosystem & sustainable land & water management strategies, landform analysis, and natural resource efficiency assessments in agro-ecosystems (Climate-Smart Agriculture Sourcebook, 2022). CSA can be divided into five sections: expanding the evidence base for CSA, supporting enabling policy frameworks, strengthening national and local institutions, improving finance choices, and improving CSA field practices (Climate-Smart Agriculture Sourcebook, 2022). One experience from the CSA is the recommendation to plant improved seeds in Uganda.

Due to warming-related causes, the world's grain production has decreased by 1% to 5%, and the world's suitable area for beans is anticipated to decline noticeably (30–50%), which is the main seed plant in Uganda (Schubert, 2015). Moreover, according to the World Bank, Uganda`s population is going to double in 2060, reaching 104 million people (Myers et al., 2021). Therefore, for Uganda, achieving food security is critical. In 2013, Climate Change Agriculture and Food Security (CCAFS) conducted a CSA site in Homia, Western Uganda, to promote drought-tolerant bean varieties through improved bean varieties. Fortunately, yields of beans have increased three times compared to local varieties, with an average harvest of 2500 kg per hectare (Recha et al., 2017). Also, the modified sweet potato genes have increased its resistance to drought and water stress, increasing yields per hectare by a factor of 6 compared to local varieties, as well as increasing protein and vitamin A content (Recha et al., 2017).

This CSA site has not only helped Uganda decrease poverty and climate change vulnerability but also has the potential to contribute to gender equality (Eriksen et al., 2019). Because the CSA programs assist smallholders with technical and financial support. Generally, Africa's smallholder agriculture is dominated by women. Therefore, by supporting women to work with new technologies and mentoring

them to others, CSA programs help women play more important roles in agriculture (Eriksen et al., 2019). In addition, smallholders are found in areas with poorer infrastructure and soil quality compared to large-scale farms (Lay,2018). So, smallholders have lower food production and weaker bargaining power compared to large-scale farms (Wu, 2020). As a result, successful CSA programs can support vulnerable populations that suffer disproportionately from climate impacts and increase their climate resilience.

5.2 Promoting Climate Forecast Program

Information and communication technology (ICT) has influenced all aspects of life. It is exploited that ICT tools could help with the efficient broadcast of specific meteorological information, improving the lives of Ugandan farmers (Tuheirwe-Mukasa et al., 2019). Specifically speaking, drought-related monitoring and reporting actions provide a baseline of data for agriculture and serve as a barometer of changes in the climatic environment that can foreshadow the onset of drought (Climate ADAPT, 2022). Therefore, in drought climates, the needs of water users are considered in advance, and smallholders can increase crop yields on their land (Climate ADAPT, 2022). Moreover, climate predictions can also be utilised to predict flood events faster and more precisely and provide earlier warnings to those affected (Climate ADAPT, 2022). State-of-the-art technology can predict floods 3-10 days before they arrive (Climate ADAPT, 2022). Thus, it can lessen the harm brought on by flash floods, such as the destruction of hospitals and sanitary infrastructure.

In 2017, Uganda's National Agricultural Research Organization (NARO) and CCFAS collaborate on another CSA project to integrate local knowledge with scientific forecasts (Recha et al., 2017). Farmers were actively involved in the collection of rainfall data in this area. For example, rain gauges were installed on a few fields, and farmers were asked to take daily readings and submit them for professional study. Through farmer communities, this climate information was subsequently shared with other farmers. As a result, this climate forecast program has benefited over 720 households (Recha et al., 2017). It improved smallholders` capacity to make informed decisions about planting dates and crop varieties. It also decreased crop and sanitation facility damage, which was caused by weather extremes like flooding, as well as climate-related water security issues.

However, the promotion of CSA in Uganda was limited because of financial problems. Farmers were unable to take action to deal with climate change due to lacking access to finance or credit support, such as restricting the purchase of improved seeds (Atube et al., 2021). In addition, smallholder farmers are mainly women. Compared to men, women have a significant challenge in accessing credit support (Bank, 2020). As a result, there are various gender-based disparities in risk, as well as adaptation and adaptive capacity. Therefore, it is suggested that the government should, firstly, attempt to raise farmers' understanding of higher technology and climate change strategies, as well as develop affordable loan schemes using new methodologies. Second, climate-smart agriculture success stories from Hoima, such as improving plant genetics and monitoring climate change, should be implemented across Uganda to

improve the population's ability to adapt to climate change. Finally, the Ugandan government should collaborate closely with international organizations to form new and better ways to empower Ugandans in coping with climate change challenges.

6. Conclusion

By the end of this century, global temperature is expected to increase by approximately 5-6ºC. Uganda, one of the youngest populations in the world, lives in poverty with 41% of its residents. The agricultural sector accounts for 23% of its annual GDP, affecting more than 69% of its population`s income and life quality. Uganda's agriculture is highly dependent on the weather because only 0.7% of its land is irrigated. As a result of climate change, Uganda`s average monthly rainfall has decreased by 6.0 mm per decade, and droughts are more frequent and last longer. These challenges have hurt Uganda's economy, made smallholder farmers poorer, and undermined the blue economy and feminism. To help achieve SDG 1 "No Poverty" and SDG 5 "Gender Equality", this paper proposes a sustainable solution based on the Ugandan context. In the short term, it is suggested to develop a climate-smart agriculture program, like planting seeds with improved genes, to increase crop yields. Promoting climate forecasts is also recommended. Thus, climate resilience will be improved, and the vulnerable communities can have a better life quality in Uganda.

Acknowledgement

None.

Funding Statement

None.

Author Contributions

The author confirms sole responsibility for the following: A review of the potential negative impact on vulnerable communities in East Africa arising from climate change - Uganda as a case study.

Availability of Data and Materials

The data on which the study is based were accessed from a repository and are available for downloading through the following link:

Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. Agriculture & Food Security, 10(1), 6. https://doi.org/10.1186/s40066-020-00279-1

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Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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