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COVID-19 and the water–energy–food nexus in Africa: Evidence from Nigeria, Uganda, and Tanzania

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Abstract

Water, energy, and food are necessary resources for well-being and economic development. The physical and economic access to these resources in most Sub-Saharan countries remains very low while the outbreak of COVID-19 is projected to worsen the situation. Therefore, this study aims to assess the impacts of COVID-19 on the access to water, energy, and food as well as to identify innovations in water sanitation and hygiene (WASH) practices and examine the current policy interventions in Nigeria, Uganda, and Tanzania. An online survey through a Google Forms sampling 842 respondents was adopted and responses were analyzed. Results indicate that there is an insignificant correlation of COVID-19 with water and energy access in all the three countries. However, there is a significant relationship with food access in all the three countries though still minimal in Tanzania. Interestingly, there is an improvement in WASH due to increased local innovations and continued mass sensitization. The study highly recommends policies that could improve affordability and encourage innovations in the factors studied.

KEYWORDS

COVID-19, innovation, policies, water–energy–food access

1 | INTRODUCTION

Water, energy, and food are necessary for human well-being. It is evident that understanding the interlinkage between water, energy, and food (WEF) has gained more importance as a major contribution to sustainable development globally. The complex interlinkage is termed as a nexus and this recognizes the components—WEF as a subset of the WEF nexus (Terrapon-Pfaff et al., 2018). This inextricable linkage considers the relationship between the three components, how the demand of one resource can drive demand for another, and similarly how an increase in the cost of one subset affects the other's efficiency of production (Gulati et al., 2013).

Meanwhile, since the declaration of COVID-19 as a global pandemic by the World Health Organization (WHO), awareness has been raised by WHO on the importance of water sanitation and hygiene (WASH), especially regular hand washing as a preventive measure to spreading the virus (FAO, 2020). COVID-19 is a disease caused by a novel strain of coronavirus linked to the same family of viruses such as Severe Acute Respiratory Syndrome (SARS) and some types of common cold (UNICEF, 2020). While the measures are necessary, this is a dilemma to people living without basic access to water and sanitation among the urban poor and vulnerable in the world and mostly in developing countries. In another dimension, Ogunbiyi (2020) argues that the pandemic adds pressure on countries that were already facing energy access challenges particularly Sub-Saharan Africa countries. Social distancing which is described as avoidance of crowded area, maintaining at least 2-meter distance between persons and staying at home when necessary has been identified as a preventive measure to spreading the virus. Social distancing is enforced on the assumption that population has access to reliable, affordable electricity to stay connected and continue communication, this is not a reality for most African countries such as Nigeria, Tanzania, and Uganda.

Furthermore, FAO (2020) reports that 113 million people in the world were already struggling with severe acute food insecurity before the onset of coronavirus due to pre-existing shocks and crises such as man-made conflicts, climate change, and economic crisis, meaning they already faced extreme hunger and are weak and less equipped to avoid the virus. The novel coronavirus is particularly deadly for populations with impaired immune systems. Hence, reduced access to nutritious foods in the face of this pandemic exposes the vulnerable to COVID-19 including, the elderly and those with underlying health conditions (WFP, 2020). No doubt, the global pandemic COVID-19 is escalating these challenges and threatening the development goals of increased human well-being, economic development, and poverty eradication.

Meanwhile, the WEF nexus approach has been highlighted as helpful in combating the challenges of water, energy, and food insecurities in Sub-Saharan Africa and fastening regional development (Nhamo et al., 2018). Most importantly, the accessibility and affordability of these basic resources to all sections of the population are expected to be the main focus of the nexus. Therefore, this study aims to assess the impacts of COVID-19 on the access to water, energy, and food nexus in Nigeria, Uganda, and Tanzania and identify the current policy interventions that aid in alleviating the impacts of COVID-19 on WEF nexus. To do this, the study would analyze the cases for water access, energy access, and food access in the countries under study individually, after which a general comparison will be made. Furthermore, the study examines the importance of localized innovations in improving access to water sanitation and hygiene. In line with the aforementioned, this study addressed the following research questions:

1. What is the nature of the relationship between the COVID-19 pandemic and water access in Nigeria, Uganda and Tanzania?
2. To what extent does a relationship exist between COVID-19 pandemic and energy access in Nigeria, Uganda, and Tanzania?

3. What sort of relationship exists between COVID-19 pandemic and food access in Nigeria, Uganda and Tanzania?
4. How is the government expected to intervene to address key water, energy and food (WEF) challenges caused by COVID-19?

The hypotheses of the study also follow the research questions thus:

HO1: There is no significant relationship between COVID-19 and water access in Nigeria, Uganda and Tanzania?

HO2: COVID-19 has no significant effect on energy access in Nigeria, Uganda and Tanzania.

HO3: There is no relationship existing between COVID-19 and food access in Nigeria, Uganda and Tanzania.

HO4: There is no expectation for government intervention on WEF challenges caused by the COVID-19 pandemic.

1.1 | Overview of COVID-19 pandemic in the world and Africa

According to WHO the first case of COVID-19 was reported in China on 31 December. From 31 December to 31 July 2020 the disease had spread to more than 200 countries worldwide, approximately 16 341 920 confirmed cases, 650 805 people had died globally, while Africa had 734,783 confirmed cases, with 12,476 deaths (WHO, 2020). Figure A1 shows weekly accumulation of cases globally and in Africa from the start of the pandemic to 31 July 2020.

The spread of the disease was rapid with Nigeria being among the first countries in Africa to report the first case on 28 February, followed by Tanzania on 16 March and Uganda on 22 March. Among the three countries studies, Nigeria has been severely hit by the pandemic causing a sharp decline in oil prices (WHO, 2020). Nigeria recorded 41,804 cases, Uganda recorded 1,135 cases and Tanzania recorded 509 cases with 891 death cases in total among the three countries within the period of study as shown in Figure A2 (WHO, 2020). The lower cases in these three countries and Africa generally has been solely attributed to low levels of testing among the population by some experts. In contrast, Chitungo et al., (2020) argued that even though low testing capacity and poor health systems could

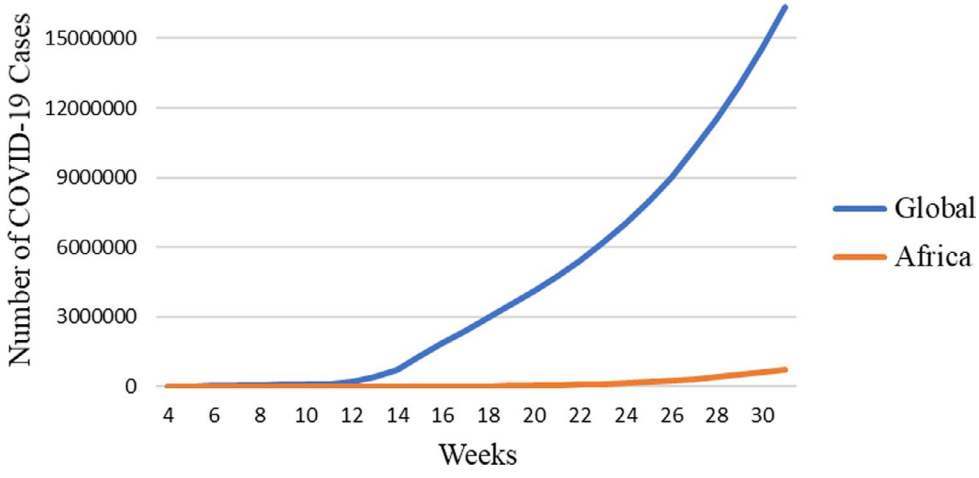

FIGURE A1 COVID-19 weekly cases globally and in Africa, February 25th −31st July 2020 (Source: WHO, 2020)

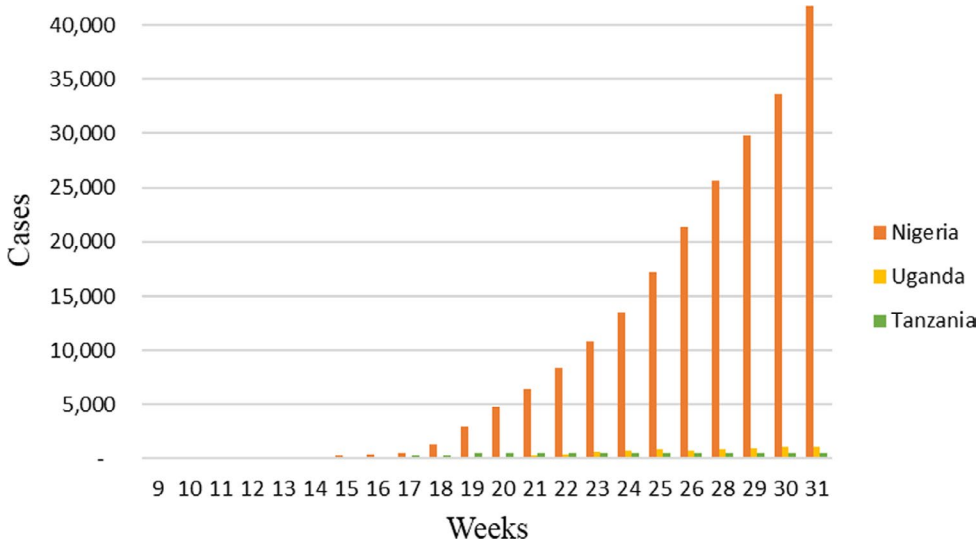

FIGURE A2 COVID-19 weekly cases in Nigeria, Uganda and Tanzania, February 25th −31st July 2020 (Source: WHO, 2020)

be among the reasons for low cases of COVID-19 in Africa, other factors such as early preventive measures (such as lockdowns) and low risk of importation of the disease from badly affected countries could be more responsible.

To contain the spread of the virus as the cases rise, the countries under study imposed different measures such that Uganda and Nigeria enforced a total lockdown where only essential workers continued while observing the Standard operating procedures (SOPs) including wearing a mask, washing hands with water and soap, social distancing, and closure of both national and international borders. In addition to the above, schools and public transport means were all closed, including social and public gatherings (churches, bars, funerals). Tanzania on the other hand responded by closing schools and universities, regional movement restrictions, social gathering restrictions, closure of international borders, traditional medicines, and incubation but also observed the standard SOPs like social distancing, hand washing, and wearing of mask.

While the pandemic has claimed lives and caused other serious challenges like loss of employment, the governments in these countries have taken measures to mitigate the impacts and provided relief to households. The Federal government of Nigeria reviewed the budget for 2020 in response to COVID-19, an intervention fund of N500 billion was set to support health related resources and income of the vulnerable (IMF, 2020). COVID-19 pandemic is projected by World Bank (2020) to contract Nigeria's output in advanced economies by 7 percent in 2020 adding strain on oil prices. As of 7 April 2020 , the Ugandan parliament approved UGX 304 billion in supplementary budget as an immediate response to facilitate Covid-19 outbreak (Development Initiatives, 2020). The government of Uganda also anticipated an increase in the number of poor people by 2.6 million, and a reduction in revenue from UGX 288.3 billion in FY 2019/20 to UGX 350 billion in FY 2020/21 owing to reduction in economic activity (UNDP, 2020). Additionally, due to the nationwide lockdown, it led to major reduction in both industry and manufacturing. Tanzania not being spared, the pandemic largely affected the country's economy causing decline in tourism, agricultural exports, and prices of commodities. Tanzanian government has spent about $8.4 million to address the effects of COVID-19 furthermore the government received grants to fund health sector to palliate the risks of the Pandemic (IMF, 2020).

1.2 | WEF nexus in Sub-Saharan Africa

Recently, the WEF nexus approach has gained popularity among scholars, researchers, international organizations, and other stakeholders (Endo et al., 2017). Meanwhile, access to clean water and sanitation, energy services, and sufficient food supply is key in reducing poverty and improving sustainable development. The complex relationship between these three resources is further expected to intensify due to increasing environmental pressures and climate change, population growth, urbanization, economic development, and changing consumer behaviors (Gulati et al., 2013; Terrapon-Pfaff et al., 2018). As population and urbanization increase, the need for more water, energy, and food resources also increase so as to fit to its growing needs.

However, achieving water, energy, and food security has been the biggest challenge facing the world. OECD (2014) reports that more than one billion people lack access to safe drinking water, one billion people suffer from hunger and 2.5 billion people do not have access to modern forms of energy. Worldwide the level of energy access is very low in Sub-Saharan Africa (SSA). Approximately half of the people have access to electricity whereas one-third access clean cooking; about 600 million people have no electricity (IEA, 2018).

Water and energy scarcity are severe in most parts of the world with an estimated 1.6 billion people already under severe water stress, an additional 1.2 billion are under medium water stress and 1.1 billion people still have no access to modern energy services (Lele et al., 2013). Food production is expected to increase by 60% by 2050 to feed the projected 9 billion global population, in which the most growth is expected to occur in South Asia and Sub-Saharan Africa. Global energy demand is expected to increase by 60%–85% (IEA, 2013).

In West Africa, electricity has conventionally been provided through hydropower that is the most well established and widely used technology in the region. Nigeria was the top producer of hydropower in West Africa region with the capacity of 2 GW installed in 2015. Ghana followed with a total of 1.6 GW (IRENA, 2017). According to the World Bank statistics the rate of electricity access in Nigeria, Tanzania, Uganda as per 2017 is 54.4%, 32.8%, and 22% respectively. With this level of lack of energy access, economic growth, and sustainable development are highly interrupted. (World Bank, 2017).

By 2010, according to the analysis of SSA annual food statistics, none of the five East African countries were able to meet their Global hunger Index targets (ECA, 2012). In 2017, a technical report prepared by IPC stated that approximately 10.9 million people were experiencing acute food insecurity while 1.6 million suffered a crisis situation (IPC, 2017). According to the observations of Mukuve and Fenner, (2015), food security is a major concern in Uganda and water scarcity has been identified as a major contributor to this problem. This further shows that water, food and energy are inextricably linked. Furthermore, Uganda needs to embrace climate resilient technologies such as rainwater harvesting to overcome the challenges of water scarcity and food insecurity at the same time (Durodola et al., 2020). Water is an essential input for food or energy production however scarcity for all three WEF sectors can manifest as water scarcity.

Sub-Saharan Africa, particularly the rural section is noted to have the world's greatest water and sanitation challenges (WHO/UNICEF, 2008). In addition to the above claim, Nigeria is among the countries most affected by global water scarcity, and out of the 783 million global population without access to clean water 40% of these reside in SSA (Rodriguez, 2019).

1.3 | Connection of COVID-19 with water and sanitation

It has been 10 years since the United Nations recognized water and sanitation as a fundamental human right. Access to sufficient and safe water and adequate sanitation is a human right and a

keystone to protecting human health in the light of COVID-19 pandemic. Furthermore, targets 6.1 and 6.2 of the Sustainable Development Goal 6 (SDG 6) aims to achieve universal and equitable access to safe and affordable drinking water as well as achieving adequate sanitation and hygiene for all by 2030 According to UNESCO (2019), about two billion people are still left behind due to lack of access to water and sanitation facilities. The global pandemic raises awareness on the importance of water and sanitation as means to fighting the spread of the virus and what needs to be done to ensure access to water and sanitation to everyone both as a human right and protection of human health.

Despite the challenges faced by many water utilities in developing countries towards ensuring water access, some have resorted to drastic measures of ensuring constant water supply, covering water bills for the poor communities, and freezing water shutoffs in the face of COVID-19 (Godfred, 2020).

1.4 | Connection of COVID-19 with energy

The energy sector has a special relationship with COVID-19, the global pandemic has clearly highlighted the importance of energy equality. Energy equality means "practice of providing all individuals with equal access and use of energy resources" (Jenna, 2020). Energy inequality happens most in developing countries. The pandemic adds pressure on countries that were already facing energy access challenges particularly Sub-Saharan Africa countries. About 840 million people in Sub-Saharan Africa have no access to electricity plus more than hundreds of millions have limited access to reliable electricity necessary to cook, store food and cool homes (Ogunbiyi, 2020). The ability of health facilities to treat infected populations depends on full access to sufficient, uninterrupted, and reliable electricity. As cases grow in Africa, healthy facilities face more challenges to cope with infrastructure and sufficient energy access in treating critical patients. According to WHO in 2014 only 34% of health facilities in Sub-Saharan Africa have reliable access to electricity without prolonged interruptions (WHO, 2014).

1.5 | Connection of Covid-19 with food

While COVID-19 pandemic unfolds, the global food system is at risk especially in the developing and least developed countries. Furthermore, the pandemic poses threat to the realization of target 2.1 of the SDGs which is to end hunger and ensure access to sufficient and nutritious and sufficient food by all people especially the vulnerable people and infants by 2030. FAO (2020) reports that 113 million people in the world were already struggling with severe acute food insecurity before the onset of coronavirus due to pre-existing shocks and crises such as man-made conflicts, climate change, and economic crisis, meaning they already faced extreme hunger and are weak and less equipped to avoid the virus.

Presently about 1.2 billion people in Africa are highly malnourished meaning they are more vulnerable to COVID-19. Social distancing in Africa in the face of pandemic COVID-19 will impact food access and production (WFP, 2020). Many dwellers in urban and peri-urban areas face poverty and already struggle to get food as a result of working in informal sectors, most can afford to buy in small quantities of food from small shops and open-air markets. Efforts to combat the spread of viruses might compromise people's ability to access food (Moseley, 2020).

1.6 | Impacts of COVID 19 on water, energy, and food nexus

International human rights laws bind the state's commitment towards achieving universal access to water and sanitation for all, without discrimination, while prioritizing those most in need. More than three-quarters of households in developing countries do not have sufficient water facilities (UNESCO, 2019). Poor policy implementation is worsening the situation leaving many at risk of contracting the virus due to lack of access to water and sanitation, in Cape Town water disconnection policy is still implemented by municipalities despite the pandemic at the same time, mobility is limited as a result of quarantine (Bui, 2020).

While it is argued that the novel coronavirus has not shown a direct impact on the supply or price of staple food globally, policymakers are still contending on the impacts around COVID-19 on food supply, demand, and trade, to ensure that the pandemic does not translate into a food crisis (Moseley, 2020). The coronavirus is not only a global health crisis but also a major energy supply and access crisis. Universal access to electricity is a target (7.1) of the SDGs and the pandemic could delay its realization. However, COVID-19 has caused a reduction in oil demand, resulting in oil prices and production dropdown as a result of the Russia-OPEC price war (PWC, 2020).

2 | METHODOLOGY

In this study, an online survey using Google Forms was administered through the use of the internet in the study areas—Nigeria, Uganda, and Tanzania. The survey targeted the nationals of the aforementioned countries who were, at the time of the survey, living in the country and not abroad across all socio-economic backgrounds. These three countries were selected as the case studies for the following reasons:

TABLE A1 Geographical distribution of respondents

NIGERIA		UGANDA		TANZANIA	
Region	**Number of responses**	**Region**	**Number of responses**	**Region**	**Number of responses**
Lagos	50	Buganda	47	Dar es Salaam	80
Oyo	27	Ankole	36	Arusha	19
Ekiti	11	Kigezi	18	Zanzibar	26
Rivers	47	Rwenzori	27	Dodoma	24
Anambra	37	Tooro	16	Kagera	15
Enugu	23	Bunyoro	12	Mwanza	22
Imo	28	West Nile	26	Lindi	7
Katsina	15	Busoga	23	Pwani	9
Adamawa	29	Teso	17	Morogoro	18
Abuja	33	Lango	14	Tanga	12
Kogi	20	Acholi	16		
Abia	24	Karamoja	14		
Total Responses	**344**	**Total responses**	**266**	**Total responses**	**232**

Source: Authors.

a. The peculiarities of access to water, energy, and food in the pre-COVID-19 era.
b. The three countries have different policy approaches to curtain the virus.

The study also targeted, not just the private individuals who may bear the brunt of the availability or lack of access to water, energy, and food, but including experts in organizations involved in water, energy, and food such as National Water and Sewerage Corporation of Uganda, Ugandan Ministry of Energy & Mineral Development, IrriSol Engineering Company, Tanzanian Energy and Water Utilities Regulatory Authority, Nigerian Water Board, Energy Commission of Nigeria, the Institute of Agricultural Research and Training in Nigeria and many others. Even though the specialists in these organizations were not interviewed separately, they are regarded as the key informants for the study.

Geographically, respondents were drawn across 12 regions in Nigeria, 12 regions in Uganda and 10 regions in Tanzania. Table A1 presents the number of responses across these regions. It shows that the survey covered all the regions where COVID-19 cases were reported in the three countries as at the time of this study.

A close-ended or multiple-choice survey questions were chosen to ensure precision in the analysis and avoid over-quantification of the core variables of the study. Availability of research assistants in the countries who monitored the data collection. The three specific objectives of this study are to investigate the relationship between COVID-19 and (a) water access, (b) energy access, (c) food access in Nigeria, Uganda, and Tanzania." The software employed for this analysis is Microsoft Excel 2016 and EViews 9.

2.1 | Study design and data collection

In determining the appropriate sample size for the three countries, Smith's formula (Smith, 2013) given in Equation 1 was employed for the study. A confidence level of 99%, a 5% error margin, and a standard deviation of 0.5 which gives a corresponding *Z*-score of 2.576 was used. The result when these values are inputted into Equation 1 gives a sample size of 664 from the study areas.

$$\text{Sample size} = \frac{(Z-score)^2 \times standarddeviation \times (1 - standard\,deviation)}{(Error\,margin)^2} \quad (1)$$

The questions of the survey were structured according to the objectives of the study which are similar to the questions of Geldsetzer (2020). The survey had instructions for the respondents such as stating that the form must not be filled twice and guidance on making the filling of the form easy. The questions were close-ended, multiple-choice, concise, and easy to answer. The questions of the survey were divided into two (2) sections; the first section covered socio-economic status, educational level, sex, and country of the respondents while the second section centered on the impacts of the pandemic on WEF nexus. Also, the questions on WEF nexus was based on the 5-point Likert scale of the questionnaire (Falola et al., 2018). It is also important to note that the survey was conducted in Swahilli for Tanzania and English for Nigeria and Uganda being the official languages for these countries.

Furthermore, following lockdown and movement restrictions currently enforced in the study areas, the survey was administered online throughout. The target population of the survey were practitioners in the WEF, WEF students, farmers, food supply chain workers, and policy makers. Consequently, to reach a wide range of respondents, reach different parts of the countries, and cover several socio-economic statuses, the link of the survey was shared through different media. The media utilized in administering the survey include emails, Facebook, LinkedIn, Instagram, and WhatsApp to ensure

a paperless survey which is part of climate actions. Preceding the administration of the survey, it was tested and feedbacks were received on the contents. Finally, the survey was administered for fifteen (15) days from 10 April to 25 April 2020. Thereafter, the response option of the online form was blocked thereby terminating further responses. In total, 842 responses were received. In detail, 344, 266, and 232 responses were recorded from Nigeria, Uganda, and Tanzania, respectively, and this number of respondents is in line with a priori expectation and the targeted number of respondents. As suggested by Israel (1992) also, a sample size within the range of 200 and 500 is usually robust enough for a modest statistical analysis as carried out in this study. Our sample size, therefore, meets the criteria.

2.2 | Ethical issues

For this research, ethical issues were adequately observed with the corresponding ethical guidelines strictly followed. First, to assure the respondents of their confidentialities, a consent declaration was written at the beginning of the survey. Thus, the form was anonymous which implies that the respondents' names and other personal information that could make them uncomfortable were avoided. Second, the relationship with the respondents was professional as the respondents were not compelled to participate in the survey thus participating in the study was completely voluntary. Third, the respondents did not need to answer all the questions as they may feel uncomfortable with some of them.

2.3 | Data analysis

For objective one, fluctuations in water access are captured using such indicators as water access during the pandemic, sanitation mode, hand washing pattern, type of hand washing facility used, and government actions relating to water access to reduce the spread of coronavirus, and were analyzed using the responses from the online survey conducted as these are core parameters for promoting sanitation according to Orencio et al. (2016). To effectively do this, the responses with the highest frequency for all the questions on water access in one country, say Nigeria, are weighed against the same for the other countries. This approach has been suggested by Guillaume et al. (2015) and hence, forms the basis of the analysis from where the conclusion ensues. Also, to analytically describe the variables mentioned above and the other variables used to indicate energy access and food access, a numerical weight is assigned to each of the responses it ranges from 1 to 5, depending on the variable under consideration and the number of the responses therein.

For the second objective, the relationship between COVID-19 and energy access in the three countries under study, energy access is indicated by such variables as electricity access during the pandemic, fluctuations in energy product prices, energy affordability, energy situation before the pandemic, and preferred government action for improved energy access (Keskinen et al., 2015). The estimation technique employed for this objective is the same as that of the first objective described above.

Some of the variables that will effectively indicate the third objective are food access since the outbreak of the pandemic, food prices, affordability of food, the nutritional value of available food, and the most desired assistance during the pandemic, in line with the submissions of Abdallah and Rosenberg (2014); Al-Bakri et al. (2013). The analytical technique also remains the same with the other objectives. This also implies that, for the entire analysis carried out to address the stated objectives, the responses were weighted accordingly.

2.4 | Limitations

There are few limitations identified in this study. First and foremost, it is imperative to acknowledge that the number of respondents in this study is small compared to the population of the three countries. Consequently, the study aimed to offer insights and examine relevant policy frameworks as well as innovations during the pandemic in these countries. Thus, the findings of this study should not be generalized to reflect the exact situation of the factors studied in the study area but can provide strong background for policy makers. Second, the survey is limited to internet users who are largely urban dwellers and fall within the lower, middle or upper-income brackets, mainly attributed to the fact that the urban dwellers mostly have access to the various online media through which the questionnaire was administered. This further implies that the impacts on rural dwellers might not be adequately captured by these findings, and hence, we are not able to predict how the inclusion of rural dwellers could have influenced the results of the study. Third, although, there was no incentive attached to filling the survey which could have prompted multiple responses from a respondent, still no method of identifying multiple responses from a respondent was utilized. But there is no basis for a respondent to send multiple responses thus this does not pose any bias to the sampling. Finally, the survey did not capture the family size of the respondents which could have provided more insights on the results. It is assumed that the socio-economic status of the respondents catered for this.

3 | RESULTS AND DISCUSSIONS

In this section, we present and discussed the results of our analysis in line with the aims of the study stated earlier. It also highlights also, how the effects of the COVID-19 pandemic has been felt more in Nigeria and Uganda than in Tanzania and how individuals from these countries expect their respective governments to intensify efforts in reducing the cost of energy.

3.1 | Socio-economic background of respondents

Figure A3 shows the gender distribution of the respondents from the three countries. More than half of the respondents in each of the three countries under study are male; 54.9% of total respondents in Nigeria, 69.5% of total respondents in Uganda and 55.6% of the total respondents in Tanzania. This implies that the remaining percentages are female. A few respondents prefer not to disclose their gender. The gender distribution of respondents is purely random. Also, looking at the total respondents from the study countries combined, 503 are males, 327 are females and 12 prefer not to say, making the total number of respondents—842 since all responses are complete and valid.

The educational status of the respondents is shown in Figure A4. It reveals that majority of the respondents from the three countries have at least a bachelor's degree followed by people who are undergraduates or have a certificate higher than high school but not up to bachelor's degree.

This is also not surprising since the survey was conducted online. Many of the respondents were also employed in both private and public organizations as at the time of the survey, with their portfolios ranging from lecturers, and civil servants in federal government parastatals to shop owners, business people, independent researchers etc.

According to Figure A5, the majority of the respondents in Tanzania belong to the middle-income class when compared to Nigeria and Uganda that have the majority of the respondents in low-income class. The categorization also follows the World Bank's classification of countries based on their per capita income; where countries with less than $1,026 per capita are within the low-income bracket,

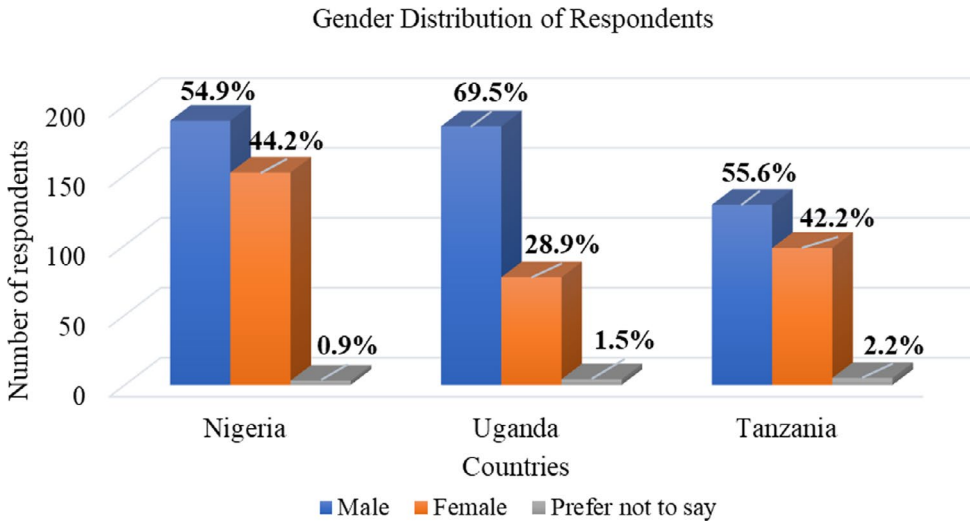

FIGURE A3 Gender distribution of respondents

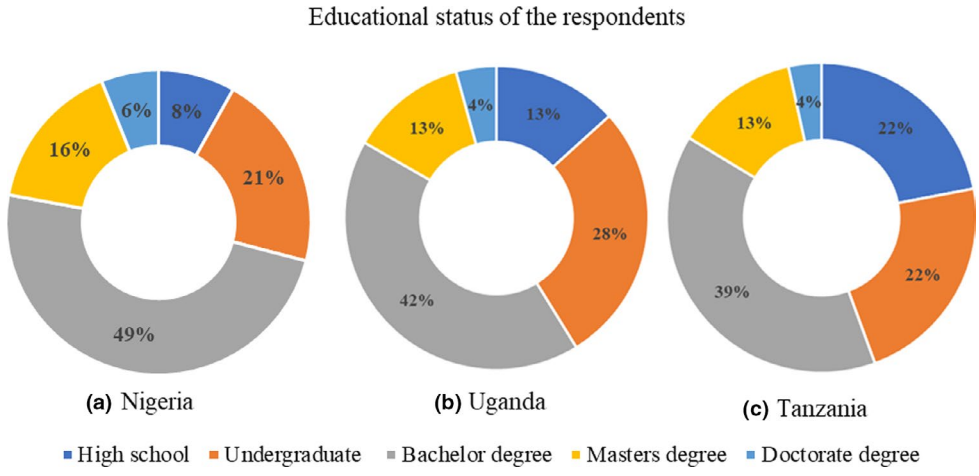

FIGURE A4 Educational status of the respondents

those with a per capita income ranging from $1,026 to $12,375 are middle income countries and those whose per capita income are above $12,375 are high income countries. This income classification was adopted for the survey, because, based on an earlier pilot study, the respondents are not very explicit with their income and spending details both before and during COVID-19 times due to the cultural and environmental beliefs. This is also a limitation.

3.2 | Sources of water, energy, and food of the respondents

The sources of water, energy, and food of the respondents were also sampled as given in Table A2. For source of water supply, the majority of respondents in Nigeria (31%) buys water from water vendors (boreholes) while those in Uganda (36%) and Tanzania (33%) mostly use public tap (provided by government. Meanwhile for energy in this study, only energy for heating (cooking), lightings, and cooling

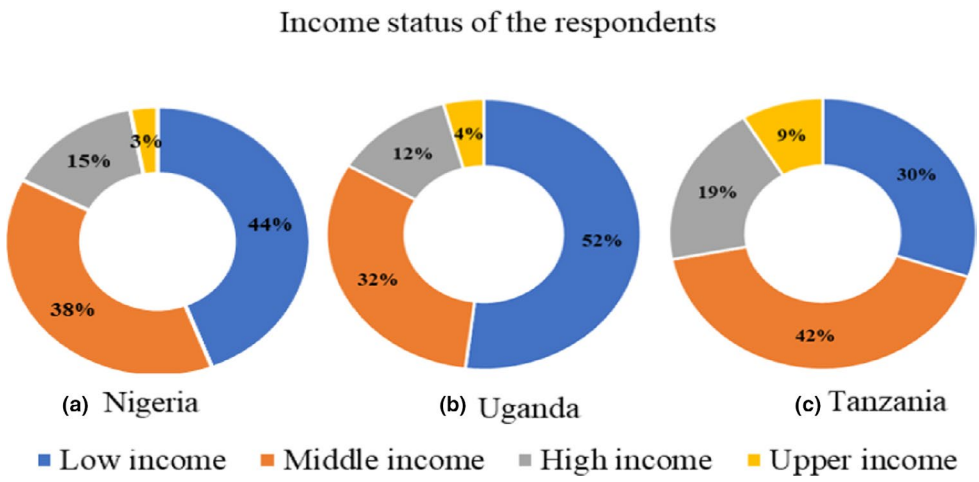

FIGURE A5 Income status of the respondents

TABLE A2 Respondents' sources of water, energy, and food

(A) Water	Own tap/borehole (%)	Public tap (%)	Water vendors (%)	Open sources (rivers etc.) (%)
Nigeria	26	15	31	28
Uganda	13	36	29	22
Tanzania	32	33	17	18
(B) Energy	**Solar (%)**	**Gas (%)**	**Kerosene (%)**	**Charcoal and firewood (%)**
Nigeria	9	30	32	29
Uganda	3	21	13	63
Tanzania	7	18	26	49
(C) Food	**Produces own food**	**Buys food**	**Produces and buys food**	
Nigeria	12	61	27	
Uganda	11	36	53	
Tanzania	28	47	25	

were considered. The energy supplied from the National grids were not considered. The results show that majority of respondents from Uganda (63%) and Tanzania (49%) uses charcoal and firewood than other sources of energy while their counterparts in Nigeria (62%) uses more of kerosene and gas. This could be attributed to the fact that Nigeria is an oil producing state which makes these products available and affordable. In terms of sources of food, majority of respondents in Tanzania (47%) and Nigeria (61%) buys all their foods while those in Uganda (53%) produces and buys their foods at the same time.

3.3 | Relationship between COVID-19 and water access

The first objective of this study is to ascertain the relationship between COVID-19 and water access in Nigeria, Uganda, and Tanzania. To achieve this objective, the results of the survey are presented

below. First, the descriptive statistics for the core variables used to depict water access in the three countries under study were defined and examined as follows:

Waccess: Level of water access in the presence of the COVID-19 pandemic.

Sanmode: Mode of sanitation used.

Hwfacility: Hand washing facility available.

Handwash: Hand washing as a preventive measure to COVID-19.

Govaction: Preferred government action for combatting the spread of coronavirus.

Table A3 in Appendix A, therefore, show the descriptive statistics of these variables for the countries under study: (a) Nigeria, (b) Uganda, and (c) Tanzania, respectively.

From Table A3 for (a) Nigeria, *waccess* has the highest median of 4.000 while *sanmode* and Hwfacility have the lowest median of 1.000. The median values are the middle values of the total observations for each of the variables mentioned above. Also, the variables that have the highest maximum values are *waccess* and *govaction* and the maximum value is 5. From Table A3 which describes the observations from (b) Uganda, three of the variables have the same median score; *waccess*, *handwash*, and *govaction*, while *waccess* and *sanmode* have the highest and lowest mean values, respectively. This is very similar to the observations describing (c) Tanzania. For all the variables, the minimum is 1 and the maximum is 5, possessed by *govaction* and *waccess*, which also has the highest median score.

TABLE A3 Descriptive statistics of water access in the presence of COVID-19

(a) Nigeria					
	WACCESS	**SANMODE**	**HWFACILITY**	**HANDWASH**	**GOVACTION**
Mean	3.625000	1.113372	1.415698	2.953488	3.351744
Median	4.000000	1.000000	1.000000	3.000000	3.000000
Maximum	5.000000	3.000000	4.000000	3.000000	5.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	344	344	344	344	344
(b) Uganda					
	WACCESS	SANMODE	HWFACILITY	HANDWASH	GOVACTION
Mean	3.353383	1.372180	1.586466	2.947368	3.462406
Median	3.000000	1.000000	1.000000	3.000000	3.000000
Maximum	5.000000	3.000000	4.000000	3.000000	5.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	266	266	266	266	266
(c) Tanzania					
	WACCESS	SANMODE	HANDWASH	HWFACILITY	GOVACTION
Mean	3.512931	1.211207	2.956897	1.525862	3.435345
Median	4.000000	1.000000	3.000000	1.000000	3.000000
Maximum	5.000000	3.000000	3.000000	4.000000	5.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	232	232	232	232	232

TABLE A4 Effects of COVID-19 on water access

	Responses with the highest frequency for Nigeria	Responses with the highest frequency for Uganda	Responses with the highest frequency for Tanzania
Rate your access to water for personal hygiene and sanitation during COVID−19	5 – Very High *(30.8%)*	5 – Very High *(26.3%)*	5 – Very High *(33.2%)*
What mode of sanitation are you using?	Private toilet *(89.2%)*	Private toilet *(64.7%)*	Private toilet *(79.3%)*
Do you wash your hands as a preventive measure to COVID−19	Yes, with water and soap *(89%)*	Yes, with water and soap *(88.7%)*	Yes, with water and soap *(96.1%)*
What type of hand washing facility are you using during this period?	Existing facility *(57%)*	Existing facility *(66.5%)*	Existing facility *(55.6%)*
Which of these has the government done to reduce the spread of coronavirus?	Raised awareness on hand washing *(83.1%)*	Raised awareness on hand washing *(88.3%)*	Raised awareness on hand washing *(80.2%)*

Table A4 in Appendix A analyses the results of the effect of COVID-19 on water access in Nigeria, Uganda, and Tanzania. From the responses, it is easy to see that the three countries have similar realities in terms of water access, judging from the responses with the highest frequencies for all the questions on water access. This could also be because most African countries have different water sources, although some may not be very safe for drinking and/or other household activities, and also have similar sanitation facilities (Kumar, 2015). In this study, adequate access to water supply and sanitation are classified jointly because, according to the UNICEF Report (2006), safe water, sanitation, and good hygiene are fundamental to health and survival, and could be discussed together to address the environmental realities. It is also pertinent to say that a separate discussion of water supply and sanitation could aid in a deeper understanding of the two, especially as they affect African countries.

Majority of the responses from the three countries revealed high access to water for personal hygiene and sanitation despite the presence of the COVID-19. This is justifiable as a threat to water security in a community may not have an instantaneous impact on water sources that are already in existence, for example, the household borehole system, rainwater harvesting, etc. (Bekchanov & Lamers, 2016). Also, the use of private toilets has become commonplace in these countries under study, shown by the observations. This might not be unconnected with the socio-economic status of the respondents. Public toilets in most countries in Sub-Saharan Africa tend to be unhygienic most times, and are, therefore, avoided by the general populace unless in an emergency situation (Haie, 2015). 89%, 88.7%, and 96.1% of the respondents from Nigeria, Uganda, and Tanzania indicated that they make use of water and soap for washing their hands as a preventive measure for COVID-19. This may be highly correlated with the fact that the government actions in the three countries in the presence of the pandemic focus more on sensitizing the masses on the importance of hand washing, and not on the other palliatives, as also shown in the last question in Table A4 relating to water access. It is also worthy of note here that 39.7%, 16.2%, and 9.9% of the respondents in Tanzania, Uganda, and Nigeria, respectively, have devised new facilities for hand washing and exhibited innovations in their responses to the pandemic. The place of innovation cannot be underestimated in increasing access to hand washing during this pandemic. Meanwhile, analysis shows that the majority of hand washing and personal hygiene used in these countries to combat COVID-19 have been in existence before the outbreak. However, this study shows that innovations in WASH using localized materials have been encouraging and there are emerging innovations that will certainly remain relevant after the pandemic since people are constantly devising new ways of solving basic developmental problems (Elbehri & Sadiddin, 2016). Furthermore, these innovations in hand washing and sanitation might be the game changer that will accelerate the realization of target 6.2 of SDGs in these three countries.

Figure A6 in the Appendix B also shows the respondents' rating of their access to water and sanitation on a scale of 1 to 5, with the latter indicating the highest access and the former indicating the lowest access. From the figure, respondents from Tanzania have the highest access across the three countries with about 33% of them saying that their water access is still high despite the COVID-19 outbreak, followed by Nigeria with 30.8% of the total respondents and then Uganda with 26.3% of the respondents. This scale of 5 therefore, got the highest selections across the entire histogram. For Nigeria, the responses follow a descending order (chronologically from 5 to 1), but this is not the case with Uganda and Tanzania.

From the analysis, therefore, it could be deduced that while COVID-19 has improved the general hygiene of the people in the three countries under study as well as triggering innovations in handwashing facilities. The results of this study are also in accordance with several studies and news. For instance, SATO developed an innovative handwashing solution for households in Nigeria and extended it to other African countries which helped in curtaining the spread of the virus (Africa News, 2020). Similarly, a new handwashing technology with simplified soap was developed by the London School

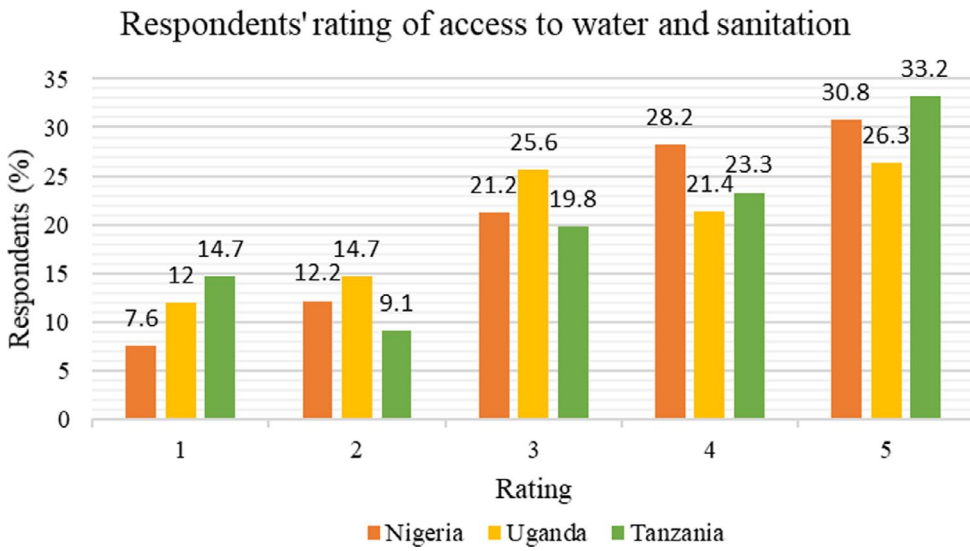

FIGURE A6 Respondents' rating of access to water and sanitation (5 is highest)

of Hygiene and Tropical Medicine (LSHTM) which has being piloted in Tanzania showed some outstanding results in curtaining infectious diseases such as COVID-19 (Imperial College London, 2020). Apart from these, many pedal operated handing washing machines have been innovated in different parts of Africa such as Kenya (GeoPoll, 2020). Nevertheless, there are no evident changes in water supply sources, as many people still collect water from sources that they are used to. This further implies a negative but weak relationship between COVID-19 and water access in Nigeria, Uganda, and Tanzania.

3.4 | Relationship between COVID-19 and energy access

To effectively analyze the effects of COVID-19 on energy access in Nigeria, Uganda, and Tanzania, the descripted statistics of the variables used to indicate energy access derived by renaming the questions relating to energy access in the questionnaire were defined and examined as follows:

Electaccess: Level of electricity access.

Enafford: Energy affordability.

Enprices: Prices of energy products.

Greaccess: Preferred government's role towards improving energy access.

Sitbp: Energy situation before the COVID-19 pandemic.

Also, each of these variables has different numerical values, based on the number of possible responses for each. The descriptive statistics for each of the countries are numbered: Table A5 for (a) Nigeria, (b) Uganda, and (c) Tanzania, respectively.

From Table A5 in Appendix A, the basic descriptive statistics of the core variables indicating energy access are revealed. With a sample size of 344 observations for (a) Nigeria, 266 for (b) Uganda and 232 for (c) Tanzania, electricity access has the highest mean in (b) Uganda and (c).

Tanzania while the government's role towards energy access has the highest mean in (a) Nigeria. Also, electricity access for all the countries has the highest maximum value because the number of possible responses to the question that generated the variable is equally higher than that of others.

Analyses of responses.

TABLE A5 Descriptive statistics of energy access in the presence of COVID-19

(a) Nigeria					
	ELECTACCES	ENAFFORD	ENPRICES	GREACCESS	SITBP
Mean	2.857558	1.950581	1.822674	3.145349	1.491279
Median	3.000000	2.000000	2.000000	4.000000	1.000000
Maximum	5.000000	3.000000	4.000000	4.000000	3.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	344	344	344	344	344
(b) Uganda					
	ELECTACCES	ENAFFORD	ENPRICES	GREACCESS	SITBP
Mean	3.293233	1.902256	2.296992	3.093985	1.319549
Median	3.000000	2.000000	2.000000	4.000000	1.000000
Maximum	5.000000	3.000000	4.000000	4.000000	3.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	266	266	266	266	266
(c) Tanzania					
	ELECTACCES	ENAFFORD	ENPRICES	GREACCESS	SITBP
Mean	3.693966	1.706897	2.038793	3.349138	1.564655
Median	4.000000	1.000000	2.000000	4.000000	1.000000
Maximum	5.000000	3.000000	4.000000	4.000000	3.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	232	232	232	232	232

Table A6 in Appendix A presents results regarding the perceived effects of the COVID19 pandemic on the three countries under study, judging from the responses to all the questions on energy access. While the majority of the respondents in Nigeria and Uganda opined that their electricity access in the presence of the pandemic is only moderate or enough to attend to the basic energy needs, mostly under lighting, heating, cooling, and cooking as suggested by Kumar (2015), when compared to the period before the outbreak of the virus, the Tanzanian counterparts indicated that their electricity access, despite the outbreak of the virus, remains very high. This reduction in the electricity access rates in Nigeria and Uganda did not affect the prices of the energy products such as kerosene, gas, diesel, and petrol; as the bulk of the respondents agreed that there may not have been any changes in the prices of these products. This reality is especially useful to Nigeria and Uganda as it will enable them to easily complement their moderate electricity access with the use of alternatives such as the generating sets, which require these energy products to function.

One interesting observation from Table A6 is that even though the prices of energy products are reported not to change, or at least significantly, the majority of the respondents from Nigeria and Uganda further revealed that they still cannot afford them. This is justified by the number of responses on the negative, and in line with the argument of Hamiche et al. (2016) that there is an upward trend in the prices of key renewable energy products such as petrol and kerosene in Nigeria and Uganda within the last 2 years The regular income of many workers could drastically reduce in the case of a global crisis because most companies resort to pay cuts to keep their organizations afloat, and this reduces

TABLE A6 Effects of COVID-19 on energy access

	Responses with the highest frequency, for Nigeria	Responses with the Responses with the highest frequency, highest frequency, for Uganda for Tanzania	
Rate your access to electricity during the pandemic	3 – Moderate *(34.9%)*	3 – Moderate *(25.6%)*	5 – Very High (34.1)
The prices of kerosene, gas, diesel, and petrol in my area during the pandemic	Remain the same *(48%)*	Remain the same *(63.9%)*	Remain the same *(68.5%)*
I can afford the cost of energy I need at home	No *(35%)*	No *(42.9%)*	Yes *(51.3%)*
Was the situation different before the pandemic?	Yes *(57%)*	Yes *(72.6%)*	Yes *(50.6%)*
The government can help in increasing energy access during the pandemic if they	Reduce the cost of energy *(55.2%)*	Reduce the cost of energy *(57.5%)*	Reduce the cost of energy *(68.5%)*

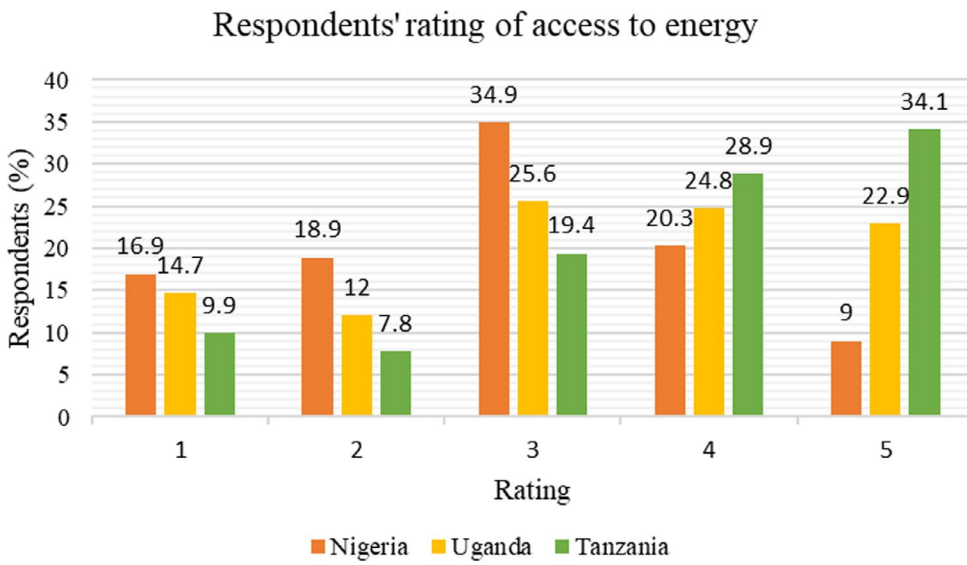

FIGURE A7 Respondents' rating of access to energy (5 is highest)

the overall purchasing power of workers. Thus, this could further affect the affordability of water, food, and energy by those affected. In this scenario therefore, even with no changes in prices of energy products, the income may not be enough to cater for it. The case is different for Tanzania, where 51.3% responded in the affirmative meaning that they can afford their energy needs even in the presence of the pandemic. It is also worth mentioning that the energy affordability of the majority of the population of the three countries was better before the outbreak of the virus, as also seen in Table A6. Finally, the most desired government action is that which will lead to a reduction in energy cost, either

in the form of reduced electricity bills, subsidized energy products, or energy holidays. This implies that, for most of the respondents, their major needs during the pandemic are energy needs, especially electricity to power the gadgets for online meetings, receipt of information about global happenings, as well as for online transactions since most physical markets are also affected. As mentioned above, the percentages in Table A6 are at 99% confidence interval.

Figure A7 in the Appendix B also highlights the respondents' rating of their access to energy on a scale of 1 to 5, with the former indicating the lowest access and the latter indicating the highest access. For Uganda and Tanzania, the largest proportion of respondents agree that their energy access, even with the presence of the COVID-19 pandemic could still be described as high. This is not the case with Nigeria, as most of the respondents suggest that their energy access since the outbreak of the virus is only moderate.

Furthermore, from the analysis above, a negative relationship between the COVID-19 and energy access in Nigeria, Uganda, and Tanzania was observed. Yet, while the effects of the virus are very high and much more significant in Nigeria and Uganda, as suggested by the responses, the effects in the East African country of Tanzania are mild. It is important to note here that the study focused on household energy consumption for heating, cooling, lighting etc. The type of energy also is fossil-based, for example, kerosene, diesel, and gas. This is because these energy products are the major sources of energy for household consumption in these countries, in addition to fuel wood. Another interesting observation is that many of the respondents do not keep adequate account of their energy expenditure, and this could be attributed to the lack of energy efficiency consciousness in most Sub-Saharan African countries (Akrofi & Antwi, 2020).

3.5 | Relationship between COVID-19 and food access.

The third objective of this study was to investigate the relationship between COVID-19 and food access in (a) Nigeria, (b) Uganda, and (c) Tanzania. A descriptive statistic of the core variables used to indicate food access, derived from the questions about food access in the online survey conducted was examined. The variables are defined as follows:

Faccess: Access to food in the presence of COVID-19.

Fafford: Food affordability.

Fprices: Prices of food in the presence of COVID-19.

Nutval: Nutritional value of food available.

Mirelief: Most important relief needed in the face of the pandemic.

From Table A7, *Fprices* has the highest mean score while *Nutval* has the lowest. Also, the highest median score is possessed by *Mirelief* while *Faccess* has the highest maximum score in line with the number of possible responses to the question that generated the variable. In Table A7, (b) Uganda is also similar to (a) Nigeria as it shows the 266 observations for (b) Uganda. *Fprices* have the highest mean score and *Nutval* has the lowest. Finally, from (c) Tanzania, *Faccess* has the highest mean score and *Nutval* also has the lowest. For the three countries, the minimum value for all the variables is 1 while 5 is the maximum score for *Faccess* and *Mirelief*.

Table A8 in Appendix A shows a higher standard of living for the Tanzanians compared to the Nigerian and Ugandan counterparts, as also suggested by Mukuve and Fenner (2015a). This also might be associated with the socio-economic status of the respondents. The respondents from the three countries agreed that their access to food in the presence of the pandemic could be best described as moderate. This is expected as many governments implemented a lockdown policy which has a negative toll on food production since the major players in the food supply chain are barred from working.

TABLE A7 Descriptive statistics of food access in the presence of COVID-19

(a) Nigeria					
	FACCESS	FAFFORD	FPRICES	NUTVAL	MIRELIEF
Mean	2.895349	2.136628	3.084302	2.005814	2.802326
Median	3.000000	2.000000	3.000000	2.000000	4.000000
Maximum	5.000000	3.000000	4.000000	3.000000	5.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	344	344	344	344	344
(b) Uganda					
	FACCESS	FAFFORD	FPRICES	NUTVAL	MIRELIEF
Mean	2.755639	2.082707	2.872180	2.003759	2.492481
Median	3.000000	2.000000	3.000000	2.000000	2.000000
Maximum	5.000000	3.000000	4.000000	3.000000	5.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	266	266	266	266	266
(c) Tanzania					
	FACCESS	**FPRICES**	**FAFFORD**	**NUTVAL**	**MIRELIEF**
Mean	3.284483	2.637931	1.758621	1.711207	3.129310
Median	3.000000	3.000000	1.000000	1.000000	3.000000
Maximum	5.000000	4.000000	3.000000	3.000000	5.000000
Minimum	1.000000	1.000000	1.000000	1.000000	1.000000
Observations	232	232	232	232	232

TABLE A8 Effects of COVID-19 on food access

	Responses with the highest frequency for Nigeria	Responses with the highest frequency for Uganda	Responses with the highest frequency for Tanzania
Rate your access to food in this pandemic	3 - Moderate *(41.9%)*	3 – Moderate *(30.8%)*	3 – Moderate *(28.9%)*
The prices of food in my area	Increased up to 50% *(63.7%)*	Increased up to 50% *(65%)*	Increased by up to 50% *(47%)*
Can you afford the foods you want now?	No *(41%)*	No *(54.1%)*	Yes *(52.2%)*
Are you getting the nutritional value you want?	No *(57%)*	No *(59%)*	Yes *(52.6%)*

This could have contributed to a hike in the prices of the available food by more than half of the old prices, as indicated by the majority of the responses in the three countries. Despite this hike in prices, however, it is interesting to see that many of the respondents from Tanzania agreed that they could still afford basic food items (about 52.2% of them), unlike the respondents from Nigeria and Uganda.

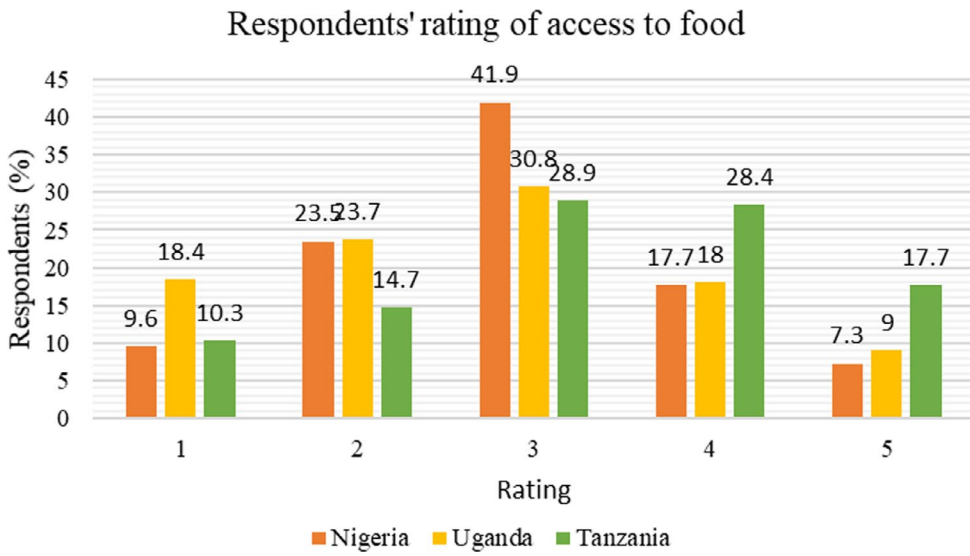

FIGURE A8 Respondents' rating of access to food (5 is highest)

This could also be a pointer to the stability of the existing economic structure in these countries as well as the per capita income (Mukuve & Fenner, 2015b). Since the standard of living incorporates nutritional well-being, it is only expected also that majority of the Tanzanians agree that they still get some nutritional values from the available food supply. This is not the case with Nigeria and Uganda. Note that the type of food items being assessed in these countries are staple household food like rice, beans, cassava, meat, tomatoes, potatoes, plantain and others. While the study findings above point towards the general economic conditions of the three countries under consideration, it did not capture or highlight the amount people in these countries spend on food in relation to their average incomes. Also, the survey does not cover for the amount of food consumed by the respondents before and during the COVID-19 pandemic.

Figure A8 in the Appendix B shows the respondents' rating of their access to food on, classified on scale of 1 to 5, with the former suggesting the lowest access and the latter signifying the highest access. Across the three countries under study, the highest proportion of respondents have agreed that their food access since the COVID-19 outbreak is only moderate, that is, on scale of 3, with Nigeria having the highest percentage of 41.9%, followed by Uganda with 30.8% and finally, Tanzania with 28.9%.

Therefore, from the analysis above, we can say that while the pandemic outbreak has a significant negative impact on food access in Nigeria and Uganda, the impact on food access in Tanzania is only minimal, at best, insignificant.

3.6 | Palliative required by respondents

Meanwhile, the respondents were also required to choose the most important relief they need. The options of palliatives given were cash, subsidized water prices, and soaps, free food items, free face masks as well as subsidized electricity.

Table A9 in Appendix A, it shows that the most important palliative needed by the respondents varies across the countries. Cash, free food items, and free nose masks were the most important

TABLE A9 Most important palliative required by respondents

	Responses with the highest frequency for Nigeria	Responses with the highest frequency for Uganda	Responses with the highest frequency for Tanzania
Which is the most important relief you need during this pandemic?	Cash *(50%)*	Free food items *(40.6%)*	Free nose masks *(29.7%)*

palliatives for respondents in Nigeria, Uganda, and Tanzania, respectively. Since the Tanzanian respondents enjoy a higher standard of living, their major expectation from governments is mainly focused on things that will prevent the spread of the virus, hence, the selection of free nose masks as the most important relief material need in the face of the COVID-19. However, since hunger remains a bigger issue in Nigeria and Uganda, many of the respondents there agree that cash and free food items are the most important relief materials in the presence of the pandemic.

The study indicates that there is a weak co-movement between COVID-19 and water and energy access in all three countries studied, even though a negative relationship exists between them. This implies that the outbreak of the pandemic reduced people's ability to purchase basic energy products and hence, utilize the needed amount of energy. This is justifiable as correlation and regression are essentially different. This finding is in line with Akrofi and Antwi (2020) who opined that the pandemic unleashed unprecedented shocks on Africans' ability to access basic energy. They also added that the pandemic is a threat to a smooth transition to clean energy utilization in Africa in the near future.

Further results in this study indicate that there is a significant negative relationship on food access in Uganda and Nigeria, similar to the findings of Devereux et al. (2020) that the pandemic undermined and has continued to undermine food security in most countries of the world by disrupting food systems and limiting households' access to food shops due to lockdowns, and a modest negative relationship in Tanzania. Furthermore, it indicates that energy access in Uganda and Nigeria remains moderate while Tanzania has an increase in the presence of the pandemic. Although there is no significant increase in energy costs, the majority of the people in Uganda and Nigeria still cannot afford it especially during the pandemic due to lockdown.

Furthermore, an improvement in general hygiene was noticed during the pandemic which was facilitated by the increased sensitization on personal hygiene and increased access to handwashing facilities, also supported by Amegah (2020) that improved handwashing has increased hygiene in Africa. COVID-19 has also triggered innovations in water, sanitation, and hygiene but it may have not increased water access, as most people still utilize water sources that existed in the time past. In the presence of the pandemic, food access in all three countries is moderate which is attributed to the lockdown policy that barred most people in the food supply chain from working and consequently hiked food prices. It is important here to note that in a bid to ascertain government's role in curtailing the effects of COVID-19 on WEF in Nigeria, Uganda, and Tanzania, different approaches were taken. For water access, emphasis was placed on what the government has done already, but for energy and food access, the focus was shifted the what the citizens of the countries under study still expect of their governments. These approaches are intentional to reconcile government's action with the what is still to be done to effectively address the citizens' WEF challenges attributable to the outbreak of the pandemic. Akrofi and Antwi (2020) found that government interventions in African countries are mostly short-lived and include initiatives such as the provision of free electricity, waiver/suspension of bill payments, and VAT exemptions on electricity bills.

Generally, compared to the pre-outbreak of COVID-19, the challenge is not physical access to the resources but rather the economic access (affordability) to water, food, and energy. This shows

that the affordability of WEF by the respondents is largely dependent on their economic statuses. The implementation of the lockdown policies left the biggest fraction of the population with no income.

4 | CONCLUSIONS AND RECOMMENDATIONS

The impact of COVID-19 on water, energy, and food access was examined from a sample of 842 respondents in Nigeria, Uganda, and Tanzania through an online survey. From the results of this, study, we reject the null hypotheses of the study stated in the introduction and thus, conclude with the following: (a) there is a significant relationship between COVID-19 and water access in Nigeria (b) COVID-19 has an effect on energy access in Nigeria, Uganda and Tanzania (c) there is also a strong relationship between COVID-19 and food access in Nigeria, Uganda, and Tanzania, and (d) there is a huge expectation on the governments to aid in reducing energy costs hiked by the prevalence of the COVID-19 pandemic and also formulate policies that will promote energy efficiency, cost effectiveness, and overall sustainability in Nigeria, Uganda, and Tanzania. It is important at this point to say that, even though the cases of water access, energy access, and food access have been analyzed individually, there has been a conscious attempt here to jointly discuss the outcomes because, in a bid to effectively adopt a nexus approach in investigating WEF in relation to COVID-19, we need to explore their complex and inter-relationships. The study therefore showed that, for Nigeria, Uganda and Nigeria, food, water, and energy are inextricably linked, and actions in one sector tend to greatly influence the others.

In line with the research outcomes, it is recommended that during and after this pandemic, policies and strategies that improve economic access to water, energy, and food resources such as subsidizing food, water, and energy in addition to the sensitization of the masses on improved hygiene should be implemented. In addition to these policies, continued research and development of innovative technologies and processes such as renewable energy, water reclamation, food preservation, food value addition, and circular economy which could improve the accessibility of WEF to the vulnerable are recommended. This will greatly reduce the cost and increase the availability of the resources thereby increasing both physical and economic access. Also, although the most advocated government role to reduce the effects of the virus on citizens is a reduction in the cost of energy, this study also recommends that, in addition to that, they should put policies in place that will ensure energy efficiency, cost-effectiveness, and sustainability. One example could be a project that would replace older cooking stoves that are more energy-consuming with more energy efficient ones. Additionally, policies to easily bridge and reduce the inequality gap between the different socio-economic statuses are recommended. It is also recommended that more nexus-centered research be conducted to generally reflect the entire situation of the factors studied, and this can be actualized when governments adopt a policy framework for managing nexus challenges that could emanate from the complexities of water, energy, and food access in Africa.

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CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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