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Article

Wood Charcoal Fuel Resilience in Kampala Capital City; Charcoal in the Water Energy and Food Urban Nexus

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Abstract: Kampala is the capital city of Uganda. Over the years the population growth in the city has more than doubled, and this has increased the demand for energy. However, electricity and gas are not only limited in supply but are also expensive for the majority of the households hence the use of charcoal remains the main source of energy. There is little known about the energy situation in big cities of Africa, and Kampala is not an exception. Therefore, we examine the urban nexus amidst energy poverty, vulnerability, and resilience with a focus on; the role of charcoal in the urban Nexus in Kampala Uganda. Literature review and content analysis of scientific materials such as journal articles and reports were done. Charcoal fuel in Kampala and surrounding urban areas does not only facilitate cooking meals and boing water for over 95% of households but also a source of livelihood for many women in the nexus. This process impacts not only on energy use but also the entire water, energy, and food system in the urban nexus. Even though charcoal fuel doubles as a source of household income, it is greatly responsible for most deforestation. Furthermore, charcoal production also accounts for prolonged droughts hence impacting on water and food supply in the nation. Therefore, we propose subsidizing alternatives such as gas and electricity to reduce the complete reliance on charcoal.

Keywords: charcoal fuel; deforestation; electricity; livelihood; resilience; vulnerability

1. Introduction

Urban cities in most developing countries are becoming complex because of various or cross-cutting challenges related to water, energy and food security [1, 2]. In the study conducted by Biggs [3], some of the challenges including poor or lack of infrastructure as well as the social organization as a result of population increase continue to intensify the situation. In the same line with Biggs [3], Artioli et al. [4] add that water, energy and food systems remain at the core of human survival, and all activities done across the globe rely on this nexus.

Carbonnier & Grinevald [5], suggest that energy definitely influences the general way of life for residents, and this apply to developing countries as well in terms of health, business and ultimately transportation, and economic development.

Compared to other African cities especially in the East African region, Kampala has a small population compared to Nairobi the capital city of Kenya with populations of 1.5 million and 3.5 million respectively. The demographic situation is different for Tanzania where the capital city has been exchanging hands from Dar es salaam to Dodoma and the cities have populations of 3.4 million plus and over 400,000 people respectively. Like the East African cities, most regions and urban areas in Africa seem to depend on charcoal energy for cooking as the primary source of energy [6,7]. This situation can be illustrated in Figure 1, where the various domestic needs of cooking, boiling water, and the impact this causes to the environment.

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The majority of homes in Africa depend on charcoal and fuelwood as their primary source of energy [6]. Kampala is one of the cities in Africa that are sought to depend on charcoal as the energy source. Kampala is Uganda's largest urban center and commercial capital that is bordering Lake Victoria, which is Africa's largest lake. The city is growing fast (with more than 1.5 million population) and it has a distinctive setting spread across several hills. It is a vibrant modern city adorned with beautiful gardens and parks for both citizens and tourists to admire. More so, Kampala has many hotel facilities that range from 5* to average standards. The Parliament building, which is the seat for Uganda's government is at the center of Kampala. Other important places in Kampala include Universities such as Makerere University (oldest institution in East Africa) and several other institutions.

On the other hand, the city has several other important places such as markets, shopping centers and religious landmarks. One of the popular shopping centers, but very congested is Owino market in Nakivubo. Other markets for foodstuff include Nakasero fruits and vegetable market. However, the city has many suburbs surrounding it with many people that live in poverty. In fact, most families in these suburbs struggle to have one meal per day, and most of them depend on charcoal to prepare their meals. Furthermore, charcoal is the core energy source in slum areas of Kampala such as Kisenyi, Katanga, katwe, Kamwokya and kifumbira.

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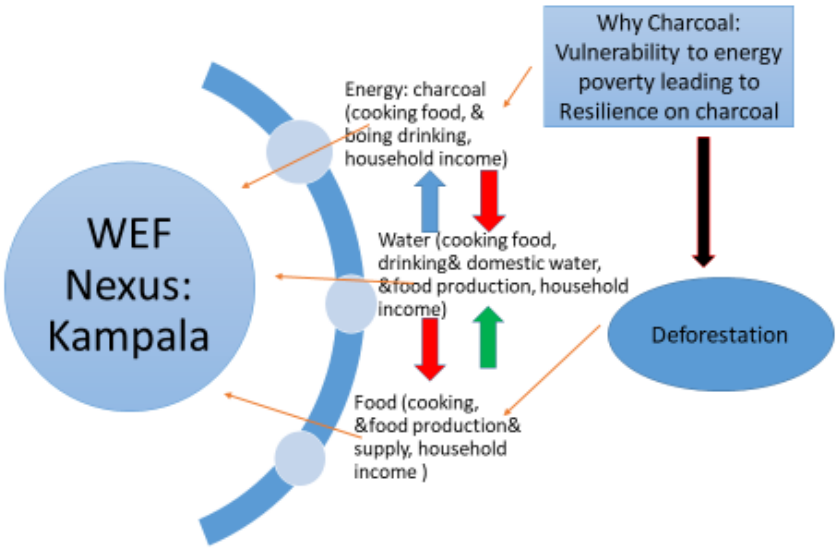

Figure 1. Illustrating the role of charcoal in Water Energy Food Nexus in Kampala Capital City: a framework of the study

Source: Authors' analysis

Charcoal fuel is seen to be the option for the energy poverty in Kampala (Figure 1). Most studies have been written about the subject, especially production, and economic aspects [6,7]. Little is still known about the inter-connection between water, energy, and food in Kampala Capital City (Figure 1). Also, the role of charcoal in this nexus has not been given attention. Therefore, we review various studies and sources to capture the charcoal use in the urban nexus amidst energy poverty, vulnerability and resilience.

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The aim of our study was to examine the role of charcoal in the Urban Water, Energy, and Food (WEF) Nexus in Kampala Capital City, Uganda. Literature review and content analysis facilitated the investigation in order to achieve the goal of the study.

2. Literature Review

Definition of Major Terms

Urban Nexus

The concept Urban Nexus is considered to be the interconnectivity, linkages, and interdependencies regarding the urban systems [8, 9]. These systems include energy, water, food as well as material provisioning systems [8, 10]. Like never before, modern cities, especially those in developing countries require to integrate a holistic approach that involves core sectors in this nexus. In fact, Fang & Chen [11], explain that the nexus between resources such as water is vital when it comes to the sustainable management of modern city systems. Furthermore, Lehmann [8] adds that urban nexus usually focuses on integrating management processes that are essential in increasing efficiency of natural resources as well as infrastructure systems.

More so, urban nexus is usually described as one of the interrelated complex systems that integrate energy, food, and water and waste treatment systems [8]. However, Huang et al. [12], explain that integration management of urban nexus is always limited by the realities of a given city. Nonetheless, urban nexus is always focused on solving most of the problems related to energy, water, and food despite the multi-faceted vulnerabilities urban poor in developing countries continue to face. In this case, therefore, it is not surprising that the concept of urban nexus has become one of the prominent areas attracting the attention of global policymakers as far as city management is concerned.

Vulnerability

The term vulnerability implies various risks combined with some level of social and economic viability, as well as, the ability to survive the resulting event [13]. In this case, vulnerability is considered to be the level or degree to which systems may work and react adversely in the event of hazardous circumstances [13]. Luna [14], gave a more comprehensive background of the term vulnerability. For example, it is indicated that the term vulnerability comes from the Latin word *Vulnerare*, which means to wound. In this case, the concept of vulnerability has been considered to be a situation or possibility of being wounded. The term vulnerability is a fundamental concept to understanding theoretical and practical dimensions of disasters [15].

Some studies discuss vulnerability based on modern energy services [16]. For example, vulnerability involves insufficient access to modern energy services as well as lack of energy security [16]. In a situation where the urban poor struggle to pay minimum costs of their energy, water, and food bills, it makes them vulnerable to any unusual event. It is from such background that Proag [13], speculate that people usually become vulnerable if access to basic resources, especially at the household level is the most critical element in an attempt to achieve great recovery from any form of disaster. In other words, urban poor are always vulnerable in case of any disaster since they have little or no choice but to relocate themselves in more threatening situations. In this case, therefore, in developing countries where urban poverty continues to create a situation of high vulnerability, especially for women and children, their lives remain at risk unless nexus of energy-water and food is implemented at different levels.

Resilience

The concept of resilience has a long history, especially with ecology, engineering, and psychology [17]. In this case, the term has been defined in different ways. The term resilience reflects on the capacity to recover from extremes of stressful events [18]. On the other hand, Windle [19] explains that resilience is the rate at which a system regains structure and functions, especially after unusual or stressful event.

Studies focused on urban resilience highlight that urban resilience is the capacity of various systems in cities, communities, organizations, businesses, and individuals to recover and maintain their functions, especially in situations after a shock or disastrous event [17,18,19]. More so, it also means the ability of cities, communities, and individuals to adapt in circumstances that expose them

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to a hazard [20]. Urban resilience is considered to be a transformative term, which requires comprehensive planning approaches that are tailored to address resilience qualities in one way or the other. Therefore, it is worth mentioning that resilience is related to both individuals and organizational approaches or responses when it comes to recovering from extreme events.

The Role of Charcoal in Urban Water, Energy, and Food Nexus

The water-energy and food nexus continue to attract the attention of policymakers and researchers because human survival heavily depends on them [4]. In fact, they indicate that water, energy, and food systems are the core resources that almost every individual needs to survive. Water is one of the necessary inputs for food and energy production across the globe [21]. In this case, its scarcity can affect the whole chain. However, Mukwaya [6] highlight that charcoal is one of the components that support the nexus of water-energy, and food security in Uganda.

Urban dwellers continue to rely on charcoal as their source of energy for cooking food and boiling drinking water, the increasing demand continues to cause deforestation [21]. Charcoal production is poorly managed, and policymakers in the country have not linked it with other areas [10]. More so, charcoal is part of energy, water, and food nexus because each component affects the other [10]. Most developing countries including Uganda are still separating food and energy as different areas, and this has affected the nexus of water, energy, and food in one way or the other. From the nexus viewpoint, the challenging task policymakers in developing countries must work on, is integrating charcoal as source of energy, water, and food [22].

Charcoal remains the core element in the nexus of water, energy, and food in many developing countries [6]. Research speculates that more than 70% of households in urban areas depend on charcoal as their source of energy for cooking [6,22]. Nonetheless, it is worth mentioning that less attention has been paid, especially in countries such as Uganda when it comes to the role of charcoal in human survival. According to Mwampamba et al. [23], most policymakers in developing countries do not understand the role of charcoal in the nexus of energy, water, and food. Instead, charcoal many people still think that charcoal is source of energy for the poor, that it is economically irrelevant to mention but a few. As a result, charcoal production has not been given much attention, especially in countries like Uganda despite the fact that the majority of urban dwellers depend on it for energy.

3. Materials and Methodology

The paper used qualitative research methodology, synthetic and content analysis approaches were mainly used to study data and information from various sources including scientific data banks such as SCOPUS, and Web of Science from the years 2006 to 2018 (Table 1).

Year	Number of Publications used
2006,2007, 2008,2009	4
2010	3
2011	2
2013	4
2014	1
2015	4
2016	7
2017	13
2018	11

Table 1: Illustration of the number of publications used in the study from the various years

Source: Authors' analysis

Researchers conducted a systematic literature study while using the stated electronic databases. Out of the 250 selected papers and reports, 49 of them were consulted in the study herein, this is because they contained desired data and were of quality.

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Qualitative Approach

Qualitative methodology is considered to be one of the core research methods that is essential to the scientific process. Qualitative research method usually applies a systematic as well as a self-critic approach to induction and deduction. More so, qualitative research is a process-oriented that help researchers to draw certain conclusions regarding the information under scrutiny [24]. The nature of qualitative research method (descriptive) usually offers the researcher the opportunity to build a complex, holistic picture in a natural setting [25]. Furthermore, this is an approach that centrally captures the aspect of entities such as the meanings and processes, which are not evaluated or measured through experiments [26]. In this case, researchers use qualitative approaches to investigate the social structure as well as the nature of realities. On the same note, Castleberry & Nolen [25] explain that one of the challenges of using qualitative research is the open-ended nature of information as opposed to numbers only.

Qualitative research method allows researchers to collect data while using a wide range of approaches [24,25]. For example, some of the data collection tools employed in this method include questionnaire responses, interview transcripts, filed observation to mention but a few. Qualitative research methods usually suggest how inquiries should proceed while indicating various problems that are worth investigating [27]. More so, it shows how to frame a problem that can be explored, develop appropriate data generation, how to make logical links regarding the problem, data collected, analysis and conclusions [27]. In this perspective, it is worth mention that qualitative research methods usually aim at providing a way for researchers to get in-depth information and underlying reasons, motivations or attitudes of people's behavior.

Leppink [28] asserts that qualitative research approach help in explains phenomena in a given study group in a systematic manner. However, instead of working from certain hypothesis, especially with predetermined codes, qualitative research methods allow researchers to code data after it has been collected.

Researchers performed a narrative synthesis to synthesize interesting findings from selected studies. Based on the fact that studies selected for the current investigation presented different findings, researchers decided that a narrative synthesis was appropriate to explore results of various studies. For example, a preliminary synthesis was conducted, and it involved searching for studies and listing findings. Later, findings from selected studies were discussed, structured and summarized in a narrative synthesis [24,25,2628].

Qualitative research usually deals with responses or information collected, and minimally with numbers [28]. Traditionally, Hammarberg et al. [26] speculate that the qualitative research methods are usually used in two circumstances including when the researcher is investigating people's actions. On the other hand, qualitative research approaches are used to investigate a particular topic, especially from the perspective of participants in a bid to develop a survey that can help in drawing upon a large, generalizable sample [26]. In this case, therefore, the qualitative research approach is usually used to investigate and understand people's beliefs, experience as well as meaning systems from different perspectives. In other words, qualitative research investigates phenomena systematically while capturing the opinions or viewpoints of different individuals, especially from the population under study in the process of getting to the core of the issue or a problem.

Basically, we employed content analysis, and literature review of various data from scientific sources. Also, one research assistant made field observations in Kampala Capital City (KCC) to support the information already obtained from scientific peer reviewed journal papers, books, and websites. The field observation also included photograph shooting some of the practices and evidences from charcoal selling to cooking.

The study employed content analysis to investigate the various studies and materials and especially the scientific sources. Content analysis is considered to be one of the several analysis methods that can be used in qualitative research [29]. However, content analysis is not usually liked to specific science, and sometimes, there are fewer rules that researchers must follow. In line with Bengtsson [29], Wang et al. [30], explain that content analysis is one of the easy-to-use as well as explicit and systematic tool used to analyze text that can help researchers to understand different

contexts. In fact, it is not surprising White & Marsh [31] speculates that content analysis is a highly and at the same time flexible research method, which has been used by a wide range of studies. In other words, content analysis research method practice usually aims at exploiting, analyzing and coding numerous words of textual data thus attaining valid duplicated inferences.

In this study, content analysis was used as an approach to comprehend message content as the basis from which inferences and conclusions about the role of charcoal in energy-water and food nexus research are drawn. While reviewing literature, a wider range of online materials such as journal articles, and reports, especially scientific literature were searched by entering keywords in popular search engines including Google and Yahoo. In a bid to easily access materials focused on the subject under study, the researchers used various keywords such as; energy poverty, energy-water-food nexus, charcoal use, and the role of charcoal in energy-water-food nexus in urban cities of developing countries to mention but a few. At this point, this method was used to analyze written literature material on energy-water-food nexus situation in big cities of Africa, and Kampala in particular. In other words, content analysis methodology was used to analyze a wide range of content regarding the subject while applying text evaluation techniques. Being one of the popular research methods adhered to for a multiplicity of disciplines, it was considered to be a reliable approach for this investigation.

Furthermore, this methodology helped in availing knowledge, and fresh perceptions on energy situation in big cities of developing countries, and Kampala in particular through objective representation of facts collaborated with holistic courses of action. In this way, this transparency in this research method presented the researchers with high level of abilities to formally summarize content within written content coupled with competence for comprehending the author's perceptions of that material. In this case, therefore, content analysis allowed the researchers to understand the intended message from several literature materials on the energy-water-food nexus situation in Kampala.

Considering ethical issues especially with photographing, the researcher asked involved persons for consent. The photographs included herein were taken after acceptance upon the research team's request. For example in Photo D, where we captured charcoal cooking food and boiling water in Kabalagala near Kampala International University, the own accepted the team to only capture charcoal cooking stoves and not her and the two children. We did observe ethical standards including asking for permission from the Local council chairman who heads the last unit of administration as stated in Uganda. The University requires researchers to obtain informed consent in a process that allows open and honest communication between researchers and respondents. In the current study, researchers ensured that study participants received all the necessary information regarding the current study. For example, researchers provided all the necessary information to respondents regarding the objectives of the study, risks, benefits, procedures, alternative opinion, contact information and confidentiality elements.

4. Findings and Discussion

While reflecting on a wide range of literature reviewed in this study, charcoal is very vital for the everyday life of households and businesses in Kampala. This was not only observed in the analyzed studies but also field observations (Figure 1 & Figure 2). However, it is indicated that Uganda's entire charcoal value chain is being run by an informal system. In fact, it is also indicated that this value chain has received little or no interest from investors and government who can develop it into a powerful and sustainable business. Besides, it was revealed that the system is characterized by several inadequate regulations, which are poorly implemented. Poor organization of key players from top to the bottom of the chain and the use of inefficient technologies has contributed to deforestation in Uganda. It is from such background that charcoal value chain lacks standards despite its ever-increasing demand in Kampala, the capital city of Uganda. In this case, interventions that are required must focus on reducing most of the negative environmental challenges caused by the increased charcoal burning or production in Uganda.

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More so, such interventions should also focus on standardizing charcoal production in a bid to ensure its sustainability since it contributes much as a source of energy in Uganda, and Kampala in particular. In other words, charcoal production in Uganda requires strong and effective regulations, which can help in reducing the rate of deforestation; hence saving the already threatened but greatly needed forests. In fact, deforestation is a critically persistent ongoing issue threatening a multiplicity of significant forest ecological systems in Uganda. According to Namaalwa et al. [32], most of the mid-west and central districts have become deforestation hotspots in the country. High deforestation rates are increased by the demand for the forests products, particularly in the form of charcoal and fuelwood. In other words, the biggest population in Uganda heavily reliant on charcoal as the primary energy source resulting from high electricity tariffs. In this case, the government should invest in increasing alternative sources of energy, which are affordable by the majority. On the same note, policymakers and environmental actors should sensitize people in Uganda about the threatening dangers of deforestation to the environment. Besides, over-using charcoal is reported to have negative effects on people's health, especially women who are always in the kitchen cooking. In this case, regulating charcoal production should start with enforcing several measures tailored to stopping illegal charcoal production in central and surrounding districts. For example, imposing heavy fines to those found engaged in illegal charcoal production can help regulate the system; thus saving the already threatened environment because of deforestation.

Besides deforestation, over-relying on charcoal has many implications. In most cases, smoke released from burning charcoal is of unique complex, consisting of a majority of air pollutants, and factors which if consistently exposed to, greatly risks human health. In most households that use charcoal, women are usually vulnerable. Just like in many other countries, it is cultural responsibility of women cook meals, and smoke resulting from charcoal sometimes cause complications.

Charcoal in Kampala City

In Uganda, charcoal is produced throughout the country and supplied to major towns, especially the capital City (Kampala) where the demand is always high [32,34]. In fact, charcoal is considered to be the main source of energy for the majority of people who live in urban centers including Ugandan Capital Kampala. Due to the high and ever-growing demand for charcoal, it is not surprising that Namaalwa et al. [32,34] explain how several mid-west, as well as central districts in the country, which are characterized by woodland vegetation, continues to be the main source of charcoal despite the warnings and dangers of deforestation. On the same note, Shively et al. [33] add that the highest production of charcoal in Uganda is happening in areas that have woodland ecosystem, which supports high-quality vegetation for its production. In most cases, production of charcoal is usually undertaken as a primary activity for households that have limited income generating opportunities. Nonetheless, Bamwesigye et al. [34] speculate that charcoal business continues to be one of the lucrative trade in the country due to its high demand in major towns (Figure 2).

Furthermore, urbanization has far-reaching implications on urban areas such as Kampala. Lyytimaki et al. [48] explain that lifestyle of people living in urban centers is conceived based on behavior patterns, which are linked to pressure from the environment. For example, some of the factors that influence lifestyle of people include family situation, income, education levels, technology advancement to mention but a few. From the observation, groups of people that depend on charcoal in Kampala are low-income families, low education, and they have limited access to technology. As a result, their lifestyle affects the environment ecosystem in one way or the other.

On the same note, urban vegetation plays a significant role in mitigating urban heat, reduce air pollution and enhance recreation and cultural values [49]. However, the demand for charcoal in Kampala has affected urban system and ecosystem services as a whole. Besides, most of the urban ecosystem services such as recreational services, and air quality are sometimes neglected by urban planners and policymakers. The rate of deforestation in Kampala and other surrounding districts prove that the city lacks strong regulations to save forests.

Kampala Capital City and its surrounding suburbs remain the core destination for the bulk of charcoal, which is always produced in various upcountry and central districts in Uganda [6,33]. Some

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of the districts that are leading in producing charcoal include Hoima, Masindi, Nakasongola to mention but a few. In fact, the same research shows that Masindi attracts a large-volume of traders from Kampala who usually purchases standing trees around the district and manages the production process. According to Mukwaya [6], much as charcoal use is a uniform source of energy in Kampala, the largest consumer demand is usually from the slum population. One of the driving factors is that the slum population in Kampala have limited income generating opportunities and they cannot afford the high retail prices for electricity or gas [6]. In this perspective, it is not surprising that charcoal and fuelwood account for more than 93 percent of the country's core energy source.

In Uganda, around 67 percent of the urban population use charcoal as the source of energy and cooking in particular [6]. Kampala city has an estimated but ever-growing population of about 1.5 million people, and the demand for charcoal remains high; thus putting the available forests at risk of deforestation [33]. Like never before, energy demand patterns in urban population such as Kampala, especially the poor who live in slum suburbs largely rotate around household energy end-uses including cooking food and boiling drinking water. For example, Mukwaya [6], explains that more than 43.9 percent of charcoal that is supplied in urban centers is always used for cooking. Khundi et al. [35] highlight that charcoal remains the most popular source of energy for cooking in the urban setting. Besides, the same study indicates that electricity continues to be expensive for urban dwellers, especially in the suburbs as using it requires a high initial investment in addition to high retail prices.

Electricity supply in urban cities such as Kampala accounts for about 6%, and this is attributed to high cost involved [6]. The same study describes energy poverty in Uganda and the region. Both electricity and gas which are some of the other energy sources in the urban nexus in Uganda are limited in supply and their prices are equally high for the majority of urban dwellers. This, therefore puts the population in Kampala Capital City (KCC) in a vulnerable situation hence the urban poor left to devise means of resilience. Adeyemi & Asere [6,7], highlight that less than 10% of Uganda's hydropower potential is exploited with only 1% of energy supply drawn from hydropower. Uganda utilizes a mix of energy sources, Producing and consuming about 459 MW of Hydroelectricity, 100 MW of thermal energy and about 41 MW of energy from cogeneration. However, the ever-growing national population of Uganda, only 20% readily access electricity including households, services and the manufacturing sector. This accounts for both rural and urban population. Household electricity is limited in supply and very expensive for most urban dwellers hence charcoal use. Some of the initial investments include buying electric cooker or oven, and this has pushed many people to the edge as far as use of electricity as a source of energy is concerned. At this point, it is worth mentioning that such factors are increasing the use of charcoal in Kampala and other surrounding urban areas.

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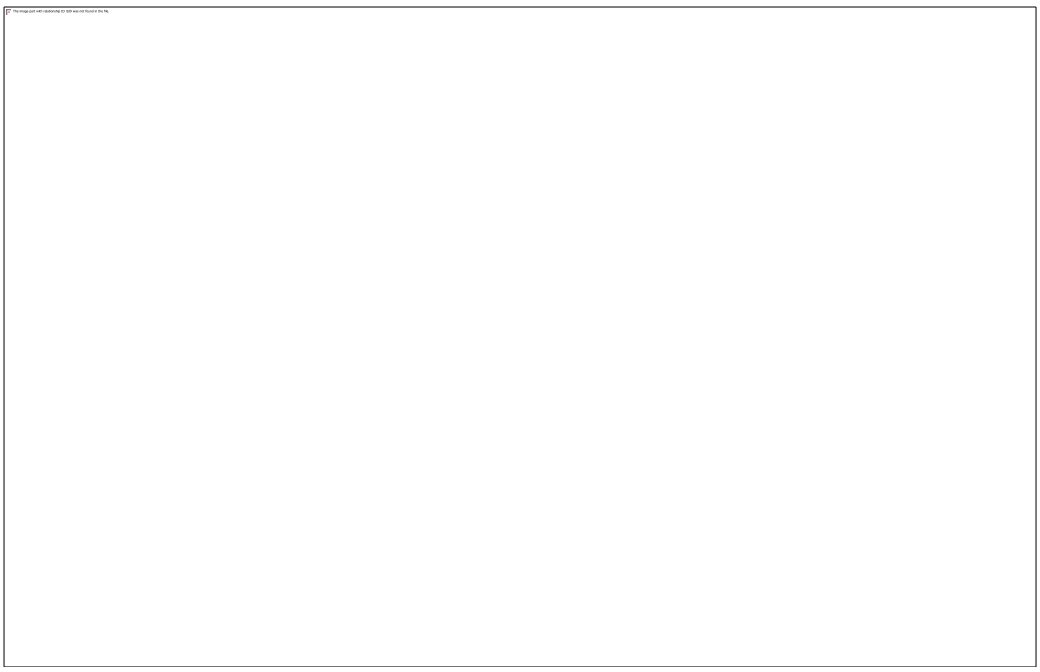

Figure 2. Charcoal value chain in and around Kampala

Source: Authors' analysis

Photos; C and D: showcase retail in the charcoal value chain and mainly owned by women (*on Photo: Dastan Bamwesigye, a member of our researcher team*)

A and B: represent the charcoal trade by whole sellers on road-sides to the main cities and urban areas which are mostly male-dominated.

D, illustrates the charcoal use, one boiling water and the other cooking food.

While reflecting on the research finds and insights highlighted in several studies [6,33,35], it is not surprising that Bamwesigye et al. [34] claim that charcoal business is one of the thriving trade that makes a livelihood for many Ugandan households in Kampala. However, the same study shows that charcoal trade in Kampala and other urban centers in Uganda is being driven by women who have no shortcut but to sell charcoal and feed their children. On the same note, Khundi et al. [35] add that charcoal production and trade is found to be extremely important for individuals with low agricultural capacity as well as limited capital to engage in other lucrative businesses.

According to Hoffmann et al. [36], charcoal production continues to provide a significant transfer of financial resources from urban centers in developing countries such as Kampala city to rural areas. As a result, many people consider charcoal to be one of the economic engines for development. However, the same research investigation indicates that charcoal production in most developing countries including Uganda is usually done illegal or informal from forest areas. Nonetheless, Zulu & Richardson [37] explain that one of the challenges is that most of the cities in developing countries such as Uganda have growing demand for charcoal due to poverty levels. In other words, other available alternative sources of energy are expensive for almost 90 percent of the population that live in Kampala and other surrounding suburbs. In this case, therefore, this explains why charcoal retailers have increased, and they are concentrated in various market centers around Kampala suburbs [33].

Furthermore, charcoal vendors (Figure 2: Photos; C & D) in Kampala increase day in day out, and most of them have their own producers, agents as well as suppliers. Much as men dominate charcoal production, Mukwaya [6], speculate that women dominate market centers. When it comes to charcoal transportation, Namaalwa et al. [32] explain that the process involves the transfer of full bags of charcoal to sale centers along the main access road. Still, in the case of the charcoal value chain, retailers dominate selling the product to final customers around the areas. In Kampala and other surrounding areas, charcoal retailers (Figure 2: Photos; C & D) are usually concentrated in different marketing centers [33]. In most cases, these retailers use mobile phones when contacting their agents and other traders to update them on the business. In the process, other small retailers use

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motorcycles and bicycles to deliver charcoal in other surrounding sale points in Kampala. On the same note, Shively et al. [33] insist that depending on the location of a selling point, different charcoal traders usually sale in various sizes. Some sale long large loads of bags, which are more than 7kgs and others sale in polyethene bags for small families.

Charcoal for boiling water

Much as Kampala, the Capital City of Uganda has a fully functioning piped water system, research shows that this water is always not fit for people to drink before cooking. In this case, water must be boiled (Figure 2: Photo; D) to avoid health consequences such as the outbreak of waterborne diseases. It is from such background that boiling water for drinking is considered a must for people to survive diseases like typhoid and cholera [38]. However, the process of boiling water remains expensive for Ugandans, especially for urban dwellers in Kampala. The majority use charcoal as source of energy for boiling water [39]. Charcoal is commonly used by the Ugandan population for cooking and boiling water for drinking [39]. In most cases, urban population in Kampala suburbs use charcoal stoves to boil water since other alternative energy sources are expensive. The process of boiling water involves putting charcoal on the stove depending on the size, light fire on dry charcoal while using dry sticks or used polythene bags to allow charcoal catch fire [40]. After that, water is usually put some of the common items such as saucepans or stainless steel pots, which is placed on top of the fire stove to allow boiling [40]. In this case, the process of boiling water while using charcoal causes prolonged exposure to indoor air pollution, which usually compromises women's lives.

Charcoal for Cooking Food

Charcoal is commonly used in Uganda for heating, and cooking food (Figure 2: Photo; D) at both household and industrial levels such as hotels, and some food processing factories [39]. Much as many households in Kampala use charcoal burning stove for cooking food, some people in various suburbs such as Bwaise still use firewood, and they cook in a traditional three stone setups because of high prices of charcoal [41]. For those using charcoal, there are various types of charcoal stoves that range from clay ones (traditional stoves), metallic as well as improved stoves. In most cases, the type of charcoal stove usually determines charcoal usage. For example, improved charcoal stoves are reported to be using charcoal more efficiently compared to other types [40]. Just like using any other sources of energy for cooking, individuals go through a process to ensure that food is ready for consumption.

The use of charcoal for cooking food requires one to have charcoal stove and skills to light a fire, and keep it going throughout the process [40]. In most cases, many households in Kampala suburbs use polythene bags for lighting charcoal stove despite the fact that the smoke produced in the process is dangerous to their health. These households usually opt for polythene bags, popularly known as "kaveera" to light charcoal stove because it is cheaper. However, it is worth mentioning that using polythene bags to light charcoal stove many implications in relation to health. For example, it usually takes a few minutes for a person (mostly women) to start experiencing the discomfort of the smoke that comes from burning polythene bags. Smoke released from charcoal can be extremely deadly to women, especially when cooking from enclosed space. In Kampala, it was observed that most families that use charcoal for cooking are exposed to smoke because they cook from indoors. In this case, therefore, there is a need for the government and international community to intervene and save women from healthy implications caused by burning polyethene bags while lighting their charcoal stove to feed their families.

When it comes to preparation for cooking while using charcoal, the main meal in a day (Lunch) usually start early, especially when the household is cooking beans, peas and other food items that take longer to get ready [41]. In most cases, charcoal can be transferred from one charcoal stove to another depending on the number of different dishes a household is preparing. In this case, people are always encouraged to learn how to utilize charcoal in the process of cooking [41]. Just like boiling water, cooking food while using charcoal requires households to use some of the common items such as saucepans, and stainless steel pots to mention but a few. In most cases, small saucepans are used to cook breakfast and lager ones for cooking the main meal, which is lunch [41]. While leaving other factors constant, it is worth mentioning that cooking food using charcoal remains one of the hectic

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processes that has the potential to cause health complications to some people, especially women and children [34,42]. However, women and children still get exposure to the smoke from some poor burnt charcoal or a poor quality stove which also becomes a health hazard for the mothers.

Charcoal Livelihood

In addition to being the core source of cooking energy, charcoal is also considered to be one of the sources of income for both rural and urban individuals involved in the production process [37]. In Uganda, poorer households are usually at the center of charcoal production in rural areas, but their counterparts in urban centers sale charcoal to supplement other sources of income in one way or the other [33]. According to Vollmer et al. [43], charcoal production is also among the most significant semiformal economic industry in various developing countries. In countries such as Uganda, charcoal is one of the key cash income sources to local households that are involved in the process (Figure 2: Photos; A, B, C, & D). However, other studies highlight that its role in alleviating rural poverty is still low because of a wide range of factors [44].

Much as charcoal production has been considered to be one of the potential sources of livelihood for many people, the inability of most households involved to meet minimum national and international living standards proves otherwise. In their research investigation, Vollmer et al. [43] speculate that charcoal income has not done much in alleviating poverty levels to those involves. For example, Smith et al [45] explain that the contribution of charcoal to livelihoods of economic activities should consider not only income but also the health of people involves, access to good services, social relations as well as food security. In this case, it is not surprising that charcoal producers are likely to remain poor, and with limited capacity to engage in other industries such as agriculture to boost their income [33].

In most cases, charcoal producer usually joins this industry because they lack skills and other opportunities to participate in other income generating activities [37]. Much as charcoal producers are usually from poor households who live in rural areas, most consumers in urban centers including Kampala, the Capital City of Uganda are drawn from all different income levels [33]. According to Ainembabazi et al. [44], it is always important to understand the value chain of charcoal production (trade and consumption), and this can help in assessing the contribution of charcoal to livelihood of those involved. In other words, any information related to value chain of charcoal production is vital when it comes to forecasting its contribution to enhancing people's livelihoods. For example, it is indicated that men have always dominated charcoal production in Uganda despite their continuous low-quality lives [6].

Furthermore, Mukwaya [6], speculate that much as the process of charcoal production continues to be dominated by men, a significant number of women are usually found in charcoal market centers. In this case, it is worth mentioning that both men and women consider charcoal trade and production as their source of income. However, the difference usually comes in based on the fact that some charcoal traders, especially those involved in transportation, retailers to mention but a few, they consider charcoal as a supplementary source of incomes. On the other hand, poor charcoal producers in rural areas usually take charcoal to be their only source of livelihood despite its inability to alleviate their poverty levels. As the study conducted by Namaalwa et al. [32] highlight, charcoal remains one of the sources of livelihood for many people regardless of their level of involvement. For example, there are many people who are involved in the charcoal transportation process. Drivers of trucks full of charcoal bags also depend on charcoal value chain as their secondary source of income. The fact that the process involves transfer of full bags of charcoal to sale centers along the main access road, Namaalwa et al. [32] claim that many people benefit from charcoal production in one way or the other.

Many people from poor households in rural areas consider charcoal as their source of income because they provide labor to those involved [46]. In other words, some people in rural areas are not themselves charcoal producers, but they provide labor, transportation of charcoal from deep places to the main road where trucks collect from and sometimes provide trees to be cut and burned by producers. For the case of Uganda, Branch & Martiniello [46] explain that small household charcoal producers take it as a full-time job and source of income. However, some small households usually

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give up their trees and small land to others to produce charcoal, and in return, they are given some percentage on the products. Much as sometimes people who give land and their trees to charcoal producers rather than doing it themselves get cheated in the long run, they still consider charcoal as their source of livelihood. Besides, such people usually save themselves from the hectic process of charcoal production, which sometimes cause health issues to those at the center of production.

However, much rural poor still earn a living from charcoal production process, a lot has changed and household charcoal production is now overwhelmed by large-scale producers from the central. In this case, many rural people involved in charcoal production process are limited to providing labor, land, and trees to large-scale commercial producers to take over [46]. As a result, such people earn less, and smart people from Kampala and other surrounding urban centers take the biggest share. At this point, it is not surprising that charcoal value chain is still dominated by large-scale producers and retailers selling the product to final customers around urban areas [33].

5. Conclusions

Charcoal remains the core aspects in the nexus of water, energy, and food in Kampala. This is attributed to vulnerability of lack of other alternative. We found out that over 95% of households in Kampala depend on charcoal as their source of energy for cooking. The research found out that Kampala Capital City and its surrounding suburbs remain the core destination for the bulk of charcoal, which is always produced in various upcountry and central districts in Uganda. More so, this study revealed that most people use charcoal as source of energy for boiling water and cooking food for majority city dwellers. In most cases, urban population in Kampala suburbs use charcoal stoves to boil water and cook food since other alternative energy sources are expensive. Besides being the core source of cooking energy, charcoal is also considered to be one of the sources of income for both rural and urban individuals involved in the production process.

In a bid to understand the dynamics of the role of charcoal in urban nexus in Uganda, major terms were defined. For example, the term urban nexus was defined as the interconnectivity, linkages, and interdependencies regarding urban systems. Other key terms defined include vulnerability and resilience. According to study findings, we conclude that charcoal cannot be easily excluded from the Water, Energy and Food nexus (WEF). It is both a source of livelihood for the traders and the many women in the value chain, as well as the primary source of energy for household cooking in the Ugandan cites (Figures 1 & 2).

There is a huge dependence on charcoal in Kampala and Uganda at large for energy which has its own negative implication on the environment. Due to very poor methods of utilization, and of course, the rate of use, the rate at which Ugandan natural forests has been reducing is worrying [34]. The process of charcoal production to meet the increasing demand in Kampala city among other urban areas is responsible for deforestation and its impacts such as prolonged droughts and crop failure. This again impacts on the WEF nexus in terms of food production, availability and prices with high prices in the urban areas (47).

We suggest subsidizing gas and electricity to reduce the over-reliance on charcoal for most of the population and other areas connected on the grid. This could enable the majority of Ugandans, especially urban dwellers to switch to clean alternatives. In the process, this might help to save the already threatened forests in one way or the other. However, further research should point out whether this is the way to go or that another solution can be found for sustainable development.

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