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Full Length Research Paper

Clean eco-friendly cooking energy as sustainable approach and mitigation to climate change: A case study of Ankole, Western Uganda

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ABSTRACT

The study investigates how communities in the Ankole region, western Uganda are coping with a shortage of cooking fuels, climate change and what strategies they have set up to counteract its effects using innovative, sustainable, renewable and affordable technological methods. The objectives of the study are: 1) to investigate the type of cookstoves used in cooking that is being used in the area under study. 2) To suggest eco-friendly cook stoves that can be used for cooking to save the environment and reduce health hazards that are related to inhalation of smoke. It was carried out in the districts of Mbarara and Bushenyi which are diverse in their setting. The main objective was to investigate how traditional cooking fuels have become a health hazard to many mothers and children in Ankole, human activities and rural-urban migration, have caused hiking of prices for fuel for cooking; wetland drainage, bush clearing for farming, charcoal burning, brick making associated with social and economic developments have affected the environment. Traditional methods of cooking still dominate in Ankole, where three stones are still used. Charcoal has become a major fuel for cooking in many homes as an alternative to firewood, in addition to briquettes, biogas, LPG and volcanic rocks. A sustainable eco-friendly stove is proposed to mitigate environmental degradation.

Keywords: Cooking fuels, climate change, health hazard, black termite mound, beehive briquettes, volcanic rocks, affordable, reliable, sustainable, modern energy.

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INTRODUCTION

Ankole stands astride the equator and its landscape is characterised by ridges. The hilly lands of the western and southern are mainly agricultural, while the eastern grassland plateau is known for rearing the famous long-horned Ankole cattle. Traditionally, in Ankole food was prepared over an open fire, with a vessel supported by three large rocks (stones), using firewood gathered from bushes and agricultural fields. While it was effective and less costly, it was not very efficient and it was also a health hazard. The primary health risk came from the inhalation of smoke daily, with secondary issues of the risk of burns and accidents to the children from the open fire. This traditional method used large quantities of firewood, a resource that was quickly depleted by human activities. This has called for innovations in making smokeless ovens that combat all three issues in an ingeniously simple design.

Uganda's population stands at about 45.7 million (Uganda Population, 2020) and over 95% of its population still lives in rural areas. Nearly three billion people in the developing world still rely on wood fuel for cooking, boiling water, and heating their homes during cold weather. The use of wood for fuel has resulted in the current loss of about 2% of Uganda's forest cover annually. According to the Uganda Bureau of Statistics (UBOS) 2016 figures and findings, Uganda meets more than 89% of its energy demand with biomass, 10% with fossil fuel combustion and only 1% with electricity from hydro and fossil-fueled thermal power plants. In recent years there has been a high rural-urban migration, and

many urban dwellers use predominantly charcoal stoves while in rural areas, households still mostly burn firewood in traditional three-stone fireplaces.

The demand for wood put Uganda's forests under tremendous pressure because there was almost no alternative fuel for cooking. Gas and electricity were too expensive for the common Ugandan, and electricity was not available in many Ugandan villages. Reliance on biomass for cooking and heating leads to environmental degradation from increased pressure on local natural resources and forces women and children to spend many hours each week collecting wood. They walk long distances every day in search of firewood, keeping girls out of school and preventing women from performing more productive chores. Inefficient cooking also contributes to climate change through emissions of greenhouse gases such as carbon dioxide and methane, and aerosols such as black carbon.

According to González-Eguino (2015), family and household empowerment relate closely to access to energy. The United Nations Agenda for Sustainable Development (UN, 2015) includes the Sustainable Development Goals SDG 7 affordable and clean energy, which calls for access to affordable, reliable, sustainable, and modern energy for all and the absence of which is known as "energy poverty" (UNDP, 2000). The International Energy Agency (IEA) defines access to modern energy as, "household access to a minimum level of electricity; to safer and more sustainable cooking and heating fuels and stoves than traditional biomass stoves; access that enables productive economic activity".

Furthermore, González-Eguino (2015), argued that energy poverty has three dimensions: (i) technological, (ii) physical, and (iii) economic. The technological dimension refers to access to modern, affordable, reliable, high quality, safe, and environmentally benign energy services (everything except traditional biomass use) and the choice between equivalent options (UNDP, 2000). This covers energy facilities and knowledge on how to use and maintain them. The physical dimension addresses the (minimum) energy requirements — the amount of energy a person or a household needs to serve their basic needs. Finally, the economic dimension quantifies the percentage of household income spent on energy. According to IEA (2017), households spending more than 10% of their income or their household members' working hours on energy are considered energy poor. For example, in 2012/13 the Ugandan population spent around 15.0% of their income on rent, fuel, and electricity (UBOS, 2017b). In 2016/2017, this rose to 16.4% (UBOS, 2019). At present, *wood energy* is the most crucial energy source in Uganda, serving the cooking purposes of 94% of the population (UBOS, 2017a). Roughly two-thirds are estimated to come from firewood and one-third from charcoal. The firewood is mostly collected in a bush or forest sites, only 26% comes from plantations; an estimated 9% is bought. The price of wood fuel increased by up to 10% between 2005 and 2010 (UBOS, 2017b). According to Chidumayo and Gumbo (2013), charcoal production in tropical regions of the world is often perceived to have devastating ecological and environmental effects and governments, public forestry institutions and non-government organizations have been particularly concerned about these charcoal-related impacts. The most commonly cited impact is deforestation, i.e., the clearance of forest or woodland.

The biomass is now mostly burned in traditional three-stone stoves with a very low-efficiency rate. Improved cook stoves (ICS) have higher fuel efficiency and reduce indoor air pollution yet are not well-established in the market. According to the Global Alliance for Clean Cookstoves (GVEP International 2012, only 6% of rural households and 14% of peri-urban households own an ICS in Uganda.

In addition, Uganda currently hosts more than 1.25 million refugees, most of whom rely on natural resources in and around refugee settlements for domestic fuel, construction and livelihoods. According to the UN High Commissioner for Refugees (UNHCR),(2021), Uganda's refugees consume at least 1.1 million tones of firewood every year, as fuel wood is the primary source of energy security. The impact is not only environmental, but it also fuels increased competition over natural resources between refugees and the Ugandan host community. While the latter continues to show considerable generosity in hosting refugees, they rely on the same trees, grass and water sources as refugees. As scarcity increases, so do tensions over access to, and management of, natural resources.

According to Okiror (2019) the cutting down of millions of trees has sparked angry clashes in parts of Uganda between local people and refugees who have been fleeing conflict in neighbouring South Sudan and the Democratic Republic of the Congo. The timber is being used for house construction, fuel and to make charcoal. In the north and west of the country, where an estimated 1.1 million refugees are living, massive deforestation is drawing protests from local communities.

It has been reported by UNHCR Uganda (2016) that despite numerous energy access interventions, results from the rapid assessments conducted in August 2015 revealed that 97 percent of refugees use firewood for cooking and yet have to walk a distance of 4 to 10 km to access firewood. This has resulted in refugees undercooking and skipping meals, while others sell some food rations to buy firewood, thus affecting their nutritional status. Women and girls, who mostly collect firewood, have also suffered from Sexual and Gender-Based Violence (SGBV) in the form of assaults, rape, attempted rape and defilement among others. These are serious protection issues that have become a cause of tension between the refugees and host communities. The

situation has been exacerbated by the use of inefficient open fires and three stone stoves by 65 percent of refugee households. In addition, cooking is done in poorly ventilated kitchens which causes indoor air pollution and predisposes refugees to health conditions such as respiratory infections. In addition, Viola (2012) suggests, "safe access to cooking fuel is critical for the most vulnerable in humanitarian, transition and development settings. Without it, people face risks to their health, safety and well-being".

Asimwe (2022) argues that charcoal burning and cutting down of trees are some of the human activities responsible for the environmental degradation in Western Uganda. Environmentalists have decried the drastic decline in natural forests, which has worsened in the refuge-hosting districts of Kamwenge, Kyegegwa and Kikuube. Several wetlands and forests have been destroyed. The uncontrolled cutting of trees and bush burning has led to severe degradation of the environment and soil erosion. As a result, wood fuel reserves are depleted at a faster rate. He adds that in the Kamwenge district, trade in wood fuel has reached alarming levels, with over 1,000 bags of charcoal sold daily and unspecified tonnage of wood harvested for building, cooking and fencing. The destruction is mainly due to human activity and poverty, as most people, especially women, rely on trees to feed their families.

Nakivale Refugee Settlement, one of the refugee settlements in Uganda, is located in the Insingiro district, southwestern Uganda, which is part of the area under study. It was first established in 1959 to accommodate Rwandan refugees of Tutsi origin fleeing the ethnic cleansing initiated by the Hutus. However, since its establishment, Nakivale has been hosting refugees of diverse origins. At present, Nakivale is housing refugees of nine different nationalities: Ethiopia, Somalia, Eritrea, Rwanda, Democratic Republic of Congo, Sudan, Nigeria, Burundi and Liberia, for a total estimated population of about 50,000 people (Nov, 2009). According to the Office of the Prime Minister (OPM) commandant, the population in Nakivale doubled in the last two years, mainly due to influxes of refugees from Eastern DRC. At present, the Congolese are the biggest group in Nakivale with approximately 30,000 people. With the increase in population, there is competition for scarce resources, especially firewood. Mariangela (2009) argues, "in Nakivale, the recent increase in the population in the settlement has dramatically accelerated the pace of deforestation around the camp, and women refugees are required to walk further to collect firewood for cooking and household purposes. In addition, tensions with nationals over access to dwindling resources such as land, water and wood have increased".

In addition, Asiimwe (2022) further reports that as a result of increasing human activities in Bugoma Forest Reserve which is near these refugee settlements, the number of Chimpanzees has significantly reduced. from 570 in 2001 to 390 in 2022. This has been attributed to the clearing of Budongo Forest for subsistence and commercial farming, leaving the primates concentrated in small spaces, occupying mainly the corridors of the forest reserves. It was further reported by Hatanga (2022) that most of the chimpanzees were killed in the process of clearing their habitat for cultivation. The few remaining could not reproduce when the environment around them is being tampered with because primates are situation-sensitive.

Smoke from indoor cooking has caused respiratory diseases, particularly among women and children. Bickton et al. (2020) argues that globally, over four million deaths are attributed to exposure to household air pollution (HAP) annually. In relation to this, the Energy Sector Management Assistance Programme (ESMAP) (2016) reports that nearly 95% of Ugandans still use solid biomass fuels for cooking, such as charcoal and wood. This poses a significant threat to the health of household family members through exposure to indoor air pollution, which currently affects over 35 million people and causes over 13,000 premature deaths every year in Uganda. Smoke from cooking contributes to a range of chronic illnesses and acute health impacts such as early childhood pneumonia, emphysema, cataracts, lung cancer, bronchitis, cardiovascular disease, and low birth weight. Meanwhile. according to Nshimiyimana (2021), in Uganda, Acute Respiratory Infections (ARIs) remain the leading cause of childhood morbidity and mortality among under-five children. This could be attributed to the use of firewood and wood charcoal for cooking among other factors.

It has been noted by Blum (2005) that a vast majority of women, especially in densely populated areas, are experiencing an ever-increasing shortage of firewood. They find that they have to spend more time gathering enough firewood, or agricultural wastes such as coffee or tea branches, maize cobs and stalks. Meeting the daily needs for fuel to cook the meals for the family is often a struggle for women. As more and more land is currently cleared for agriculture, the problem increases, and few trees remain, planting more trees is vital, but conserving firewood or fuel is also essential. Byekwaso (2009) argues, "deforestation is a rising problem in Uganda. It has led to very long drought seasons in central and south-western Uganda. Drought was unheard of about 15 to 20 years ago". In Uganda almost everybody uses firewood and wood charcoal, it is concerning that one day it may become a desert because of the deforestation going on every day.

In its 2003 report on energy, the Energy Advisory Sector (EAS) reported that over 94 percent of the energy utilized in Uganda for cooking was obtained from biomass. Currently, acres of valuable ecological resources are going up in smoke at a rate of 240 million tons per year. Therefore, it is of great urgency to focus attention and promote more efficient cooking devices in

order to minimize losses and reduce the rapidly increasing biomass energy demand. Uganda's sustainable energy for all (SE4All) initiative action agenda (2015), reports that "access to modern and clean energy services is a necessary precondition for achieving development goals that extend far beyond the energy sector, such as poverty eradication, access to clean water, improved public health and education, women's empowerment and increased food production".

Byekwaso (2009) further argues that a significant part of Uganda's population, especially those who live in villages, lack access to modern cooking fuels and technologies and breathe indoor smoke every day. It is now scientifically consensual that women and young children are at the greatest risk because they spend the most time near indoor cooking fires daily. Animals that eat a lot of plant materials, particularly grazing animals such as cattle, elephants, goats, horses, etc., produce large amounts of biogas. The biogas is produced not by the cow or elephant, but by billions of micro-organisms living in its digestive system. The production of biogas involves using biogas digester plants (machines) which facilitate the process of anaerobic digestion. The plants can be built on a domestic level, which can enable most households to own one. These plants treat hygienically kitchen waste and other bio-waste and produce gas for cooking instead of using firewood or charcoal. It also prevents the tendency to throw waste materials on roads and in public places, which is a common practice in Uganda's trading centres.

According to WHO, IEA, GACC, UNDP and World Bank, (2018) closing the household energy access gap is now a priority on the global sustainable development agenda. Having access to reliable, clean, modern cooking energy enables people to live to their full potential. Inefficient cooking is a root cause of poverty, poor health, gender inequality, environmental degradation, air pollution, and contributes to climate change. Universal access to clean and modern cooking is integral to reducing poverty and advancing human dignity. The co-benefits of clean cooking can help achieve 10 of the 17 Global Goals, including health and well-being, gender equality, environmental protection, climate action, and sustainable cities. Moreover, clean cooking is particularly relevant to fulfilling the commitment to “leave no one behind.” The harmful consequences of inefficient, traditional cooking disproportionately affect the world's most vulnerable citizens – women, girls, and infants, as well as those living in extreme poverty and displaced populations.

Traditional cooking also poses barriers to women’s and girls’ equality, since they often spend hours each day caring for their families and performing routine, unpaid household chores, such as cooking, cleaning, and collecting water and firewood, time that could otherwise be spent on income generating activities, education, or recreation. For example, girls in homes using polluting fuels spent about 18 hours weekly collecting fuel or water, while girls in homes mainly using clean fuels averaged only 5 hours in 16 African countries surveyed (WHO 2016). Without addressing the time poverty that women and girls face, gender equality (Goal 5) cannot be fully achieved.

Karekezi (1994: 30) argues that a lot of research has focused on modernizing fuel production and end-use technologies in the last thirty years. One of the most sustainable efforts was the improvement of the cooking stove, which is efficient and environmentally friendly for households and institutions in developing countries. The objective of these programmes was to uplift the living conditions of the poor majority in the developing world through self-sufficiency.

Achan (2018) reports that with forests gone, traditional cooking methods expose family members to numerous pollutants causing health problems. She further reports that a total of $2.2m (over sh8.4 billion) has been injected by the World Bank to foster the sales and adoption of cleaner and more efficient cooking technologies in Uganda under the Clean Cooking Supply Chain Expansion project. The Ministry of Energy and Mineral Development, with the support of the German Technical Cooperation (GTZ) through the Energy Advisory Project (EAP), has partnered with community-based NGOs and the private sector to promote the improved Rocket Stoves for households and institutions. The rocket stoves for households have been modified to fit the socio-economic setting of the poor by using locally available materials that can be obtained cheaply or even without a cost. Such materials include clay mixed with grass, ant-hill soil and sawdust. In his report, Kimuli (2007) further states that the Uganda Government adopted a Renewable Energy Policy (2007) with the goal of making Renewable Energy a substantial part of national energy consumption, adopted in the Central and Western districts of Uganda which included Bushenyi and Mbarara.

According to Byekwaso (2009), other attempts have been made to produce biogas involving using biogas digester plants (machines) which facilitate the process of anaerobic digestion. The plants can be built on a domestic level, which can enable most households to own one. These plants treat hygienically kitchen waste and other bio-waste and produce gas for cooking instead of using firewood or charcoal. It also prevents the tendency to throw waste materials on roads and in public places. However, statistics from the Ministry of Energy (March 2009) suggest that the usage of biogas digesters is virtually untapped in Uganda. According to Irena International Renewable energy (2017), biogas cook stoves are attractive in places with wood scarcity. They displace the use of wood or charcoal entirely, and they are particularly viable in agricultural locations due to the readily available feedstocks. Biogas can be produced from locally available agricultural residues or animal or human waste, with valuable organic fertilizer as a by-product, and it is easy to store and transport. IRENA (2017) further states that cookstoves based on biogas

and other sustainably produced renewable fuels can greatly improve health and welfare (www.indiaenvironmentportal.org.in/files/file/IRENA_Biogas_for_domestic_cooking_2017.pdf).

In addition to biogas, the Asian and Pacific Centre for Transfer of Technology (APCTT), and Research Centre for Applied Science & Technology (RECAST) (2021) describe a beehive briquette as a solid fuel made out of char obtained from the carbonization of biomass residues. It is used as a substitute for fuel wood or kerosene for cooking or space heating. RECAST states that the technology of making beehive briquettes involves partial carbonization of biomass wastes, and mixing of char with binders followed by briquetting. Beehive briquettes can be used for domestic cooking as well as for space heating purposes. These beehive briquettes are superior to any other shape of briquettes. It further states that only one briquette is used in a stove and it gives clean gaseous combustion like LPG. The technology is simple pollution free and eco-friendly. It provides smokeless domestic fuel easily ignitable with sustained uniform combustion. It suggests that it can replace fuel wood and other imported petroleum.

It was reported by Kitunzi in the Daily Monitor (2020) that three children from one family one night died after suffocating in a single rented room. The incident happened in an industrial division, of Mbale city, Eastern Uganda. It was confirmed by police that the children died from choking due to smoke from a burning charcoal stove in their poorly ventilated house in absence of their parents.

Whereas in Uganda and across Africa, there is a rise of clean cookstoves, they all use biomass as their source of fuel which still contributes to the high rate of deforestation. The initiative also includes the use of briquettes which are the source of energy and the stoves have been heavily insulated with clay to retain the heat. About 90% of Ugandans depend on biomass stoves to cook. These include charcoal, briquette and firewood users. This has called for more innovation in the cook stove industry as a measure to stop deforestation and have a clean cooking environment in the kitchen. According to Twine (2021), Eco Group Ltd has come up with an Eco stove design that uses reusable volcanic rocks to cook. The volcanic rocks retain heat much longer than any other fuel. She further states that briquettes are used as fire starters and solar is used to power the inbuilt air system that runs forced air to the stones thus increasing combustion. These are the main source of fuel used by Eco Group Ltd. It is a new concept in the country and on the continent although it is spreading across Africa, that is, Somalia and Rwanda.

She further states that the smart solar-aided eco stove kitchen that saves up 80% of charcoal usage by using reusable magma rocks supported by a solar-powered air system can enable the stove to achieve maximum efficiency. The system can provide light in the kitchen at night, and charge a cell phone in addition to cooking. Although Improved cookstoves (ICS) have higher fuel efficiency and reduce indoor air pollution yet are not well-established in the market. According to the Global Alliance for Clean Cookstoves (GVEP International 2012), only 6% of rural households and 14% of peri-urban households own an ICS in Uganda.

Meanwhile, it has been reported by Odyeko (2022) that the Uganda Government has rolled out Sh. 900 billion free cooking gas project. One million homes in Uganda are set to get gas cylinders complete with their accessories under a new initiative by the government to provide clean energy and protect the environment. It has been understood that Uganda's women bear the burden of the difficult kitchen work using inefficient stoves that deploy firewood and charcoal. Such energy sources generate uncomfortable heat and produce uncomfortable smoke that irritates the eyes and causes coughing. Therefore, such an initiative may save the environment and the lives of many Ugandan women and children.

METHODOLOGY

The study employed ethnographic research methods involving conducting interviews with some respondents in the districts of Mbarara and Bushenyi of the Ankole region, using an interview guide and participant observation. In designing questions, cognizance was taken of the type of information the researcher required. To test experience or behavioural responses and opinions or values, follow-up questions were necessary for greater depth of inquiry. The researcher also made site visits in order to observe and document activities taking place in the study area and also to observe innovative activities that were taking place to intervene with fuel efficiency and combating gas emissions. Sarantakos (1998: 207) argues that observation is one of the oldest methods of data collection. It is a method that employs vision as its main means of data collection and is open to all observable social phenomena. During the course of the study, cameras were used to document activities in the field to provide documentary evidence, depicting material reality (Shank 2006: 33).

RESEARCH FINDINGS

The researcher visited 80 homes in Bushenyi and Mbarara district to observe and document various cookstoves and fuels used in cooking. For the last twenty years the researcher has been a regular visitor to these sites, observing the different activities that take place in pottery production and pottery use. On top of that he has lived in both districts from his childhood to-date, so access to the community was not a problem. He noted that the two districts have different landscapes although

daily activities are almost similar. Whereas Bushenyi district used to have many papyrus swamps in the 1960s and 70s, which used to work as a source of fuel for cooking, most of them have been cleared for dairy farming. However, the cook stove has not changed in most homes. They still use the traditional three stone cook stove. Although they are known as three stone, in reality they are not stones. Most homes in Bushenyi and Mbarara use Black termite mounds to support pots for cooking (Figure 1).

During the study, the researcher investigated why many people use black termite mounds to support cooking pots. From the responses received from the respondents, the researcher was informed that they retain heat during and after cooking. They contain air spaces inside and they are sealed on their surface and once they are heated up one can leave food on the fire place for almost five hours keeping it warm. One respondent told the researcher that she does not need to warm her husband's food when he is in the field working. She leaves the food on a fire place wrapped in the banana leaves, and by the time he comes back, the food will still be warm.

The researcher investigated the type of fuel used for cooking in Bushenyi District. 90% of the respondents said that they use firewood, agricultural waste and twigs gathered from the bush. In the past they used to cook with dry papyrus reeds but this type of fuel is on the verge of extinction. Most of the papyrus swamps were cleared for dairy farming, and those which have remained are far away. Even the dry wood which they used to gather from the bush are rare to come by because most of the land in Bushenyi was cleared for agriculture and livestock farming. However, these days one has to organise and split wood for cooking. They depend on planted eucalyptus type of trees for firewood, because every household has to plant some trees for firewood and repairing farm fences. Those who do not have where to plant trees, have to buy firewood for cooking. The other 8% of the respondents use Charcoal stoves for cooking and about 1% use LPG gas for cooking especially those who live in urban centres; and about 1% use biogas and other types of fuel for cooking especially those in rural areas living on small plots of land and who practice zero grazing.

The researcher visited another site in Bushenyi to investigate the type of cook stove and fuel used in cooking. He documented an improved cook stove which had been modified because it has an oven for baking bread and cakes. According to the information gathered, the person who constructed it used hollow bricks to construct it because they retain heat during and after cooking and do not produce smoke in the kitchen because during the construction, the builder fixed the stove with chimneys to take out the smoke. The stove had a good finishing with ceramic tiles to make it easy for cleaning and it was also raised from the ground level which gave safety to the children from burning. The

Figure 1. Cooking on black termite mounds.

researcher was informed that the stove uses firewood for cooking and it saves fuel by about 70% compared to ordinary traditional stove. The researcher was informed by the respondent that on top of doing her domestic cooking, she also bakes wedding cakes which generate income for her. This business has helped her to educate her children who have all graduated from Universities (Figure 2).

Like in Bushenyi, the respondents in Mbarara district depend mainly on firewood for cooking especially in rural and semi-urban areas. According to research findings the respondents in Mbarara district use a variety cooking fuels and cook stoves. The study found that about 60% of the respondents use firewood for cooking but on a variety of cook stoves. Whereas most of the respondents still use three stone cook stove, some have tried to use more modified stoves in order to reduce fuel consumption and reduce smoke in the kitchen.

Figure 2. Improved cook stove with an oven.

The researcher observed some people who were constructing a rocket cook stove. They mixed grass straw with anthill mud with water and started constructing according to the size of the cooking pots. The stove was left for about 2 weeks to dry, before it was used for cooking. The researcher was informed that whereas the grass straws were meant to hold the soil together, after burning it creates some air spaces in the fire place to retain heat while cooking. They work on the same principles like those of the black termite mounds. In addition, they created two cooking places for two pots feed from one mouth with fire wood. The researcher was informed that the anthill soil works like clay, because it contains some stones and other minerals which work as temper. When mixed with water it becomes plastic and after drying, it does not crack because it is properly tempered. Those who do not have anthill soil try to use clay mixed with stone dust and grog as their temper. During the construction, they fixed the stove with a round sheet of metal to let the smoke and other gases out of the kitchen while cooking. The researcher was informed that this type of cook stove saves cooking fuel by about 60% and reduces smoke from the kitchen. It also protects children from burning because the fire is contained in the fire chamber (Figure 3).

Unlike in Bushenyi, many people in Mbarara have to walk long distances to look for firewood for cooking. Those who cannot get them from the bush have to buy them. The study documented some children carrying firewood in the evening (Figure 4) and a pile of firewood on the outskirts of Mbarara city, which is a source of fuel for cooking in homes, hospitals, and schools (Figure 5).

The researcher went ahead to investigate other types of cooking ovens in the Mbarara district. He found out that about 30% of the people in the Mbarara district use clay stoves for cooking. According to Kayamba and Kwesiga (2016:86) making clay stoves has become full-time employment because the demand for clay stoves in towns is high because they are energy efficient. The study informed that most households use clay stoves for cooking because they are strong, tough, have high thermal conductivity and are resistant to thermal shock because during the forming they use temper. It was also found that a big number of households, about 30% use charcoal as the main cooking fuel. This has led to a loss of vegetation and environmental degradation due to the high demand for fuel for cooking.

There has been an improvement in the type of clay stoves where the stove is insulated with a metal casing. This has increased the life span of the stove by making it break-resistant. The stove can be used for cooking for 2 years, unlike the clay stove which could easily break although they are strong and highly tempered. On top of that, the stoves look smart as the name suggests, "smart homes" These are mainly used in towns by those who can afford them, but those who cannot still use the traditional clay stoves (Figure 6).

Figure 3. Rocket cook stove made with anthill soil.

Figure 4. Children carrying firewood.

Figure 5. A pile of firewood for sale.

The researcher was informed that most of the charcoal comes from distant places from Mbarara city because most of the trees near Mbarara town were cleared for making farms, they are now depending on virgin areas,

Figure 6. Smart home stove insulated with metal.

which are about 20 km and beyond the city centre, where they are opening bushes to make farms. This has doubled the price of charcoal in the last two years, a bag that used to cost Shs. 35,000/ = (about Us $10) is now costing Shs. 70,000/= (about Us$ 20) (Figure 7). This has led to some innovations in the making of fuel for cooking.

The researcher documented some innovations where a group of women have come up to make briquettes from charcoal dust, commonly known as *orusenyente,* mixed with clay. The researcher was informed that these briquettes can cook for a slightly longer time than charcoal and they do not produce a lot of smoke. The same group has tried to mix some agricultural waste with clay but they found out that this produces smoke when cooking. At the same time, these briquettes can be reusable, to minimize fuel costs. In addition, the researcher was informed that a bag of briquettes costs about Shs. 15,000, which is about 4 times less than that of charcoal. However, it does not work alone, it needs some charcoal as a starter when lighting the fire (Figure 8).

At another site, the researcher documented an activity where they were making beehive briquettes. They mixed clay as a binder with charcoal dust, which they buy cheaply as residue from charcoal burners, after selling the charcoal. They mix a bag of charcoal dust with about 2 bags of clay. Then the mixture is put in a mold and it is extruded to make honeycomb briquette. They are dried for about 2 weeks before they are sold as fuel for cooking.

Figure 7. Bags of charcoal on sale by the roadside, courtesy of Mariangela Bizzarri.

The researcher was informed that one bee hive briquette can be used to cook breakfast in the morning, after that you cook beans and later lunch. In order to save fuel, one has to cook enough food for lunch and dinner, so that you leave the food on the stove to keep warm. The bee hive burns slowly without smoke which makes the cooking environment clean. The researcher was informed that after the charcoal dust has burned down, the clay remains with some air spaces which retain heat that can keep the food warm. These burnt briquettes work on the same principle as the traditional black termite mound. However, it is for single use and after it has cooled, it is crushed and thrown in the garden, where it is ideal for growing vegetables (Figure 9).

Figure 8. (a) Drying briquettes. (b) Cooking with briquettes.

Figure 9. Beehive briquette piled in the kitchen ready for cooking.

The researcher visited another site in Mbarara where he documented a family using biogas for cooking. He was informed that they mix cow dung with water and pour it in a digester, where it stays for a week and starts releasing some gas which goes through a pipe and is released from a gas cooker. The gas cooked very fast with a clean blue frame without producing smoke. However, the researcher was informed that the gas stove could not support a big cooking saucepan to cook for a big family. Instead, they use traditional cookstoves, because they can support any size of saucepan. They used biogas for preparing quick meals like breakfast, tea, and boiling water for drinking. The researcher was informed that other than clean cooking gas, they have gained by using the slyly which is a residue from the cow dung which they use as organic manure to fertilize their banana plantation, fruits and vegetable gardens. The researcher was informed by the respondent that eating vegetables daily, has helped him get the essential vitamins, minerals and other nutrients. In addition, he sells the remaining vegetables in town. However, the biogas digester has to be regularly loaded with cow dung to keep a constant supply of cooking gas. The researcher was informed that although the Mbarara district has many cows compared to the Bushenyi district, the use of biogas has not been embraced because of the costs involved in installation (Figure 10).

At another site in Mbarara, the researcher documented

Figure 10. (a) Biogas digester. (b) Biogas stove.

a family using volcanic rocks as fuel for cooking, which they called eco-stove. He was fascinated by the technology because he could not believe it at first site. The researcher was informed that they bought the built cooking stove from a supplier, who installed it for the family. The stove had two ceramic inserts which work as fireplaces for it, where volcanic rocks were placed after being chopped in small sizes. They used little charcoal or small pieces of firewood as fire starters to light it. After lighting, the charcoal was blown by a fan which was powered by a solar battery, then the volcanic rocks caught fire and started burning. The solar is used to power the inbuilt air system that runs forced air and burns the stones thus increasing combustion. In so doing, it would be able to cook the food without producing smoke. The solar panel was also able to charge the battery which did not only produce energy for cooking but also charged a cell phone, gave light in the kitchen at night and at the same time it had an FM radio receiver. The cook could listen to news or listen to music while cooking, and she could tell time according to radio programmes (Figure 11). Before that, I had visited a shop where these eco stoves are sold and the dealer demonstrated to me how it works (Figure 12).

The researcher observed that the eco stove produced red hot flames unlike the blue flames produced by LPG gas. However, the food was ready in the required time. He observed that the cook could regulate the frame using some knobs similar to that of a radio so that the food could not burn. He was informed that after cooking, the food can be left on the stove for some time without losing heat because the rocks could still retain heat like the traditional black termite mounds. The researcher tried to observe the differences and similarities between black termite mounds and volcanic rock, and he found out that both of them have air pockets which make them retain heat during and after cooking (Figure 13).

Figure 11. Cooking with an eco-stove using volcano rocks.

Figure 12. Demonstrating how an eco-stove cooks with volcano rocks.

Figure 13. Black termite mound and volcanic rock.

Similarly, the researcher noted that the volcanic rocks, the briquettes and the improved cook stove, the ceramic inserts for the cook stoves, work on the same principle as the black termite mound, where air pockets are necessary for retaining heat and minimizing heat loss in cooking. It was also observed in the making of the rocket stoves, where they mixed grass straws with anthill soil. Because the researcher was informed that after the straws had burned, the stove would remain with some air pockets which retain heat during and after cooking.

CONCLUSION AND SUGGESTION

In conclusion, the researcher observes various fuel types of cooking used in the Ankole region that does not produce smoke. These include biogas, eco stove and bee hive briquettes. He, therefore, suggests that the people of Ankole should adopt new sustainable technologies in cooking if they are to save the environment and if they are to cook from clean kitchens. These technologies like beehive briquettes are environment friendly when one is cooking because they do not produce a lot of smoke, while biogas and eco stoves do not produce smoke at all. The use of these technologies
offers several benefits such as improved health, fuel saving, reduction in greenhouse gases emissions among others. However, these technologies are not well known to the people of Ankole, and those which are known like biogas, are considered expensive. In addition, the study would like to suggest that every family in the Mbarara district should emulate the people of Bushenyi by planting trees on their farms if we are to save the environment. Therefore, the researcher would also recommend that some international organizations should come in to pattern with some grass root organizations to make these beehive briquettes and eco-stoves since volcanic rocks can be easily available. This will make it affordable to the common person if we are to reduce environmental degradation, and desertification and reduce diseases related to indoor air pollution.

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