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Policy Responses to Addressing the Issues of Environmental Health Impacts of Charcoal Factory in Nigeria: Necessity Today; Essentiality Tomorrow

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Abstract

Worldwide trebled of wood charcoal production over the last 50 years from 17.3 million tons in 1964 to 53.1 million tons in 2014 with sixty-one percent of current global production occurring in Africa, primarily to satisfy the demand for cooking fuel from urban and rural households with 2.7 billion people relying on wood fuels in the global south, while, the rural populace in Nigeria use about 80 million cubic meters of wood fuel annually for household energy. The furnaces of the world are now burning about 2, 000, 000, 000 tons of charcoal a year. When this is burned, uniting with oxygen, it adds about 7, 000, 000, 000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few countries. With Nigeria's population projected to hit 410.6 million by 2050 and 550million by 2070 and consequently, becoming the third most populous country on our planet, and with an increased population growth rate in this part of the global village is alarming and worrisome, couple with rural-urban migration in key producing states, including Kwara, Ogun, Osun, Ondo, Ekiti, Kogi, etc.

Whilst demand for charcoal is projected to increase in Nigeria, the availability of woody biomass is declining due to widespread net deforestation and biomass being the only energy source of choice due to large scale poverty and unaffordable prices of other alternatives like gas and electricity. While the human population naturally increases geometrically, the power of the improvements in resources goes up arithmetically leading to disequilibrium. This disequilibrium promotes a lot of crises bordering on economy, security, health, and politics among others. It is a fact that human populations tend to increase much more rapidly than the means of subsistence. Given the increasing demand for charcoal, and decreasing availability of biomass, policies are urgently needed that ensure secure energy supplies for urban and rural households and reduce deforestation. There is potential for charcoal to be produced sustainably in natural woodlands, but this requires supportive policies, economic diversification, and investment in improved eco-stoves. New advocacy and public health movement are needed urgently to bring together governments, international agencies, development partners, communities, and academics from all disciplines to address the effects of charcoal factories on health.

Keywords

supportive policies, charcoal production, human populations, household energy, economic diversification, COVID-19, Nigeria

1. Introduction

Nigeria, a geographic space currently in the throes and stranglehold of unprecedented inequality where wealth and suffering both co-exist in abundance. With so much wealth, many Nigerians also suffer so much on a range of issues, including high risk concerning food security, poverty, energy production, massive use of charcoal. and most importantly, unsatisfactory infrastructure and economic development (FGN, 2008; Raimi et al., 2019). The snag, however, is that Nigerian and indeed, much of the developing world, rely on the use of biomass as the only energy source of choice due to unaffordable prices of other alternatives like gas and electricity which negatively affects nearly a third of humanity globally. Schematically, massive demographic changes underway in Nigeria and has place urban and peri-urban areas at the crossroads of a range of resource demands and threats to public health and ecosystem stability. As the population increases, so does the demand for energy. For example, population growth as experienced in Nigeria in recent decades is significant, coupled with a high rate of urbanization. Although little is known about the process of urbanization across the various states. The pace of urbanization is remarkable and managing the challenges of this rapid transformation is a key policy challenge, and yet the evidence base, predominantly in the Nigeria context, remains limited. One central question for policy makers is to what degree this process can be managed by policy as opposed to being determined by fundamentals alone. To illustrate this problem, Nigerian relies overwhelmingly on solid fuels for household energy needs, causing deforestation and environmental degradation in many places. Less than 10% of the population has access to modern fuels, such as electricity, natural gas, or liquid fuels (UNDP & WHO, 2009; Gift & Olalekan, 2020). This need has led to unsustainable levels of deforestation and associated detrimental impacts, including erosion, net releases of GHGs, and loss of biodiversity (Olalekan *et al.*, 2019). Traditional options to wood-based fuels have also been problematic. Livestock waste and agricultural residues, the most common replacement for wood and charcoal, are better suited to fertilise and stabilise agricultural fields. Without it, lower fertility, soil erosion, and poor water retention affect agricultural production. In the meantime, premature deaths from household air pollution will likely increase from 3.5 million to 5 million by 2040, although they continue to be heavily linked to poverty and an inability to access modern energy. According to the IEA's World Energy Outlook (WEO), the special report highlights the links between energy, air pollution and health and identifies the energy sector contributions to curb poor air quality, the fourth-largest threat to human health, after high blood pressure, poor diets, and smoking. At the start of 2020, the global energy investment program was on track with the largest annual growth rate in six years. But the Covid-19 crisis has halted large swathes of the world economy to a standstill in a matter of months, with investment forecasts expected to plummet by 20%, or almost $400 billion, compared with last year, according to the latest edition of **World Energy Investment** report. Despite accelerated progress of the past decade, the world will fall short of ensuring universal access to affordable, reliable, sustainable and modern energy come 2030 unless efforts are scaled up remarkably, according to the latest **tracking of SDG 7 energy progress report**.

Energy production and utilisation, mostly from unregulated, poorly regulated or inefficient fuel combustion are the most significant man-made sources of key air pollutant emissions. Almost 85% of particulate matter and all of the sulfur oxides and nitrogen oxides. Millions of tonnes of these pollutants are released into the atmosphere each year, from factories, power plants, cars, trucks, as well as the 2.7 billion people still relying on polluting stoves and fuels for cooking (mainly wood, charcoal and other biomass). World Health Organization (2004) projected that more than two billion people utilise solid fuels for cooking by twigs, agricultural residues, dung, coal, etc. The burning of these fuels in very poor combustion efficiency leads to high levels of indoor air pollution. Due to poor efficiency of fuel resulting in wastage of resources may cause high fuel demand and in turn, leading to deforestation and desertification, thereby leading to heavy workload on women and children for collecting cooking fuel, while charcoal remains an important source of energy for various applications in the domestic sector as well as other sectors. Nigeria appears to be worse hit. For instance, charcoal use range from domestic fuel for cooking, heating, firing of boilers (e.g., in laundry facilities), heating of water in tea shops, and cooking in small restaurants in many emerging countries. It is the world most popular barbecue fuel and it is widely used as a domestic fuel because it produces less smoke while burning, requires little or no preparation before actual use, has a higher energy content per unit mass, while leftover after cooking can easily be transported, stored and reused. Charcoal is a more affordable option as fuel for domestic use for many households in developing countries. The use of charcoal has also been on the increase in communities and countries especially those that have been ravaged by the economic depression which has transcended to higher demand for charcoal. Nigeria is not spared in this situation, the country has experienced an increase in demand and production of charcoal in recent times as many households are turning to it as their option of domestic fuel for cooking and heating. These have led to increase in the number of local charcoal factories; increased production has been experienced in old sites of production and new sites of production have sprung up within short periods (Hosier, 1993; Chidumayo & Gumbo, 2013). Such an increase has impacts on the environment and health of people in such areas and one of the ways of examining such impacts and providing measures to control negative impacts is through Environmental Health Impact Assessment (EHIA) (Raimi *et al.*, 2019; Omidiji & Raimi, 2019; Olalekan *et al.*, 2020).

Health Impact Assessment looks at policies, programs, projects, that are not intended to impact health but that have the potential to have negative and/or positive effects on health and health equity (WHO, 2000; Raimi *et al.*, 2019; Omidiji & Raimi, 2019; Olalekan *et al.*, 2020). It is also referred to as a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential health effects on a population, and the distribution of those effects within the population and the distribution of those effects within the population (Louise & Julie, 2014; Raimi *et al.*, 2019; Olalekan *et al.*, 2020). However, environmental impact assessment usually denotes the attempt to predict and assess the impact of development projects on the environment (Omidiji & Raimi, 2019). Within the context of this, EHIA considers how these identified environmental impacts will affect the health of the population. EHIA is usually considered as a component of EIA dealing specifically with human health with the view of offering unique opportunities for protecting and promoting human health (Jadav *et al.*, 2002; Raimi *et al.*, 2019). An EHIA must be considered for the proliferation of local charcoal factories since it has been established that charcoal production affects the environment. This has the potential of maximizing and controlling the effects of these local factories especially on the people and communities in and around the site of these local factories.

Besides, in the global south, biomass is the main source of energy, with 2.7 billion people worldwide using traditional biomass as their primary cooking fuel (IEA 2010). The reliance on biomass essentially wood and charcoal is particularly high in Sub-Saharan Africa. About 81 percent, the proportion of people relying on these fuels is higher than in any other region (UNDP/WHO, 2009). Wood fuel usage for cooking purposes is associated with various negative effects on people's living conditions. The emitted smoke is a major health threat: According to WHO (2009a), 2 million people die every year as a consequence of so called household air pollution, more deaths than malaria have caused (Martin *et al.*, 2011). In Senegal alone, some estimated 6,300 people die every year because of household air pollution

(WHO, 2009b). In rural areas, firewood often has to be collected posing a burden of workload, especially for women. In urban areas, wood fuels are by and large purchased, incurring substantial costs for households. Likewise, in arid countries with relatively low production of biomass such as Senegal, this reliance may additionally cause wood to be extracted in an unsustainable manner. The resulting deforestation not only affects the global climate due to a loss of carbon sinks but also leads to more immediate regional and local environmental impacts, including land degradation and loss of biodiversity. The deforestation effect of charcoal, the primary wood fuel in urban centers, is even worse than that of firewood: First, the charcoal production process is intensive and puts more pressure on forest resources than does fuelwood collection, which is carried out by the rural population in a rather extensive way (Kammen & Lew, 2005). Secondly, the production of charcoal in a traditional form tends to be inefficient inferring that charcoal cooking requires roughly twice as much raw wood as does cooking with firewood. Not least, due to an increasingly urban usage of charcoal, a result of ongoing urbanization processes, the total consumption of wood fuel in Sub-Saharan Africa is steadily growing (FAO, 2008; IEA, 2006). Besides policy interventions on the supply side, like improved forestry management systems or reforestation initiatives, two approaches can reduce deforestation pressure on the demand side: the usage of more efficient, so-referred to as improved cooking stoves (ICS), or switching to non-wood fuels for example Liquefied Petroleum Gas (LPG) or kerosene. In other African countries such as Senegal, both strategies have been pursued for decades of years, leading to a situation in which LPG is dominantly used in urban areas. Although, charcoal is still used widely. Therefore, since the 1990’s the development partners including international donor community and national governments through the Ministry of Environment have put much effort into disseminating ICS in Nigeria and other emerging countries. Currently, the detrimental effects of biomass usage for cooking purposes and the distribution of ICS have received lots of public attention in the wake of the creation of the Global Alliance for Clean Cook stoves. As part of the United Nations Foundation and promoted by the US Secretary of State, Hillary Clinton, the Global Alliance intends to bring ICS or improved fuels like LPG to 100 million homes in emerging countries by 2020. In general, ICS is designed to reduce fuel consumption per meal and to curb smoke emissions. The meaning of ICS varies from more sophisticated bricked stoves with chimneys leading the smoke out of the kitchen to very meek transportable clay or metal stoves that had just improve the heating process. Even though the assumptions surrounding the positive impacts of distributing such cooking devices in decreasing fuelwood consumption and thereby workload and health burdens as well as deforestation pressures seem to be straightforward, rigorous impact evaluations of these development interventions are rare. For health impacts, some evidence exists from Latin America and Asia. (Smith-Sivertsen *et al.,* 2009), for example, find a substantial reduction in exposure to indoor air pollution and a reduction in risk for respiratory symptoms in the course of a field experiment for which chimney stoves were randomly assigned to replace traditional open fires in rural Guatemala (see as well Smith-Sivertsen *et al.*, 2004). Masera *et al.*, (2007) unearths similar outcomes in rural Mexico, and Diaz *et al.* (2007) notice a substantial reduction in headaches and eye infections in Guatemala, equally likewise after the introduction of chimney stoves. YU (2011) observes the effects of the behavioural intervention in combination with ICS measures in rural China and unearths that this double treatment slows down respiratory diseases amongst children below five. This effect seems to be mainly triggered by the behavioural part, though. Besides, rigorous research is at present being performed by J-Pal in India and Bangladesh (see Duflo, Greenstone, & Hanna, 2008a, 2008b). For Africa, Bensch and Peters (2011) evaluate the impacts of ICS usage in rural Senegal through a field experiment for which ICS were randomly assigned to households. They find a substantial reduction of firewood consumption and self-reported respiratory disease and eye infection symptoms. Cooking time is likewise drastically reduced, while we no longer find a substantial impact on the collection time of firewood. Beyond this study, evidence for Africa, in particular for urban areas, is completely lacking. The impacts of ICS utilisation in urban centers may be expected to vary significantly from ICS impacts in rural areas since different fuels and stoves are used here.

2. Charcoal

Charcoal is a porous carbon material, with a heterogeneous surface and a disorganized pore structure susceptible to change by adequate thermal treatments to be used as adsorbent (Pehlivan *et al.*, 2011). Charcoal typically is derived from wood. Wood is a polymeric structure consisting of carbohydrates (cellulose and hemicellulose) and lignin, with small amounts of extraneous organic chemicals (Pehlivan *et al.*, 2011). Charcoal, an age antique refined form of wood fuel, nevertheless remains an essential source of energy for domestic cooking and a huge variety of industrial and processing applications which include manufacturing of activated carbon and calcium carbide, reduction of iron ore in the steel industry, black smithies, cloth ironing, heavy-clay soil conditioner, orchid planting medium, etc. Charcoal is cheap, has the thermal capacity and a good absorbent for impurities removal in water. The addition of charcoal leads to a significant increase in the temperature of the seawater that resulted to increase in the evaporation rate. Since biomass is the main and indeed traditional source of energy for many households in emerging countries. It is the principal energy-producing fuel commonly used in both urban and rural households and institutions for cooking and heating. Charcoal is the black carbon lightweight and ash residue hydrocarbon produced with the aid of getting rid of water and other unstable constituents from animal and regularly vegetation substances (Chidumayo & Gumbo, 2013; Zulu & Richardson, 2013). Though charcoal could be made from peat, coal, wood, coconut shell, or petroleum but wood is the commonest raw materials used especially in the sub-Saharan Africa. It is produced usually by using gradual pyrolysis; the heating of wood or other materials in the absence of oxygen. The benefit of using charcoal rather than just burning wood is to remove water and other components, which permits charcoal to burn at a higher temperature and the fact that the product of its combustion is mostly carbon dioxide, resulting in very little smoke (regular wood offers a good amount of steam and unburnt carbon particles-soot-in its smoke) (Hosier, 1993; Jones, 2015). Charcoal is classified in several categories as lump charcoal, briquette charcoal, and extruded charcoal, charcoal having heating vale of 28-30 MJ/kg equal to 70% heating value of kerosene 44 MJ/kg (UN High Commissioner for Refugees (UNHCR)), due to good heating vale charcoal can be used in various application as cooking fuel, industrial fuel, automotive fuel, purification/filtration of wastewater, horticulture and drawing, making rough sketches in painting. Because of various application packages that may be making good opportunities for charcoal as livelihoods option for local people in rural villages. Charcoal making from the wooded or different waste call as carbonization because of carbon comprises approximately more than 80%. The stage of carbonization may be pivotal in charcoal production even though it is not one of the most costly. Unless it is carried out as efficiently as viable, it places the whole process of charcoal production at risk because low yields carbonization reflects via the entire production chain as increased costs and resource waste. Wood comprises three major components namely cellulose, lignin, and water. The cellulose and lignin and a few other materials are composed firmly together and make up the substances we call wood. The adsorbed water is held as molecules of water on the cellulose/lignin structure. Air dry or "seasoned" wood still contains 12-18% of adsorbed water. Growing, freshly cut or "unseasoned" wood contains, furthermore, liquid water to offer a total water content of about 40 to 100% expressed as a proportion of the oven-dry weight of the wood. The wood containing water has to be driven off as vapour before carbonization can take effect. To evaporate water entails a lot of energy so that using the sun to pre-dry the wood as considerably as possible before carbonization critically improves efficiency. The remaining water in the carbonized wood need be evaporated in the kiln or pit and this power must be provided by way of burning some wood itself which otherwise might be converted into useful charcoal. When firewood is heated in air absence, it loses unpredictable components and gets converted into charcoal as shown in the below equation. Its calorific value is higher (33 kjg-1) than wood (17kjg-1). Charcoal is blackish residue comprising of impure carbon obtained by eliminating water and other unstable constituents from substances such as animal and vegetation. Sugar charcoal, bone charcoal (which comprises a great amount of calcium phosphate), and others may be produced as well. The conversion of wood into charcoal is described by following chemical equation:

$$\text{Wood} \xrightarrow{\text{Heat strongly in absence of Air}} \underset{\text{(Black residue)}}{\text{Charcoal}} + \text{Volatile matter} + \text{Moisture}$$

The use of charcoal dates back to centuries ago and has always been considered cheap compared to other domestic fuel options. Also, the production of wood charcoal in locations where there is an abundance of wood dates back to a very ancient period, and generally consists of piling billets of conical pile forms a wood at their ends, bottom openings being left to admit air, with a dominant shaft to function as a flue. The entire pile is shielded with turf or moistened clay. The firing began at the bottom of the flue, and gradually spreads outwards and upwards (Jones, 2015). The accomplishment of the process hinges upon the degree of the combustion. Below average situations, 100 wood parts yield about 60 portions by volume, or 25 portions by weight, of charcoal; limited production on the spot often yields about 50%, while large-scale became efficient to about 90%. The process is so subtle that it was generally left to colliers (professional charcoal burners) who frequently lived alone in small huts to tend their woodpiles. However, increasing demands have brought about the proliferation of colliers and many more people going into the production and trade as large-scale production of charcoal to be on the increase (Adam, 2009). Charcoal production on a large-scale, principally in sub-Saharan Africa, has been a rising concern due to its deforestation threat, land degradation and impacts on climate change. The Climate Change Risk Index, which measure the capacity of the country to anticipate, cope with, resist, and recover from the impact of climate change, in 2018 was 68.33, meaning countries faces a high level of exposure and vulnerability to climate related events. Citing it as the most environmentally devastating period of this traditional energy supply chain, and notwithstanding it increasing per capita income, higher electrification rates, and important renewable energy potential, charcoal remains the dominant source of cooking and heating energy for eighty percent of households in Sub Saharan Africa (Zulu & Richardson, 2013). Apart from the common charcoal found in most communities, there other types of charcoal;

i. Sugar charcoal is obtained from the carbonization of sugar and is particularly pure. It is decontaminated by acids boiling to expel any mineral substance and is then burned for quite a while in a chlorine current to evacuate the last traces of hydrogen. It was utilized by Henri Moissan in his initial endeavour to construct synthetic diamonds. Activated charcoal is akin to regular charcoal yet is made particularly for medical use. To create activated charcoal, producers heat regular charcoal in the gas presence that makes the charcoal to develop numerous internal spaces or "pores". These pores help activated charcoal trap chemicals. Lump charcoal is traditional charcoal prepared straightforwardly from hardwood material.

ii. It usually produces far less ash. Japanese charcoal has had pyroligneous acid removed during the charcoal making; it, therefore, produces almost no smell or smoke when burned (Hosier, 1993; Jones, 2015).

iii. Pillow shaped briquettes are made by compressing charcoal, typically made from sawdust and other wood by-products, with a binder and other additives. The binder is usually starch. Briquettes may likewise comprise mineral carbon (heat source), brown coal (heat source), borax, sodium nitrate (ignition aid), limestone (ash-whitening agent), raw sawdust (ignition aid), and other added additives substances. Briquette sawdust charcoal is created by compacting sawdust without additives substances or binders. It is the desired charcoal in Taiwan, Korea, Greece, and the Middle East. It has a round gap through the epicenter, with a hexagonal connection. It is utilized basically for barbecue as it produces no scent, little ash, no smoke, high heat, and long burning hours (surpassing 4 hours).

iv. Extruded charcoal is made by extruding either raw ground wood or carbonized wood into logs without the use of a binder. The heat and pressure of the expelling procedure grip the charcoal together. If the extrusion is produced using raw wood material, the logs expelled are subsequently carbonized (Jones, 2015).

3. Charcoal Production

Charcoal is generally unadulterated carbon, termed char, made by cooking wood in a low oxygen condition, a procedure that can take days and burns off unpredictable compounds, for example, methane, water, hydrogen, and tar. Charcoal making is a traditional and honourable occupation. Its roots are lost in ancient times and the traditional techniques for causing it to have transformed surprisingly little from prehistoric times till nowadays. The only new factors are that the basic approaches have been streamlined and that science has confirmed the fundamental procedures which happen during carbonisation and predicted the quantitative and qualitative laws which govern the process. Conversely, in commercial processing, the burning takes place in huge cement or steel silos with next to no oxygen and stops before everything turns to debris. The process leaves black lumps and powder, about 25% of the original weight (Zulu & Richardson, 2013; Evans, 2002). Generally, common charcoal is produced through a method called pyrolysis of biomass. Pyrolysis is an irreversible chemical change brought about by heating the biomass without oxygen. During pyrolysis, biomass experiences a system of changes and typically yields a black carbonaceous solid, called charcoal, alongside a blend of gases and fumes. By and large, the production of charcoal through pyrolysis is amplified in a procedure of low temperatures and gentle heating rates, the supposed carbonisation (Senelwa *et al.*, 2008). There are five product kinds and results from the production of charcoal operations: charcoal, Non-condensible gases (carbon monoxide [CO], carbon dioxide [CO_2], methane, and ethane), pyroacids (primarily acetic acid and methanol), tars and heavy oils, and water. Except for charcoal, these emitted materials with the furnace exhaust. Constituents differ, depending upon raw materials and carbonization parameters. Organics and CO are normally CO_2 combusted and water before leaving the retort. Since the extent of this burning differs from plant to plant, emission levels are relatively variable. Some portion of the particular organic compounds that might be found in charcoal oven emissions includes methane, ethane, ethanol, and Polycyclic Organic Matter (POM).

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Particulate matter emissions from briquetting activities may be controlled with a centrifugal collector (65 percent control) or textile filter (99 percent control). Hardwood charcoal is produced abundantly in Nigeria during the dry season (from October to early June of every year) in; Ogun, Oyo, Ondo, Osun, Ekiti, Enugu, Rivers, Cross River, Kwara, Kogi, Abuja and Benue States. Here, there are two methods of making charcoal (direct and indirect); the direct method uses heat from incomplete combustion of the organic matter, which is to become charcoal. The ignition rate is constrained by regulating oxygen amount permitted into the burn and is halted by excluding oxygen before the charcoal itself starts to burn; the indirect technique utilizes an outward heat source to "cook" organic matter contained in a locked yet vented airless chamber. This is usually carried out in a metal or masonry chamber (furnace) (Chidumayo & Gumbo, 2013). Furthermore, charcoal has been made by various methods. The traditional method essentially arranges the logs in a pile leaning against a chimney (logs are placed in a circle). The chimney consists of four (4) wooden stakes held up by some rope. The logs are entirely secured with soil and straw permitting no entrance of air. It must be lit by bringing some burning fuel into the stack; the logs burn gradually and change into charcoal in a time of 5 days' burning. If the covering of soil gets torn (cracked) by the fire, additional soil is set on the cracks. As soon as the burn is finished, the smokestack is plugged to prevent the entrance of air. The genuine art of this production technique is in managing the adequate heat generation (by combusting portion of the wood material), and its transfer to parts of the wood during the process of being carbonised. A tough disadvantage of this production strategy is the tremendous emissions amount that is detrimental to human health and the milieu (emissions of unburnt methane) (Hosier, 1993).

The recent technique employs retorting technology, in which heat procedure is recovered from and exclusively provided by, the gas combustion is discharged during carbonisation. Retorting yields are significantly greater than those of kilning, and may stretch 35%-40%. Recent approaches which have been presented in certain parts of the developed world have replaced the old technology. Their originality does not dwell in the carbonisation principle itself however in the justification of the utilization of heat, handling of materials and labour and in certain cases the recovery of by-products from the smoke given off during carbonisation (Climate Tech Wiki, 2012). There exist industrial technologies about 90% of the process from the growing and harvesting of the wood to the distribution and sale of the finished charcoal is still the same as with the traditional methods. The newness of these industrial technologies resides in the carbonisation step and the replacement of labour intensive methods of materials handling with capital intensive methods (Evans, 2002). However, the properties of the charcoal produced depend on the material charred and the charring temperature is also important. Charcoal comprises variable hydrogen amounts and oxygen just as ash and different impurities that, together with the structure, decide the properties. Good stocks for hardwood charcoal contain considerable low moisture contents, low ash contents and very minimum volatile matter contents

(Senelwa *et al.*, 2008). Another good quality of charcoal hardwood is to be in sizes that are good for the most part between 20-120mm and moderately high carbon contents to suit any utilization. The constituents of good charcoal are Percentage Moisture contents (8%), max Volatile matter (5-10%) max, Ash contents (4%) max, Wood matter (2-4%), Charcoal Size: 20-120mm, Colour: Black or Dark grey, Carbon contents: 70% min, Packaging Bulk 30kg PP Bags (Chidumayo & Gumbo, 2013). However, Figure 1 below, indicates that the rate of charcoal production has been increasing at a high rate which is over 10% hence demonstrating an increase in the production. Implying that the percentage change or increase average is 16.5% (Figure 1).

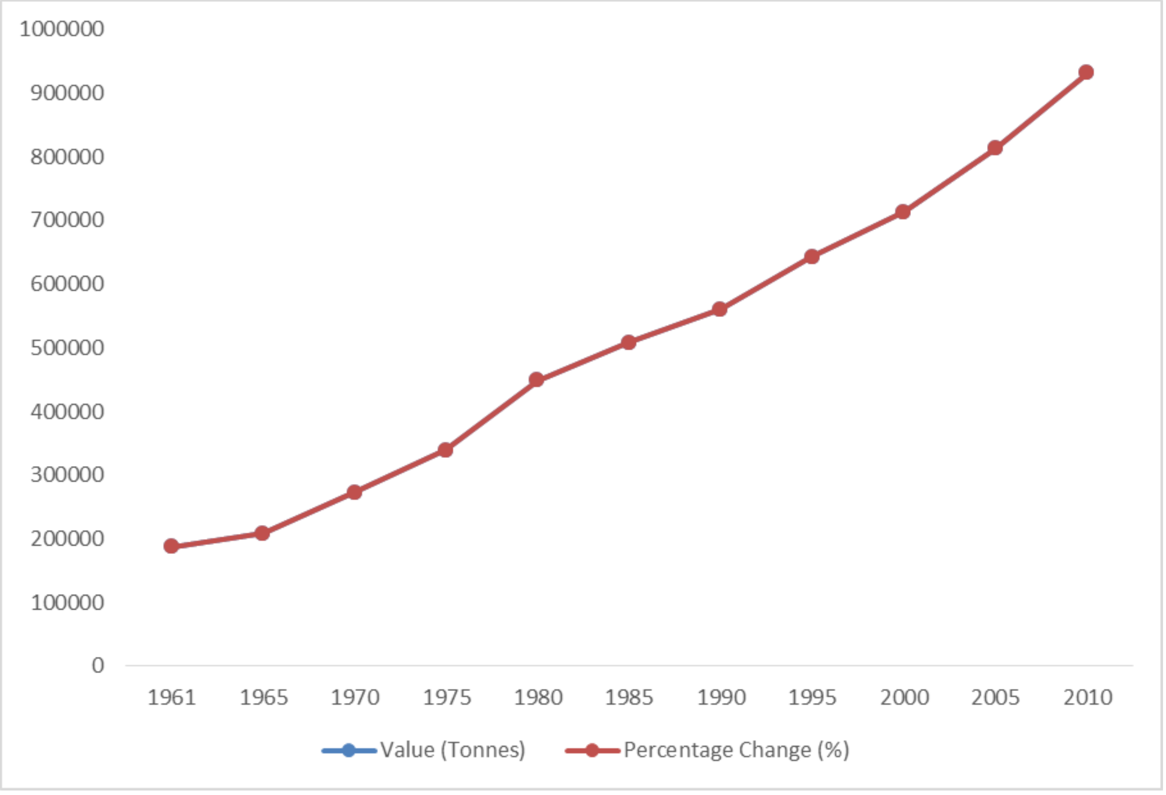

Figure 1. Shows the Percentage Change of Charcoal Production over 50 Years (1961-2010)

Adapted from FAO, 2017

4. Uses of Charcoal

Growth in charcoal demand will probably continue over the coming 25 years, particularly in lower-middle and low-income economic regions, where most citizens lack access to safe and affordable energy. The growth in global per capita energy demand is allied to developments in the standard of living in the global south and directly supports development goals. As energy is a key enabler and central to sustainable and economic development and social wellbeing and lack of access to modern energy services negatively affects nearly a third of humanity**.** In acknowledgment of energy being an important economic and social development determinant, and of health and wellbeing, the UN has declared the UN Decade of Sustainable Energy for All. The world's population must be ready to access clean sorts of energy which will offer these basic needs, which may reduce the health burden from both direct and indirect exposure from future climate change risks. The Sustainable Development Goals (SDGs) have emphasized the role that energy plays in securing a sustainable future for a global nine billion population come 2050 and have outlined four goals to support, which may act as improvement metrics. The indicators assessing improvement on the SDGs for safeguarding sustainable energy for all by 2030 include: ensuring worldwide access to affordable, sustainable, reliable energy services; doubling the share of renewable energy within the global energy mix; doubling the worldwide rate of improvement in energy efficiency; phasing out fossil-fuel production and consumption subsidies that encourage wasteful utilisation, while ensuring secure affordable energy for the poor (Open Working Group proposal for Sustainable Development Goals, 2014). While poor people remain in darkness and ill health, there is often no escape from the vicious cycle of poverty (https://www.reeep.org/poor-peoples-energy-outlook-2012). A lot of Nigerians suffer so greatly on an array of poverty issues in the country (see Figure 2 below). Considering this fact, the United Nations report that people are multidimensionally poor when they are poor in many respects including education, health, access to potable water, nutrition, electricity, their assets, among other indices. Besides, widespread poverty is directly linked to biodiversity loss. This is because rural livelihoods depend almost entirely on biodiversity. The problem must be addressed by providing alternative livelihood options to rural communities.

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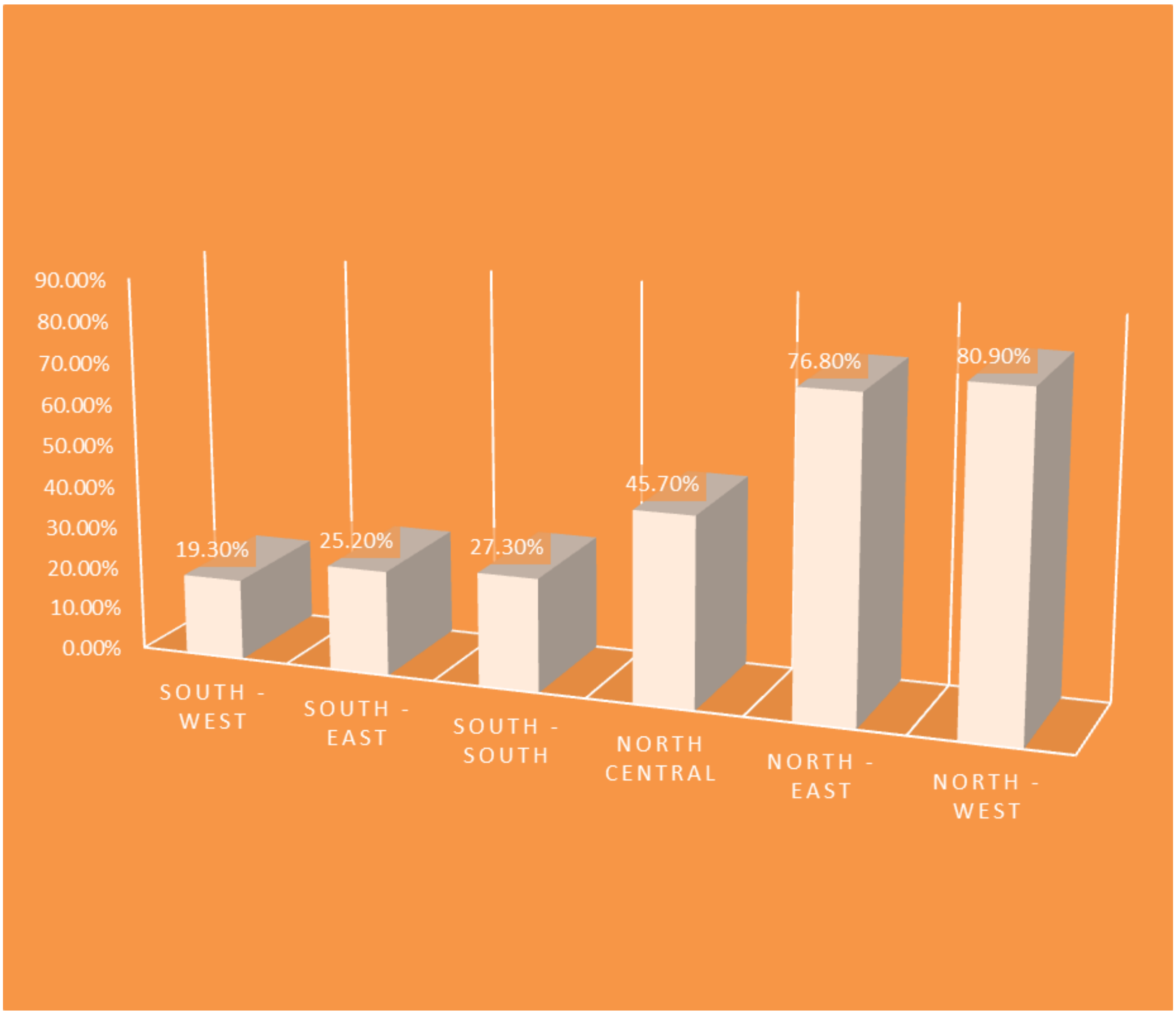

Figure 2. United Nations Global Multidimensional Poverty Index for Nigeria on Poverty Rates

Adapted from Olalekan *et al.*, 2020

About 69% of Nigeria's or about 2.7 billion people (almost half of the world's population) live in poverty which is expected to cost $2/day. Thus far, poverty reduction determinations efforts tend to affects all development traits (Ebuete *et al.*, 2019; Olalekan *et al.*, 2020). It touches all aspects of human advances such as social, economic, and environmental aspects including access to water, agricultural productivity, population levels, and gender-related issues (Raimi *et al.*, 2019; Olalekan *et al.*, 2019). None of the Sustainable Development Goals (SDGs) can be met without major improvement in the quality and quantity of energy services in emerging countries (Ebuete *et al.*, 2019). Equally noted that Nigeria has significant ways to go in achieving improvement in sustainable energy for everyone and achieving the Sustainable Development Goals (SDGs) target 7 by 2030, stating to ensure access to affordable, reliable, sustainable and modern energy for all, as was put forward by the United Nations.

There is, therefore, a need to advance and harness renewable energy potential to meet the country's energy needs (Raimi *et al.,* 2018; Ebuete *et al.,* 2019; Suleiman *et al.,* 2019). Although, there is still an increase in the use of forest wood and charcoal by the majority of rural households and some processing industries. The majority of rural households in Nigeria rely on wood products i.e. firewood and charcoal for every day local cooking and likewise projects, for example, bricklaying and tea factories. Series of studies have shown that firewood and charcoal production is the reason for increased deforestation followed by other land use such as agriculture and settlement. It is evident in the rural areas of Nigeria use firewood and charcoal for cooking their meals and boiling water for family use. Charcoal is also used by both rural, semi-urban and urban sources of energy for cooking and other domestic or commercial significance. With this, the widest usage of charcoal as fuel for domestic cooking and heating. In Nigeria, the popular "coal pot" is usually a small metal structure in which charcoal is put, lit and the cooking utensil (pot, kettle, frying pan) is put on the burning charcoal for cooking and heating. Also, it used as fuel in some industries and for powering locomotives. In time past, train engines and some industrial machines have been powered using coal (charcoal) which serves as fuel for such machines. Furthermore, activated charcoal is used for filtration. This type of charcoal purifies by absorbing organic compounds, odours, and toxins in gases. Charcoal is also used to makes charcoal sticks and pencils specifically for artworks. Moreover, medically, charcoal is consumed by some people believing that it aids digestion and also used to clean the teeth (Evans, 2002; Ministry of Pastoral Development and Environment, 2004).

5. Environmental Impacts of Charcoal Production

The charcoal production industry is a source of employment and livelihoods for millions all over the world. There are thousands of people who depend on the charcoal business as their sources of livelihoods from the producers, merchants, wholesalers to retailers. Most of the producers are found in the rural areas from where merchants purchase the charcoals to be sold in urban centers (a process associated with the development of civilization, it is estimated that 93% of urban growth will occur in developing nations, with 80% of urban growth occurring in Asia and Africa and up to 600 million people in urban areas in developing regions, nearly 28% of the developing world's urban population cannot meet their basic needs for shelter, water, and health from their resources. Up to half the population of cities in some of the world's poorest countries are either homeless or living below official poverty levels/life-threatening poverty, women and children being among the poorest people in the world). A recent observation has revealed that charcoal is becoming increasingly exported to countries with low temperatures and used in house warmers thereby expanding the business and making it more lucrative than viewed in previous times. Exported charcoal are usually reshaped and packaged in rubber nylons and cartons to preserve it during the long-distance transportation either by air or sea and also make it more appealing to potential buyers. This new development has increased the demand for charcoal and also brought more people in the charcoal business due to better financial yield from export (Chidumayo & Gumbo, 2013).

Physical observation of areas of Kwara State, particularly in Ilorin West, parts of Ifelodun Local Governments and other Northern areas of the state which has experienced increased charcoal production in recent years. The business in these areas has expanded to the level of large shipper containers being used to load and transport bagged of charcoal usually for export. Also, on the road from Ilorin township through Oke-Oyi, towards Share junction, there have been observed, numerous charcoal production and packaging sites which reveal the spread of production and business in recent times. Indeed, it can be ascertained that more people are earning from the charcoal industry and it has generated employment and source of livelihoods for more people in the country. Furthermore, in areas where charcoal production has either increased or become a new trade, there has been increased economic activities which usually transcends to economic growth. This brings about the improvement of standard of living, more jobs and general development in such communities. Communities get to enjoy these dividends of increased economic activities (Chidumayo & Gumbo, 2013). Similarly, regarding the Ebira ethnic minority group, residing in the peri-urban areas of Ado Ekiti, Nigeria, who contributes towards the economic growth of the area, mainly uses biomass fuel to cook. The peri-urban zone is an interface of rural and urban areas characterised by mixed land uses (Oluwakemi, 2012), though close to the urban areas, the communities yet lack basic facilities such as safe drinking water, electricity, hospitals, and roads. These groups of individuals enjoy better market information and lower transaction costs (Lynch, 2005), still, disparities in living conditions (s) characterise their milieu as compared to the metropolitan areas. Their constructed houses are mainly with mud blocks and wood which don't meet minimum housing requirements which are durable, safe, dry and well ventilated (Egunjobi, 1998). Also, being an ethnic minority, they are more likely to be poorer than their counterparts in the cities (De Sonza *et al.,* 2003). Moreover, their living milieu could make them vulnerable to environmental health hazards (Lin & Kelsey, 2000), particularly when biomass fuels are required to meet energy needs, hence, creating indoor air pollution problem. At the same time, when cooking places are indoors without proper ventilation, the air quality indoor is lower than that outdoor (Oluwakemi, 2012). Also, charcoal is known to be one of the cheapest fuel known to man from time immemorial and today over two billion people cook badly on slow, inefficient wood stoves that lead to wood waste, cause health challenges and cripple our forests. Economic recession and increasing price of fuel from crude oil such as petrol, kerosene, and the popular cooking gas have made a lot of households turn to the use of charcoal which is a more affordable and economical option. A bag of charcoal in the urban centers range from N1,500 - N2,000 as it can last a household for a month and beyond depending on factors such as household size, cooking frequency and quantity among other factors. In comparison, the price of kerosene has been fluctuating between N200 - N350 per liter in recent times. A liter of kerosene can hardly suffice for cooking in any household a day which makes an expensive fuel for many households in Nigeria. The option of using electricity to power cookers have been an abandoned option for many households simply because of the poor power supply in most of the country. Also, privatisation of the electricity distribution companies has made power supply more expensive as electricity bills are being strictly calculated based on the amount of power consumed and it is known that electrical appliances for cooking consume a high level of power. This has made this option not viable for many households in Nigeria. Moreover, popular cooking gas is being widely used in many households but it is still considered the next cheaper option after charcoal. Charcoal use offers more economical domestic fuel option which can be used both indoors and outdoors. This significantly reduces the cost of living because food is an essential need which must be satisfied, hence having a cheaper fuel for cooking reduces the cost of meeting such essential needs.

The most obvious environmental problems of charcoal production and utilization activities are the level and extent of tree felling, forest clearing and therefore deforestation risks, which tend to rise as coronavirus hinders protection. Production of charcoal is linked with vegetation and forest clearing projected to range from 0.087 to 1.33 million hectares yearly because of the low charcoal recoveries of earth furnaces (silos used for charcoal production). Low process efficiencies, combined with unregulated actions of many producers, cause large volumes of wood to be harvested from nearby forests (Sedano *et al.*, 2016; Minten *et al.*, 2013). These zones are frequently segments of collectively-owned land, yet can likewise make up huge parts of federally secured forests. Because of weak, unenforced or incoherent forest policies, several countries are experiencing expanded deforestation rates from production of charcoal in protected areas. Unlike the fuelwood utilization for cooking and heating, which is frequently provided from ground harvesting and has no significant environmental degradation impact (Chidumayo & Gumbo, 2013; Minten *et al.*, 2013; Msuya *et al.*, 2011; Odubo & Raimi *et al.*, 2019; Suleiman *et al.*, 2019; Olalekan *et al.*, 2019; Raimi *et al.*, 2019), current methods of charcoal production necessitate vast resources amounts for moderately little return.

Deforestation is the long-lasting obliteration of forests to make the land accessible for other uses and make utilisation of the wood logs as raw materials as in the case of charcoal production. According to the United Nations and FAO, an estimated 18 million acres (7.3 million hectares) of forest are lost yearly. It is also affirmed that deforestation has increased over the last 50 years (Hosier, 1993). The effect of climate change is being felt all around the world and one of the major contributory factors to climate change is deforestation. This affects the global carbon cycle; greenhouse gases absorb radiations and their abundance can trigger climate change. When trees die, they release carbon dioxide (CO_2) which also adds to the concentration of CO_2 in the atmosphere as a result of the processes involved in charcoal production. People and communities around sites of production of charcoal are usually saturated with CO_2 (Msuya *et al.*, 2011). Also, the water cycle is affected when trees are lost to human activities such as charcoal production. A lot of water is held in plants and it is also known that trees lessen pollution in water (Raimi *et al.*, 2018; Raimi, 2019). In addition, trees can play such roles as surface cover for our land, erosion mitigants, carbon sequesters, temperature regulators, they are catchment area for underground water, they serve as upland water shed, advance transpiration and offer shade, they are vital piece in keeping an equilibrium in our ecological systems, offer refuge for many species of mammals that are endangered, birds and reptiles, save the milieu through pollutants filtering from the water, create a barrier that shields coastal areas from storms and tides, they are recognised as salt excluders, have sieves that thwart the entrance of salt through the root surface, they are otherwise called salt secreters, letting the salt access to the plant then rapidly secreting it, frequently through exceptional salt glands on the leaves, their latex has properties that are medicinal in nature and has been utilized to treat sores and stings, they form the source of a complex food web, leaf litter and decomposing vegetation are a basis of food for micro-organisms, many living things makes the tree their habitat, their feeding ground, their breeding habitat, or their nursery, trees are extremely useful ecosystem/regulators of micro climate and forestall surgent wind, they function as nostril for birds and ecosystems, there are many mineral resources been deposited, they are a big lungs of the ecosystems, they are particularly considered to be efficient in reducing concentrations of pollutants, although the capacity can vary by up to 15 times between species (Raimi *et al.*, 2018; Raimi, 2019). Other environmental effects of deforestations include soil erosion which is one of the most striking features of the land surface of South-Eastern Nigeria which has impacted negatively on overall land use in the region (Ayuba & Dami, 2011) and has lessened the land quality and reduce the yield of use especially planting yield (Raimi *et al.*, 2019; Suleiman *et al.*, 2019).

Desertification is seen as a process by which productive arid and semi-arid land is rendered unproductive economically. It is desert expansion, desert creeps and usually ends up in aridity. It involves interaction among human beings, land, and climate. It is caused by the increase in the human and livestock population, over-grazing, the expansion of agricultural land and demand for fuelwood. It is noticeable that the desert creeps into the land area at the rate of six million hectares per year. More than 11 million hectares of tropical forests are destroyed per year in Africa (Raimi *et al.*, 2019; Olalekan *et al.*, 2019; Suleiman *et al.*, 2019; Raimi *et al.*, 2019). Desertification is another problem that results from deforestation, this brings about so many social and environmental problems including migration and loss of species (plants and animals) among other problems (Msuya *et al.*, 2011). Similarly, the urban heat island has become a growing concern and is increasing over the years. The urban heat island is formed from industries, charcoal factory inclusive when industrial and urban areas are developed and heat becomes more abundant. In rural areas, a huge part of the approaching solar energy is utilized to dissipate water from vegetation and soil. In urban communities, where less vegetation and bare soil exist, the majority of the sun's energy is enthralled by asphalt and urban structures. Thus, throughout warm sunlight hours, less evaporative cooling in urban areas permits surface temperatures to ascend higher than the local areas. Additional city heat is radiated by factories and vehicles, just as industrial and domestic heating and cooling units. This effect causes the city to become 2 to 10^o F (1 TO 6^{o}C) warmer than surrounding landscapes. Impacts also include reducing soil moisture and intensification of carbon dioxide emissions (Suleiman *et al.*, 2019).

Moreover, foreseeable dependence on charcoal, despite drastic attempts to establish reliable electricity and fuel infrastructure, should raise some concerns regarding the sustainability of this essential industry in regards not only to its economic value but the proper management of forest resources as well as livelihoods of those most responsible for producing this fuel. The common situation is that there is a lack of regulation and the use of conventional methods for production permeates the industry (Jones, 2005; Ministry of Pastoral Development and Environment, 2004; Suleiman *et al.*, 2019). The use of traditional earth-mound kilns is commonplace. These "ovens" vary significantly in size and are made completely of organic materials. The time amount necessary to simply set up the kiln for production can be as long as about fourteen days; producers first dig an opening in the ground, saving the soil for later use.

The extraction of wood from the surrounding forests is typically the most labour intensive phase in the entire production process. Producers go to different sites to cut, collect and haul wood to the production site. Once they have reverted to the site, producers arrange the wood in a particular way to guarantee that the wood is uniformly 'cooked'; this procedure has been refined over generations. When the wood is configured in this way, it is topped with grasses and brush; the soil is added last to permit the wood to experience combustion in the absence of oxygen, this is the same as an aforementioned process called pyrolysis (Evans, 2002). These processes bring about a lot of risks and problems such as highly demanding physical stress on the body structure, high consumption of natural resources (trees), high risk of physical injuries, exposure to attacks from animals in the wildlife among other negative outcomes which have direct linkages to negative social health outcomes. Notwithstanding the unsafe work conditions linked with the wood extraction, fabricating the furnace and the charcoal packing, doing so frequently establishes a remarkable individual time investment. Not including time spent during extraction and packaging, producers will often spend over two weeks vigilantly monitoring the kiln to ensure that the process of carbonization in the absence of oxygen, or pyrolysis, is properly conducted. Extreme temperatures combined with volatile chemical compounds, including carbon monoxide and sulfur dioxide, create an extremely dangerous environment for any human, especially those without adequate safety protection (Chidumayo & Gumbo, 2013). Producers are frequently known to go through the night inside a few feet of a burning furnace to guarantee that any gaps are swiftly sealed. For instance, it is recognised that pyrolysis, the procedure used for charcoal production, releases remarkable amounts of gaseous by-products, as well as carbon monoxide, sulfur dioxide, and others, identified to be deadly to humans in moderate concentrations (Adams, 2009; Jones, 2015). Producers from the rural area are recognised to work inside proximity to high-temperature furnaces that off-gas these extremely toxic compounds, generating potential high threat for poisoning.

Exposure to toxic gases and extreme temperatures pose a great health risk to these producers. The communities around sites of production are also exposed to these toxic gases which usually result in various respiratory illnesses such as lung irritations, inflammation of the airways and fluid accumulation in the lungs among other conditions. Also, the use of primitive tools can potentially lead to moderate or severe injuries, which can prove fatal in rural areas that lack access to adequate medical care. Lack of modern tools most often results in the use of human labour throughout the entire production process. Authorities have usually referred to the working conditions of charcoal producers as unsafe (Sedano *et al.,* 2016; Ministry of Pastoral Development and Environment, 2004); however, little attention is paid to these "hazards". It is important to add that the use of charcoal in poorly designed appliances and houses exposed residents to high levels of carbon monoxide emissions (4166-6147 mg/m^3) and other products of incomplete combustion. A study tested charcoal samples from common tree species for Carbon monoxide (CO), Carbon dioxide (CO_2), Nitrogen dioxide (NO_2) and hydrocarbon emissions using a Flue gas analyzer. It is known that these gases at high or accumulated levels do have detrimental effects on health and wellbeing (Msuya *et al.,* 2011). A working report featured the perils linked with the industrial production of charcoal in the emerging world as well as the precautionary measures that ought to be taken by producers. The thirty years' sheer volume of guidelines published, proposes the seriousness and potential risk of these working conditions. In any case, inadequate proper knowledge, institutional capacity, and financial resources forestall these safety measures from being taken in many areas that produce charcoal for residential use, adding to the prevalence of moderate to severe injury and illness. Many of the producers have little or no education and are found mostly in rural areas. Though there have been publications that have identified the dangers/risks that come with charcoal production and some safety measure that can prevent and control these risks, many of the producers do not have access to these publications either are they sensitized about the subject's prevention and control of risks associated with their work.

6. Control Measures for Negative Impacts of Charcoal Production

The adoption of the United Nations Sustainable Development Goals (SDGs) in 2015 is an unprecedented revolutionary step for the international community. The 2030 Agenda for Sustainable Development is a one-of-a-kind roadmap that tackle wide-ranging issues from the eradication of poverty to fostering partnerships to achieve the goals. With virtually all of the SDGs relying in one way or another on environmental resources, thus does not only equip us to recognise the interlinkages between the SDGs, but also to supporting the development of strategies that are more effective and socially acceptable. While the Sustainable Development Goals (SDGs) strive to achieve the three pillars of sustainable development: environmental, social, and economic. Of the 17 SDGs, water, waste, and energy cut across all (see Figure 3 below), but Goal 7 ensure access to affordable and clean energy. However, ensuring access to energy services and increasing substantially the share of renewable energy [7.1, 7.2] may impair water quality or otherwise introduce pollution into the environment (see Figure 3 below) (Morufu & Clinton, 2017; Raimi & Sabinus, 2017; Raimi *et al.*, 2017; Raimi & Sabinus, 2017; Olalekan *et al.*, 2018; Premoboere & Raimi, 2018; Olalekan *et al.*, 2018; Raimi *et al.*, 2019; Olalekan *et al.*, 2019; Henry *et al.*, 2019; Raimi *et al.*, 2019). As COVID 19 lockdowns are lifted, policies will be crucial in determining whether mobility changes triggered by the current pandemic are positive or negative in terms of their impacts on energy use, safety and long-term environmental and health outcomes. “Even before today’s unprecedented crisis, the world was not on track to meet key sustainable energy goals”, said Dr Birol. “Now, it is likely to become even harder to achieve. This means we must redouble our efforts to bring affordable, reliable and cleaner energy to all especially in the global south, where the need is greatest in order to build more prosperous and resilient economies”.

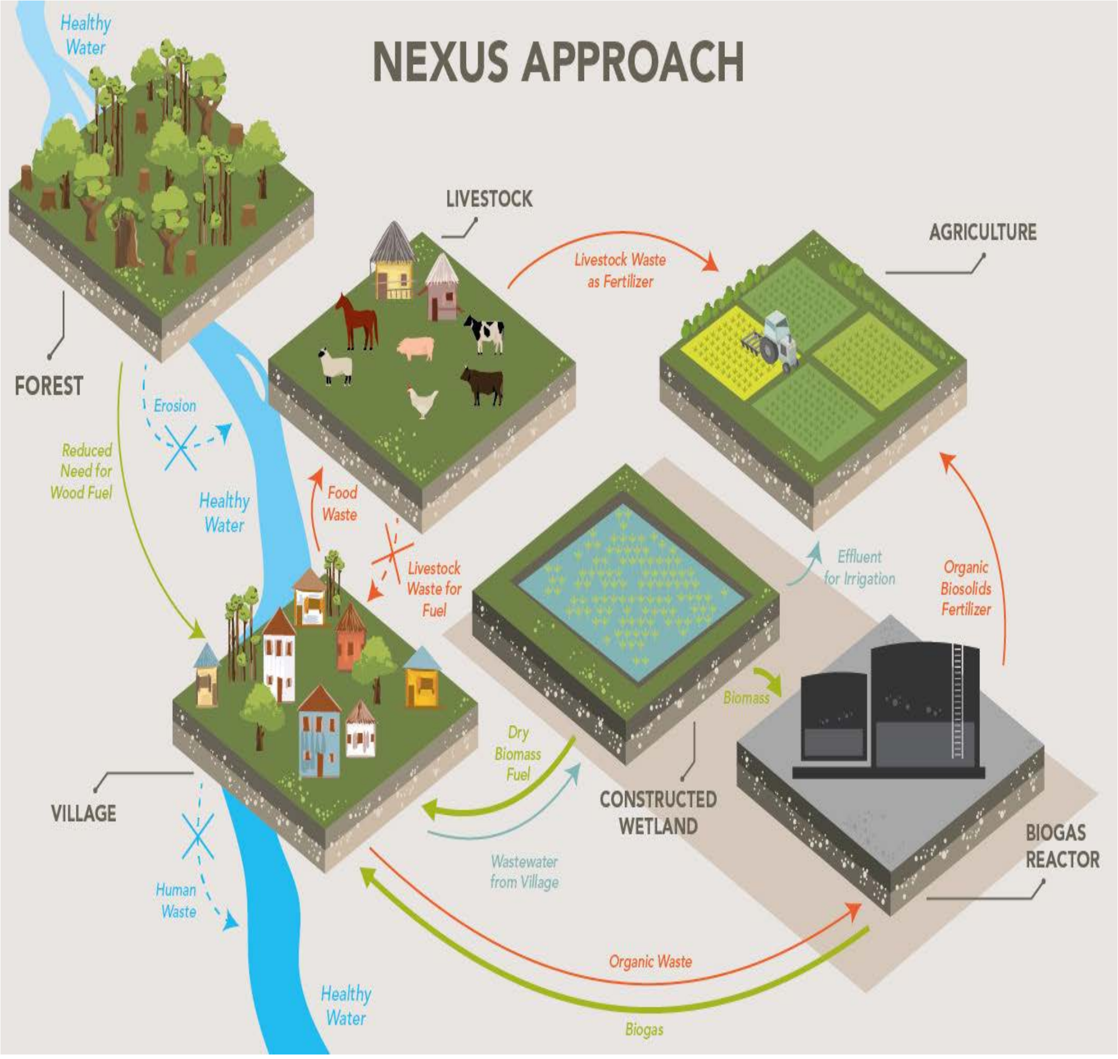

Figure 3. Applying the Water-Waste-Energy Nexus Improves Sanitation, Reduces Energy Dependence on Forests, and Improves Food Security (Design: UNU-FLORES/Claudia Matthias)

Adapted from United Nations University Institute for Integrated Management of Material Fluxes and of Resources.

“Clean air is a basic human right that most of the world’s population lacks”, “No country, rich or poor can claim the task of tackling air pollution is complete. But governments are far from powerless to act and need to act now. Proven energy policies and technologies can deliver major cuts in air pollution around the world and bring health benefits, provide broader access to energy and improve sustainability”. However, the total reliance on biomass fuels freely collected from the forests has been the major means of meeting household energy demands in emerging countries. Fuels wood burning including charcoal, sawdust, crop residues, and animal dung frequently compromise indoor air quality, particularly during periods of cooking in open fires. The rural areas in the Least Economically

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Developed Countries (LEDCs) are faced with problems of indoor air pollution (Bruce *et al.*, 2000). About 80% of the rural populace in Sub-Saharan Africa rely on biomass fuels (wood, charcoal, animal dung, agricultural residues, sawdust) and coal for household energy (Dasgupta *et al.,* 2009; Ezzati, 2005). A huge amount of those fuels are burnt on open fires in poorly ventilated spaces, thus revealing the householders to health hazards. Regular exposure to indoor air pollution from the incomplete combustion of biomass fuels and kerosene results in major health concerns, leading to an estimated 36% mortality from respiratory diseases in developing countries (Fullerton *et al.,* 2008; WHO, 2002). Of the pollutants, particulate matter and carbon monoxide increase susceptibility to adverse health risks amongst the rural people, especially to women and children (Rehfuess *et al.*, 2011; Ezzati & Kammen, 2002). Therefore, understanding the factors that expose the rural poor in developing countries to indoor air pollution would allow for more appropriate interventions to be provided. The complex interactions between technology, economy, behaviour, and infrastructure have often been neglected in the past (Jin *et al.*, 2006). However, an important area of consideration for control measures is policy formulation. The risks and negative impacts of increased charcoal production call for well-structured policies which will cover tree planting and preserving the forests which serve as a source of raw materials for the production of charcoal (Mugo & Ong, 2006; Olalekan *et al.*, 2019; Suleman *et al.*, 2019). Policies should also focus on addressing control of the sites and areas where the charcoal production process will be allowed. Areas that are already burdened with the provision of wood for charcoal production should be protected and regulation should be provided on any land that will be allowed to be a source of wood for producers. For example, regulations can be made such that area, where trees have been fell for the purpose of charcoal production, are being allowed to get replenished by not replanting the fell trees but also staying off such areas as regards to the felling of trees for a while, long enough for such areas to recuperate. Furthermore, policies should also protect the communities and environment where charcoal production is taking place, including the health of the people that reside in such communities. It must be ensured that policies are not just made, they must be implemented and their efficiency is continuously evaluated to ensure that the issues and challenges of those policies addressed and are being solved.

Until now, fuelwood has been the principal raw material for charcoal production and because supplies of wood are fast causing deforestation of so many areas, a variety of agricultural and forestry residues that often remain unused appear to be potentially important raw materials for charcoal production. Diversification is required at the level of domestic fuel and raw materials used for charcoal production. This will reduce the burden on the forest reserves due to the increasing demand and production of charcoal. In line with this, several successful projects in the efficient charcoal production have been reported so far. A classic example is the Mafia Pilot Project in Tanzania on the utilization of coconut industry waste for energy production which was started in 1985. It had its fund from the German development agency GTZ and implemented by the Ministry of Water, Energy, and Minerals of Tanzania. This project focused on enhanced kilns and a swing in emphasis to on-farm production of wood with high biomass densities was part of the answer in heavily degraded charcoaling areas to (i) reduce pressure on natural forests and vegetation ecosystems; (ii) generate extra incomes through improved charcoal production with remnant trees for alternative uses and/or rehabilitation (Msuya *et al.*, 2013). Apart from coconut, another source can be gotten from coal mined from the earth. Diversification also applies to provide a cheap alternative source of domestic fuel for cooking and heating to reduce the demand for charcoal. Improved technology will significantly reduce toxic indoor air pollutants which will result in improved health conditions, in particular for women and children who majorly those who directly use charcoal and sawdust domestically (Raimi *et al.,* 2018; Raimi, 2019; Raimi *et al.,* 2020). Acute respiratory infections rank fourth in the list of diseases in sub-Saharan Africa and cause reduced productivity and lower life expectancy (Raimi *et al.,* 2018; Raimi *et al.*, 2020). A small scale charcoal production unit can emit quantities of Particulate Matter (PM), Carbon Monoxide (CO), Nitrate Oxides (NOx) and Sulphate Dioxide (SO_2), Hydrogen Fluoride (HF), Hydrogen Chloride (HCl), formaldehyde, phenol, acetic acid, xylene, and toluene. There are still various technologies, which permit a cleaner production of charcoal, such as the Social for Profit project whose products can acquire Eco-label and Fair-trade labels (Adams, 2009; Evans, 2002; Raimi *et al.,* 2018). Furthermore, Improved charcoal use will thus contribute to CO_2 emission reduction and fuel saving. In calculating the GHG emission reductions (mainly methane), it is recommended to use the accepted methodology for methane emissions mitigation in the wood carbonization activity for production of charcoal project (large scale activities) which has been technologically advanced under the Clean Development Mechanism of the UNFCCC Kyoto Protocol (CDM). This methodology aids to work out a baseline for GHG emissions within the absence of the project (i.e., business-as-usual circumstances), how emission reductions below this baseline can be calculated, and how these reductions can be monitored (Climate Tech Wiki, 2012). Application of these methodologies will help reduce the level of CO_2 emissions and also provides fuel conservation which will reduce the demand for charcoal and in turn the burden of negative impacts of increased charcoal production.

Improved technologies also hold prospects in the modification of charcoal production processes such that processes that pose higher hazards are either eliminated or replaced with methods that pose lesser risks (Climate Teck Wiki, 2012). For instance, processes in the course of production which emit toxic gases at high volumes can be substituted with other processes which lesser risk. Also, technology can combat these environmental health challenges associated with charcoal production through well-developed machines and technologies. However, caution must be drawn here; the majority of the charcoal factories are local factories and fall under small scale industries, hence new technologies must be one that will be easily adopted and feasible with local factories. It has been noticed that some new technologies are usually not adaptable by the people who need them. Therefore, adaptability and affordability must be considered when developing new technologies.

Research is another key way of preventing and controlling the negative impacts of charcoal factories. The research provides ways of solving problems which in this case will be proffering solutions to the associated negative impacts of charcoal factories. It is through research that new technologies can be discovered, tested and affirmed to be applicable and usable for the purpose for which it is needed. Research also has the prospect of revealing ways of diversification, educating the concerned populace and developing protective devices among other prospects. “Education is the best ladder to essential success within the 21st century, and it’s the only most significant modifiable social determinant of health”. Thus, awareness and community sensitization may be a key tool for empowering the populace on taking necessary steps to promote their health. Awareness creation provides various techniques or knowledge aspects that could be applied to actions, which is effective in coping with the vulnerability and negative impacts of charcoal factories. For the awareness process to be efficient, the exercise should be given to appropriate people, through well-defined activities and assessed through efficient techniques. Also, information dissemination has been identified to be one of the vital facets of the negative impacts of charcoal factories and awareness actions towards the community’s readiness is vital. This information can either be with a nature of the emergency or of a casual nature. Depending upon the nature of the information, it is significant to establish various means of information dissemination that could enable communities with fast and/or reliable modes of communication. To sustain the community's livelihood of members, their resources most be maintained, distributed and monitored. This procedure strives for the institutionalisation of resource monitoring and implementation management along with an active information transfer on the status of resource availability and quality to regulate community activities and resource consumption (Islam & Walkerden, 2017). Similarly, members of communities housing or around the sites of charcoal factories must be empowered with information on how to protect themselves especially practical steps towards minimizing the proximity of the negative impact of charcoal factories to them. Public awareness should be expanded down to the local citizens and local government. The results and risk assessments cannot be restricted to high-level officials and a small selected group of educated people but should be a part of daily life. Every member of the local community should be aware of the risk due to charcoal production. Education should start at the elementary school and teachers particularly should be trained so that new generations will receive proper knowledge of the health risk that may occur in their locality. Also, the workers in the charcoal factories or producers in such factories are to be educated on occupational health and safety measures as regards the risks and hazards they are exposed to. They are also to be informed on the importance of protective equipment and wears which is expected to transcend to owning and utilization of such equipment and wears. Besides, there is a need to develop an environmentally literate citizenry. Formal and informal environmental education would be an active means of creating suitable awareness of serious environmental concerns (Raimi *et al.,* 2019). In particular, formal education is important to increase awareness, sensitize people on environmental issues and build institutional capacities. Non-formal environmental education benefits individuals outside the formal education system. Communication of environmental information to all stakeholders remains a challenge. Public awareness empowers the general public to develop a robust sense of accountability on environmental issues. In addition, actions to deliver access to clean cooking facilities to an additional 1.8 billion people by 2040 are essential to reducing household emissions in developing countries while emissions controls and fuel switching are crucial in the power sector, "there is need to revise our approach to energy development so that communities are not forced to sacrifice clean air in return for economic growth". Similarly, the World Energy Outlook (WEO) special report highlights three key areas for government action in addressing environmental issues:

i. **Setting an ambitious long-term air quality goal**, to which all stakeholders can subscribe and against which the efficacy of the various pollution mitigation options can be assessed.

ii. **Putting in place a package of clean air policies for the energy sector** to achieve the long-term goal, drawing on a cost-effective mix of direct emissions controls, regulation and other measures, giving due weight to the co-benefits for other energy policy objectives.

iii. **Ensuring effective monitoring, enforcement, evaluation, and communication**: keeping a strategy on course requires reliable data, a continuous focus on compliance and policy improvement, and timely and transparent public information.

7. Summary

Charcoal is one of the affordable domestic fuel and demand for it has been on the increase in recent years due to its affordability. This situation has been linked to the recent economic problems which have been faced by some developing countries including Nigeria. Increasing demand for charcoal has brought a sharp upturn of the number of charcoal factories in the country. Charcoal production has both positive and negative impacts not only on the people directly involved in the production but also on those who are residents of the communities housing or around such factories and the environment at large. These impacts range from the source of livelihood and economic development to physical stress and injuries, exposure to high temperature and toxic gases among other impacts. In addition, land degradation has reduced global crops productivity by 23% of the global land surface and as many as 100-300 million people are at risk of floods because of loss of coastal habitat and protection (Odubo & Raimi, 2019). Pollution have become the bane of environmental issues in the global south including Nigeria. Approximately 300-400 million tons of heavy metals, solvents, toxic sludge and other wastes from industrial facilities are dumped annually into the worlds water. These among other negative trends have been projected to continue to 2050 and beyond as long as human activity continue to impact on land use change, exploitation of organisms and climate change (Olalekan *et al.,* 2018; Raimi *et al.*, 2018; Raimi, 2019). However, the serious environmental pollution that is being experienced today, would be a child's play in the next two decades or thereabouts, if the government did not strike an equilibrium between the natural resources available and human population. As environmental protection is an expensive business, but finance should not be an excuse for not protecting the environment. Nevertheless, the cost of not defending the milieu is far higher due to the direct and multiplier effects on the Nigerian economy and socio-cultural life.

Yet, the tools of human culture and civilisation destroy the ecological balance on which our very existence depends creating the ironic situation where humanity's search for a better life, implants the seed for our own destruction. Human activities have intensified desertification in the Northern part of the country and have led to the shrinkage of the surface area of Lake Chad. The African continent is losing 10 million acres of forest yearly to climate change and Ghana alone losses about 65000 ha of forest annually, representing a 2.03% average annual loss. Globally, human activities not only cause climate change, but figures show that in 2018, CO_2 emissions per capita was 0.68 metric tons compared to the 0.37 metric tons recorded in 1999 with an average annual rate of 4.08%, conversely, it has also lead to what scientists describe as the sixth extinction of life on earth. The sixth is artificially induced by human action. Human activity is effecting severe changes in biodiversity which is, in turn, induces the disappearance of plant and animal species at an alarming rate. If these trends continue the world could lose more than 20% of all existing species by 2030 and in 2018 about 12 million hectares (30 million acres) of tropical tree cover equal to 30 football pitches a minute are lost according to monitoring service Global Forest Watch. All these could have a devastating consequence for the survival of the human species has been currently experienced with the COVID-19 pandemic outbreak and if it lasts for months, "we will certainly see weakened (forest) protection". Without a doubt, the world is at the precipice of environmental collapse and crisis, COVID-19 will disrupt business-as-usual practices for forestry and industrial agribusiness companies. Across the continent, leaders in the public, private, and development sectors are already taking decisive action, both to save lives and to protect households, businesses and national economies from the fallout of the pandemic. But several leaders have told us that they need a clearer picture of the potential economic impact of the crisis. At the same time, many African countries are still in the early stages of organizing their responses into focused, prioritized efforts that make the most of the limited time and resources available.

8. Conclusion

Environmental problems are a threat to life on earth, and human continuous survival depend on our collective effort to protect nature, which supplies us with all the things we need; food, air, water and other ecosystem services. Nevertheless, continuous destructive activities, which have been at an unprecedented rate, have put the planet under immense pressure, resulting in deep decline in the ecosystem services we enjoy from nature. The scale of the crisis requires partnerships and collaborations across sectors and levels. Before involving stakeholders to tackle real-world problems, researchers need to sit together to find an integrative way to break down communication barriers between scientists of different disciplines as well as among scientists and non-scientists. Governments, the private sector, and development institutions need to double down on their already proven responsibilities and expand their existing efforts to safeguard the economy and livelihoods across States in Nigeria. The government need to foster intense and closely aligned collaboration with the private sector and development partners. As World Health Organization estimated that over 1.6 million deaths a year is due to smoke burning from solid fuel in cooking and other domestic uses to meet the need for required energy. The drive for searching novel possibilities for energy is 3E viz: economic development, energy security, and environmental sustenance by charcoal. Biomass Charcoal technology should be permitted in the urban and rural area to enhance the conservation and optimization of the use of inefficient fuelwood, especially in the rural area, However, charcoal remains a neglected subject within the concerned government departments/ministries. What is needed is a bold policy statement making adequate financial, administrative, and extension provisions to encourage sustainable charcoal making as a vibrant activity. All the same, the problem of the negative poverty/environmental linkages will largely hinge on enhanced environmental management and profitable livelihoods, then again on an enabling framework that is supportive. Consequently, empowerment and capacity building, good governance, resources tenure, education, and awareness will be as important in changing the negative linkages into positive ones as will be access to improved soil conservation and tree planting techniques. Nigerians are poorly aware of their environment and the damages being done to it through various activities like charcoal factory production among others. Likewise, the patterns of changing climate and their increasingly dangerous consequences are little valued (Raimi *et al.*, 2019). With this, efforts need to be made to minimize the negative impacts of charcoal factories which has been discovered to be on the increase, such efforts include formulation and implementation of good policies, research, developing new and better technologies and purposeful awareness to those involved in charcoal production and members of the surrounding communities. Furthermore, the Nigerian government, through the relevant authorities, implements existing forest and resource laws to ensure proper usage of the forest-related products. In addition, ensuring sustainability by meeting the livelihoods challenges and preserving the ability of ecosystems to perform long-term regulating and supporting functions requires adjustments and trade-offs. Individuals engaged in harvesting of wood for charcoal and fuelwood require trade-offs. There is a need for innovations to devise local solar heating devices that will be inexpensive and yet locally available, and communities are willing to engage in agroforestry or silviculture and would provide land to government for mass silviculture. As the communities needs to change or modify some of their farming practices, especially the slash and burn system, but it also needs farming inputs such as herbicides, fertilizers, and modern implements such as tractors, which should be made available at highly subsidized rate (Fasona et al., 2014). Community members should be actively prepared and willing to adopt alternative livelihoods that will improve the quality of ecosystems in relation to forest conservation and food production. All Local Government Authorities (LGAs) should be willing to partner with communities and other stakeholders to drive the process of natural resources management. There are trends of functionality gaps and a dearth of management schemes and tools which according to Fasona et al. (2014), about 49% of the LGAs are not aware of methods for preserving their forest land and animals; 70% of households have never been trained in forest management and 40% are not aware of the future threats to the sustainability forest and woodland that could result from their actions. In over 70% of the LGAs there are no systematic procedures for applying for logging, felling of trees for charcoal and fuelwood harvesting. This implies a lack of regulation or coordination of logging and charcoal businesses by the government.

As June 5th 2020 marked the largest global celebration of World Environment Day (WED) with the theme “Time for Nature”, it is significant that the world become very conscious of our activities that lead to environmental destruction and loss of forestry products, including biodiversity. There is need to put in the best of effort to minimise our activities that endanger the environment and be mindful that we have the means to ensure a sustainable future for the people and our planet by contributing our quota to a more sustainable approach to doing things in order to protect, preserve and enhance our ecosystem. There is need to care for the environment and this is the time for mainstreaming environmental sustainability in our development agenda as a country and as a people to help in protecting nature to continue enjoying the ecosystem services it provides. Additionally, there is a need for legislation of policy on modern and enhanced technological usage of forestry products, particularly for charcoal. Compulsory use of Improved Eco-stoves should be made available to derived and multidimensional poor rural households to ensure efficiency and effectiveness for forest sustainability. It is further recommended that:

i. The government should mainstream environmental concerns into poverty reduction programs and strengthening of forest protection programmes to ensure adequate vegetation cover in critical areas and to discourage developments likely to cause harmful changes.

ii. Develop and implement an environment-friendly job-creation initiative for poverty reduction and green growth development and combine desirable features of the traditional approach (of ecosystems management) with modern scientific methods of conservation.

iii. Move production from environmentally polluting and resource-intensive activities by encouraging the use of alternative sources of energy e.g. coal briquettes, efficient wood stoves, solar energy, wind energy, biogas, etc.

iv. Promote a shift from dirty energy to clean renewable energy options through reducing the percentage of fuel wood consumption in the domestic agricultural and industrial sectors.

v. Incentivize investment in efficient, clean and environmentally friendly technologies.

vi. Promote public awareness on the economic and environmental impacts of charcoal production and consumption patterns through encouraging communities to imbibe the culture of tree planting. There is a need to mandate the inclusion of tree planting as a criterion for building plans approval and approving authority shall determine the number of trees based on the size of the land and encouraging viable afforestation and reforestation programmes using tested drought resistant and/ or (local) economic tree species and conserving indigenous tree species that are endangered.

vii. Prepare periodic public reports on the state of the environment in various states of the federation through strict regulation and enforcement of logging activities and increasing support for non-governmental organizations (NGOs) and community tree-planting programmes.

viii. Forest reserves should be established, protected and properly maintained by both Federal and State governments. Also, all local government areas should earmark at least 25% of their landmass for forestry and this should be properly manned and protected. Other states should ensure the creation of forests on at least 15 percent of their land area.

ix. Government including Federal and State should strengthen and properly fund a reforestation and afforestation agency to handle all anti-desertification projects. The Stern Review found that, if deforestation were avoided, emission savings from avoided deforestation could potentially reduce CO_2 emissions for under \$5/tCO_2, possibly as little as \$1/tCO_2. Afforestation and reforestation may perhaps save a minimum of another 1GtCO_2/year, at an estimated cost of \$5/tCO_2 to \$15/tCO_2. The review determined these figures by assessing eight (8) countries responsible for 70% of global deforestation emissions.

x. Integrated human development issues including income generation, increased local control of resources, local institution strengthening, capacity building, and greater involvement of community based non-governmental organizations and lower tiers of government as delivery mechanisms.

xi. Enhancement of food security through improved ecosystem-based management and ecosystem restoration. Series of studies show the benefits of implementing strategies to improve ecosystem management as a means to increase not only food security but also to achieve other social goals. Examples include collaborative management of mangrove forests to promote conservation, mitigation of climate change and alleviation of poverty among people dependent on the mangroves and adjacent marine ecosystems (Dulvy and Allison, 2009). Such plans necessitate supportive institutions, partnerships, teamwork with farmers' innovation networks, and connections from sustainable farms to markets.

xii. Design and implement a National Environmental Inspection Programme (NEIP).

xiii. Compile and domesticate all environmental treaties signed or ratified by Nigeria.

xiv. Coordinate the activities of involved ministries in a Nexus Approach.

xv. Provide a locally-adapted regulatory path for the safe use of charcoal and its residues.

xvi. Assess the value of ecosystem services provided by charcoal and reuse. Benefits that can be quantified include improved soil, forest and wetland resources; nutrients, water, and energy recovered; GHG emissions reduced, and improved human health.

xvii. Establish incentives for communities to encourage them to implement a Nexus Approach and to cooperate in its implementation. For example, identify how operation costs and the resources produced are shared across the community.

Data Availability Statement

The data availability used to support the findings of this study are included within the article.

Competing Interests

We declare that we have no conflict of interest that could be perceived as prejudicing the impartiality of the research reported. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Consent

All authors declare that written informed consent was obtained from the participants.

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