# Menace and Mitigation of Health and Environmental Hazards of Charcoal Production in Nigeria

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## Contents



**Abstract**

The use of biomass and biofuels, such as wood, charcoal, petroleum, kerosene, and gas, is becoming competitive based on the level of development of each nation. However, charcoal production (CP) and marketing now tends to be a



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major business among many households in both rural and urban communities with no consideration of its effects on climate change adaptation. While the research question considers the various definition of climate change adaptation, and the importance of charcoal production in Nigeria, the manuscript speaks mainly of the problems of charcoal production, the lack of planning to address these problems, and the lack of planning to move the communities away from this practice and out of poverty. It addresses the impacts of charcoal production on agriculture, such as lack or loss of labor and destruction of arable lands. The paper discusses the effect of charcoal production on health. Also, the environmental problems of CP are highlighted in the manuscript. The policy frameworks on forestry by the Federal Ministry of Environment 2006 with its flaws will be included. Remedy such as the establishment of a Land Use Planning Agency (LUPAG) and panacea for greening the charcoal value chain issues will be discussed. Lastly, attention is given to the agricultural adaptation strategies to climate change which are capable of reducing charcoal production, such as mixed cropping.

**Keywords**

Climate adaptation change · Poverty · Deforestation · Policy framework · Alternative to charcoal utilization

## Introduction

### Definitions of Climate Change Adaptation

Climate change adaptation refers to the process of modification of the present and future impacts of climate change (United Nations Climate Change 2020). Due to the rapidly changing climate, coupled with economic, social, and technological developments, nations have no option but to look for a way to achieve a greater stride which further creates more tension in the ozone layer. According to the Victorian Centre for Climate Change Adaptation Research (VCCCAR) (2020), several views are expressed by scholars as follows: adaptation to climate change is the initiative to enable people and their surroundings to withstand the changing climate conditions (United Nations Framework Convention on Climate Change (UNFCCC) (2015). The Intergovernmental Panel on Climate Change (IPCC) refers to climate change adaptation as tampering with the natural or human systems so as to respond to actual or expected climatic stimuli or their effects. However, the UN Development programs defines it as the process through which strategies to moderate, and withstand with the subsequent effects of climatic events that are developed, implemented and improved upon. Conversely, the UK Climate Impacts Program defines it as the outcome of a process that creates limitation to the distortion or risk of problem or actualization of benefits that are related to climate variability. But the National Climate change Adaptation Research and Facility (NCCARF) views climate change

adaptation as a composition of actions undertaken to reduce the negative effects of climate change, exploiting any beneficial opportunities. Lastly, the Victorian Government states that it is a conscious step to prevent, manage, or decrease the effects of a warmer, drier, and more extreme climate and to maximize the benefits which such changes are likely to provide.

## Importance of Charcoal Production in Nigeria

Nigeria is a country that is endowed with crude oil, natural gas, and energy resources, such as solar, wind, biomass, and biogas. The country is gifted with human resources with a total population of 140 million according to the 2006 population census. The annual population growth of Nigeria is about 2.8% (National Population Commission [NPC] 2006). Currently, the national energy supply is almost entirely dependent on fossil fuels and wood fuel (The World Forest Movement 2006). For instance, the value of the charcoal market for 26 sub-Saharan African countries is said to purportedly exceed $1.8 billion per year (Food and Agriculture Organization [FAO] 2018). In terms of energy, charcoal consumption in many African countries is higher than the quantity of electricity consumed. The importance of charcoal lies in the following areas.

It is a source of considerable amount of employment in rural areas (Arnold et al. 2006). A significant number of rural dwellers relies on charcoal production as a good source of employment, especially in a devastating economy like that of Nigeria. Money realized from charcoal represents per capita income of between 24 and 14 dollars in 1990 and 2000, respectively, which are equivalent to between 1.8 and 4.8 times of per capita income from the sale of agricultural produce in the same years. Charcoal producers reveal that the average annual production in some countries is 160 bags per producer, whereas some produce significantly more than 500 bags. Also, income from charcoal is expended on food, farm inputs, and implements (FAO 2018).

Charcoal production is also one of the recognized economic drivers in some African countries aside from agriculture. However, it generates more income for the rural dwellers (Williams 1993). It also allows for quick return on investments (Stefan 2009). About 65% of the people in the rural areas have made wood fuel and charcoal production a source of income (Shackleton et al. 2006) because of its quick return on investments, unlike the involvement in arable crop production that will bring income in 3 months. In addition to its export value, charcoal trade at the local level provides income opportunities to pay education, health, feeding, and ceremony bills for most rural and urban dwellers through small-scale retail and wholesale (FAO 2018, Fig. 1). It is a reliable, comfortable, and easy form of energy for heating and cooking, with a relatively cheaper cost (Iloeje 2002).

Charcoal is produced for the poor in rural and urban areas to enable them to meet their energy needs, such as for heating and cooking. It is the most recognized commercial fuel derived from wood. It is smoke-free and can be used in small quantities during cooking (Adam 2009). Charcoal can also produce greater heat than wood, and it is useful for many industries in urban environments. In most developing

**Fig. 1** Plate showing charcoal depot in Saki derived Savannah zone of Nigeria from field study on April 19, 2013

countries, it is the chief form in which wood fuel is used in towns NL Agency (2010). Charcoal can be stored, takes up little space than firewood for heat generation, and does not deteriorate so easily. It is easier to handle during transportation and distribution. Therefore, it is more preferable to wood (World Bank 2004).

Furthermore, charcoal is used in African art to design various objects (World Energy Council 2004). Charcoal is the raw material for the manufacture of gunpowder and industrial and automotive fuel and for purification/filtration of the cottage industries, the main reason why several individuals continue to produce charcoal. It is also used by blacksmiths and for other industrial applications (Chris 2007). Various uses of charcoal greatly influence the standard of living of rural people who do not have access to agricultural inputs and finances. Charcoal has a higher energy density compared with biomass fuels, and it can be stored without fear of being destroyed by insects (Seidel 2008).

Charcoal is a cheap source of energy for both rural and urban dwellers. However, modern economic activities depend mainly on petroleum products and electricity (FAO 2018). The difficulty associated with the production and use of charcoal, the growing urbanization, and the choice of urban dwellers is at a heavy drain on local wood resources (Arnold 2001).

## Factors Responsible for the Production and Utilization of Charcoal

The factors that affect the production and utilization of charcoal in Nigeria.

Poverty are discussed as follows. The increase in the poverty level among Nigerians causes drives the production and use of charcoal. Although it is very essential for all the rural dwellers to use improved energy for cooking and heating, they lack the financial wherewithal to purchase kerosene, which is an alternative. They rely mainly on charcoal, which is cheap and available but has serious environmental hazards. Long gestation period of agricultural products in contrast to charcoal production that takes a lesser period of two or three weeks. Thus, rural dwellers prefer to use it as an alternative source of income to other agriculture income generating activities.

The lack of employment may encourage the mass movement of rural dwellers into charcoal production. The absence of job opportunities, especially paid ones, induces rural dwellers to participate in charcoal production as an alternative source of employment. The current economic recession in the country has made it possible to lay off both rank and file staffs in our various industries. Also, urban rehabilitation is forcing most motorcycle riders to relocate to the rural areas. This makes charcoal production an alternative source of employment.

The lack of awareness on the environmental effects of charcoal production is a serious issue. Most rural dwellers are not aware of the negative effects of charcoal production on their environment which, in turn, results in climate change. Poverty and level of education, among others, also influence awareness of the negative effects of charcoal production on the environment. Since the focus of every rural dweller is to obtain a means for survival, they are not concerned about the implications of their action.

Insufficiency of basic amenities in rural areas may trigger charcoal production. Rural dwellers usually depend on the government for their basic human needs, such as electricity, cooking gas, and the likes, in their domain. The inability of the government to provide such basic amenities triggers high production and consumption of charcoal as a perceived good source of energy for cooking and heating. Thus, the quantity of wood charcoal production in Nigeria stands at 4022763 tonnes per annum (World Bank 2011).

The lack of proper implementation and enforcement "by successive government" may affect our environment. There are good policies that have been established on forestry and allied matters in Nigeria. It is unfortunate that the change in government and loss of focus often inhibit their effective implementation. Sometimes, evaluation units to ensure strict implementation are absent. The focus of successive government always differs from one to another. However, irrespective of their different interests, every government is expected to focus on the mitigation process of climate change adaptation.

Industrial revolution: Before the discovery of oil in Nigeria, agriculture was the main occupation of about 70% of the Nigerian population, with most farmers having less than 1 ha of farming land. With the advent of industrialization, lands are cleared constantly. Thus, trees are cut down and used to produce charcoal.

The high cost of farming input can also increase the number of charcoal producers. Some rural dwellers lack the purchasing power for farm implements. As a

result, they see charcoal production as a cheap means of fending for themselves when the cost of farming is high.

## Effects of Charcoal Production on Agriculture

It should be noted that charcoal production has different effects on agriculture, such as lack or loss of labor. When the same labor that is expected to till the land for agricultural activities still cut down trees and makes charcoal kilns, farming activities are hindered, especially when they get quick income. It results in the reduction in the number of people in agriculture. When there are more enabling environments available for charcoal production, charcoal producers feel more comfortable in the business operation, thus decreasing the number of people involved in farming. This act will definitely lead to food shortage in the country. Charcoal production destroys arable lands. When trees are cut for charcoal production, the lands become susceptible to wind and water erosion. These negative practices eventually destroy the structure of the soil and make it infertile for arable crop farming.

## Health Implications of Charcoal Production

Aside from the effects of charcoal production on the environment, there are also human health-related challenges (UNDP 2005). These include backache, heat, and cough, among other ailments, which are experienced a lot by charcoal producers. Repetitively moving heavy woods during charcoal production induces lumbar pain and muscular soreness to the producers (Tzanakis et al. 2001). It is worth noting that some charcoal producers lose their lives during the production. Accidents may also occur during the cutting of trees, kiln preparation, and loading of charcoal onto lorries. Furthermore, producers inhale gases and smoke, and the heat produced during the charcoal production is a source of ailments, such as respiratory diseases and cough. They also experience sore hands, fatigue, and chest pain. Sputum production, dyspnea, and hemoptysis are other ailments suffered by the producers.

## Effects of Charcoal Production on the Environment

The major environmental problems caused by charcoal production in Nigeria are discussed as follows. Deforestation is a product of charcoal production which has significant impacts on the environment, especially with regard to increased erosion. It can also worsen climate change and threaten biodiversity. Deforestation is the destruction of forest areas for several purposes, such as agriculture, urbanization, and wood fuel and charcoal production. Charcoal production requires commercial felling of wood, thus leading to deforestation (Eniola 2014). Greenhouse gas (GHG) emission is a dangerous phenomenon of charcoal production. The reduction of forest cover also minimizes carbon consumption and results in the release of already-fixed

**Fig. 2** Image of the combustion process during charcoal production in Saki from a field study conducted on April 19, 2013

carbon. For instance, the effect of charcoal on forest reserves is disastrous on two grounds. First, the wood fuel equivalent is four to six times greater due to the lack of a professional production process (Fig. 2) (SEI 2016). Second, emission of gas during charcoal production is significant compared with charcoal burning. Aside from the above, ecosystem destruction has a long-term negative effect on the environment. Woods are obtained illicitly from land, and charcoal producers are compelled to harvest woods to enable immediate charcoal production (Emeodilichi 2018). Charcoal producers may sometimes gather dead woods, twigs, and branches and allow trees to regenerate. Due to the cutting of live trees for charcoal production, some important wood fuel species, such as mahogany and shea tree, which were abundant in the past years, are becoming scarce (Pabi and Morgan 2002). Charcoal production also affects the soil structure in two ways: first, it impacts on the kiln site (soil) where combustion takes place as a result of huge heat that is released from the covering process, and second, it affects the surrounding/environment of the production pit. Ogundele et al. (2011) and Oguntunde et al. (2008) revealed that the soil in the site of charcoal production has a slight increase in pH. It reduces bulk density of soil surface temperature, higher infiltration rate, and surface albedo compare to places that are not subject to charcoal production (Chidumayoa and Gumbob 2012).

## Policy on Charcoal Production-Induced Environmental Problems in Nigeria

The major objective of the Federal Ministry of Environment on Forestry Policy (2006) is to achieve an acceptable level of self-sufficiency in wood products through the use of sound management methods. Hence, the main thrust of the policy is

consolidation and increase in the forest estate and its management for the usage of the future generation. Due to the human-induced environmental problems, which the present forest estate cannot cope with, more forest estate is an area of land covered by different species of trees should be created in the country to prevent future disasters. Forest conservation and environmental protection are important. Our forests are no longer preserved adequately, unlike in the past. Cattle herdsmen can now be seen ravaging our forests, and wood fellers easily enter the forest and destroy the ecosystem. Thus, governments must exert more efforts to conserve our forests.

There is a great contrast between forest exploitation and forest regeneration. There should be a more increased rate of forest generation than forest exploitation to achieve a sustainable environment. There should be proper utilization of both the forests and its products. In addition, research on how non-forest products can take the place of forest products in all human activities, such as building and other energy requirements, need to be conducted. This will make the future generations benefit the forests and their products. Forest estates should be protected from fires, poachers, trespassers, and unauthorized grazers. It should also be noted that hunters, unauthorized grazers, and farmers endanger forest estates by setting them on fire to obtain their daily needs. These devastating habits must be prevented to secure the forests. The establishment of private forestry can significantly improve our forests. Thus, the government should permit and encourage private individuals to establish plantations of gmelina, teak, cashew, shear, and many other economic trees that can help to preserve and protect the enviroment. Also, the establishment of manmade forests for specific end-uses is a good means to regain the strength of forests. The government should establish a specific type of forest mainly for a particular tree user where they can go to without hindrance. The development of secondary forest products that are important in local economies and that support agro-forestry practices will boost the economy of the nation.

A policy that encourages the establishment of forestry to provide employment opportunities also needs to be implemented. The only thing that can reduce the occurrence of forest encroachment is to create more employment for people. Otherwise, more rural dwellers will rely on the forest and its products. In addition, more national parks and game reserves need to be created, and the existing ones should be properly maintained. An efficient use of wood energy and alternative sources of energy to wood fuel is also required. Lastly, cooperation among the international community with regard to forestry development must be encouraged (Federal Ministry of Environment 2006). Any law, regulations, and agenda in ensuring the sustainable use of the environment introduced by the international community must be strictly adhered to.

## Problems with Policies and Practice of the 2006 Federal Ministry of Environment in Nigeria which Warranted for Its Improvement by the Federal Parliament in 2019

There are so many flaws in the 2006 forestry policies which the new one to be assented to by the President of Nigeria is expected to cater for. Among them is the alarming widespread and increasing land and vegetation degradation. The policy

failed to prevent indiscriminate destruction of forests and their products. Forest users enter the forests freely and take away useful products and by-products. These nefarious acts result in fast land degradation. Every day, the influence of humans on the forest continues to increase due to the search for means of income. There are escalating real supply and demand deficits for forest products. The demands for forests and their products are greater than the available resources, which is a serious problem for the future generations. In Nigeria, credible databases are lacking, and there are no records of the quantity of woods and other products removed from the forest, of endangered species, and of future woods requirements. Moreover, the ineffective management of forest reserves is not given sufficient attention. The present system allows unauthorized grazers and poachers to enter the reserves freely. This may be due to the lack of adequate personnel, especially at the state level, and equipment to assist them in their duties. Negligible private investment in forestry is recorded in the implementation of the policy. Due to the several bottlenecks in acquiring land titles, private investors become discouraged in investing in forestry. There is abandonment of trees biodiversity that yield a low level of protection of existing reserves. Most of the forest users only prioritize their own needs at the expense of other forest products. And the protection of other forest products is being neglected. Moreover, there is a conflicting management of forests and its resources in the northern part of Nigeria. The states and local governments still compete for the control and utilization of the forest and its resources. This may be due to the fact that the environment is predominantly a grazing zone for cattle rearers.

The Climate and Development Knowledge Network (CDKN) of the UNFCCC (2015) expressed that it is very difficult for the less-developed countries, such as Nigeria, to implement any forestry policies that will give room to tangible climate adaptation strategies due to the following challenges: It is not easy to create awareness on the need and benefits of action among stakeholders, including policy makers. This may be linked to the high level of illiteracy in the country. A serious concern is how to enhance and integrate climate change into national planning and development processes. A budget allocation for climate change adaptation strategies every year can be beneficial. Also, the methods for strengthening the links between different tiers of government plans on climate change may not be easily realizable. This is because both segments of the government may develop different approaches to climate change adaptation without considering the global implications of such actions. Another method is to build capacity, analyze, develop and make use of climate change policy. There is a need for the inclusion of sound researchers in the implementation of climate change policy. How to establish a realistic mandate to coordinate actions around NDCs and drive their implementation is important to climate change adaptation in Nigeria. The best ways to address resource constraints are to develop and implement climate change policy. Both human and nonhuman resources may be considered as serious constraints, especially where expertise on climate and equipment are needed.

## Factors that Make It Difficult to Plan for Alternative Environmentally Friendly Energy in Nigeria

Nigeria, in particular, and Africa, in general, are mostly affected by climate change due to indiscriminate felling of trees, poor management of agricultural lands, and other environmental pollution activities performed by man. It may be difficult to properly plan on the energy requirements of the country due to the lack of an updated population census of the country. It should be noted that the last census in the country was carried out in 2006, which reported an estimated 140 million population, which some regions in the country view as a fraud (NPC 2006). Yet, it was suggested that another census should have been held in 2016. Today, it is already 2020, and this year is not included in the budget allocation of the country. An average of about 200 million people is expected, but it is just an assumption that is yet to be scientifically proven. Thus, if energy (for cooking and heating) requirement of the country is to be adequately budgeted for, the population of the country must know otherwise charcoal production and utilization will continue to increase.

One serious factor is the lack of unique and strategic climate change adaptation policies. Apart from the 2006 forestry policies of the country which have not been adequately implemented owing to its deficiencies, no other specific climate change adaptation policies have been made. Since charcoal production constitutes serious environmental hazard to the climate of the nation, it is expected that climate change adaptation policies will cater for charcoal production and utilization must be put in place (FAO 2010). Included in the factors influencing the choice of alternative environmental friendly sources of energy in Nigeria is the lack of recent and accurate climate information that can be used in the planning for the required energy of the teeming population of the country. Even where it is available, it cannot be relied on because the modern facilities and equipment to be used are not available. The lack of an adequate subject matter specialist to interpret climate information is also an obstacle. The government or relevant agencies cannot afford the required modern climate facilities; thus, effective climate change adaptation strategies cannot be developed in the country. This will also affect the effective dissemination of such data that can be used by farmers, charcoal producers, and other land users for future disasters. Another obstacle is the poor investment in scientific research on the impacts of climate change. It is the amount of human capital invested in the study of climate change impact by relevant professions to enhance the knowledge on how to address the challenges of climate change in the country. Another factor is that most African countries have weak governance. It should be noted that all the three tiers of our government are very weak in terms of the implementation of climate change adaptation policies. Since the federal government is weak, the local government abuses the forest resources. There is no effective monitoring at the state and local levels on climate change adaptation policies, which further creates serious damage to the climate.

## Strategies to Review the Existing Forest Policy on the Provision of an Enabling Environment for Sustainable Forestry Management and Development in Nigeria

To achieve an effective forestry management in Nigeria, the following strategies must be implemented. A land-use planning agency (LUPAG) should be established, and it should be noted that the existing land-use plan attached to the Ministry of Lands is obsolete and cannot cope with the trend of development in the country; hence, it should be an autonomous agency. This will enable the agency to really find immediate and long-term solutions to the problems on land utilization in the country.

The forest sector policy should be redefined considering the concepts of cognizance modern forestry. In the past, individuals did not own a forest. People now acquire lands for the purpose of establishing plantation. Land tenure systems and tree onwership should be reviewed. This will make it easier for everyone to have unfettered access to land and improve forestry development in Nigeria. In the ancient tradition of land ownership, a female does not receive support to own land even by inheritance. This practice limits their ability to use their resources to acquire wealth. Emerging products and services should also be considered. Before, only few airports, railways, and other transport services were available in the country. With the increase in population, the demand for these services will also increase, which will definitely have a serious effect on forest resources (FAO 2011). The foresrty policy should embrace corporate protection and management measures that will give both the states and the local government areas absolute control of the forest resources. It has been noted that the local governments mostly affected by deforestation do not even bother to campaign for activities to mitigate this. Hence, specific roles should be given to states and local governments.

Another adaptation strategy includes the implementation of law on the regulation of felling of trees. This law exists but is yet to be fully felt. Fellers have a free day in the forest to the extent that they cut economic trees, such as shea, locust bean, mango, and cashew trees, among others. Thus, the "cut-one, plant four" approach should be adopted. All tree fellers must be required to plant four trees as substitutes for a tree that is cut down on their personal lands. Aside the use of governement agencies as task force, various community heads should be involved in tree head count and serve as a force to implement the approach. Regulations for the exportation of charcoal are imperative. It should be borne in mind that the consumption of charcoal in Nigeria is lesser than the annual exportation. Europe is taking much of Nigeria's charcoal, and this has been made possible by the high amount of money paid to the suppliers. In addition, seaports and dry ports in Nigeria were also not properly monitored (Mbura 2015). Monitoring, inspection and enforcement of the modern method of charcoal production processes: charcoal producers still use obsolete means to produce charcoal and it has adverse effect on the environment in that it causes pollution and endangers the ozone layer (Bailis 2009; Bailis et al. 2015). In charcoal production, sustainably managed resources, such as natural forests, planted forests, and community forests, as well as improved technologies can be used to reduce GHG emissions (Adger et al. 2003; Olson 2009; Vos and Vis

2010). The use of other alternatives to energy, such as agricultural waste and residues of wood and twig outside forests, as well as agroforestry will be advantageous. It is noteworthy that wastes from various crops, such as maize, guinea corn, wheat and oat husks, chaffs of rice, and cassava peels, are left unused and are thus burnt instead of being converted to usable energy. Charcoal dust should be converted into briquettes. Large tonnage of the dust which can be turned into charcoal are left on charcoal production sites and loading stores. However, the rural charcoal producers lack the skills to do this. Better management of local kilns increases efficiency of charcoal production. During the monitoring stage, charcoal producers may not regularly examine the extent of the smoke formed, thereby giving the kiln the opportunity to burn without complete combustion (Otu-Danquah 2010). The use of fossil fuel for transportation should be minimized. The country should research on other energy sources aside from fossil fuel for both household and industrial energy requirements. Cooking energy such as gas should be optimally utilized. If this is achieved, the cost of cooking gas should be within the reach of the poor in rural areas.

## Climate Change–Charcoal Chain Sector: The Policy Options

Charcoal climate adaptation value chain is in dire need of policy implementation.

Various government agency regulatory bodies environments are used by charcoal value chain and should be harnessed effectively (FAO 2017). Based on this, policies must be formulated to improve charcoal production technology that will further enhance the sustainable deployment of resources in the forest. Moreover, there is need for an enduring policy projection that will enhance the sustenance of charcoal value chain through diversification and democratization of clean energy alternatives to lessen the increasing demand for charcoal. Incentives, reward distribution, meaningful management of forestry resources, land use planning, landscape management, and a green economy are important to greening the charcoal value chain (Minten et al. 2013). Technological advancement is imperative due to the differences in taxation that could have assisted the incentivization of sustainable sourcing and production of charcoal through fees and licenses. Global fiscal devices related to climate change reduction, such as the clean development mechanism, and reducing emissions from deforestation and forest degradation can provide financial boosts. Effective forest law enforcement and administration are important to boosting government income generation and investments through sustainable forest management and efficient techniques for wood conversion (Sander et al. 2013). To limit the excess of charcoal producers, in May 2016, Nigeria banned charcoal production when producers and exporters failed to adhere to the cut-one, plant four policy. It was not more than 2 months when a serious outcry from the populace crippled the restriction since charcoal is the major source of energy in the country. “The problem is complicated because the Federal Government owns the policy and the machinery to enforce the law, but the states own the forest. The states also see logging as a form of revenue generation.” Since the government fails in that regard, a serious

alternative, such as solar energy, has been targeted as it is environmentally friendly and economically viable. The big question is, how many people could afford it? Nigeria's National Council on Environment reiterates that the country needs an effective policy to promote solar energy and efficient cooking stove. Although the focus on renewable energy is a right step forward, its success will largely depend on how Nigeria is able to sensitize the people to adopt it. Improved monitoring of rural dwellers can enhance their willingness and preparation to invest in enduring methods. Traditional leaders still hold much title on land acquisition even more than the government. They place difficult conditions on land acquisition which prevent long-term investment in forestry. The transfer of responsibility and provision of financial and human resources to grassroot authorities can boost sustainable forest management and charcoal production. Formulation of policies encourages private sector participation in the dissemination of improved technologies as well as the establishment of marketing system for sustainable products. The government, private sectors, producers, and consumers have a lot to gain through proper planning and decision-making process for charcoal management. Openness in revenue channels and accountability of all players in charcoal production are important to the growth of national and local economies. A solid institutional framework comprising of forest managers, tree growers, charcoal processors, and traders is inevitable to achieve effective coordination of initiatives that will help develop a sustainable charcoal value chain as well as elucidate the mandates of the stakeholders. Charcoal chain reform should establish a firm relationship among major actors. It should be conscious of the danger of corruption as well as protection of the few policies that are designed for the regulation and improvement of the value chain. Measures that will help secure and protect the rights to energy access of those who do not have options should also be considered. For instance, despite the fact that the 2013 European Timber Regulation (EUTR) stipulates that there should be no illegal exportation of any wood products to its members countries, they do not monitor charcoal importation. Charcoal bags are labeled with tags, such as sustainably cultivated, regardless of the type of wood the charcoal is made from.

## Panacea for Greening Charcoal Value Chain

To improve the charcoal value chain, multiple concurrent interventions should be promoted to significantly lessen GHG emissions (Beukering et al. 2007). A green charcoal value chain needs financial viability that is best guaranteed through the improvement of tenure arrangements and legal access to resources. This will improve the purchase of wood and other biomass for charcoal production. It will also ensure the merits of a green charcoal value chain for the economies in the countries by placing financial premium on wood resources and incentivizing long-term practices and attractive investments that will induce a smooth movement. A comprehensive national foresrty policy framework should be developed for its sustainable administration and integration of charcoal with greater efforts across sectors to reduce the incidence of climate change. This will make climate change

specific component of NDCs. Furthermore, governments and other key players should be supported in greening the charcoal value chain through research contribution. There should be holistic methodical examinations of charcoal value chain in major countries where charcoal is produced. In addition, information on GHG emissions at diverse levels of the charcoal value chain should be available (Bailis et al. 2005) as it will facilitate in the greening of the charcoal value chain. The role of charcoal production in deforestation and forest degradation, including other forms of deforestation and forest degradation drivers in urban should be assesed at everytime before leading to devastated level; socio-economic and environmental results and trade-offs of a green charcoal value chain at the local, subnational, national, and regional levels as well as the spread, results from pilot projects, success stories, and research within the entire charcoal value chain are essential.

## Agricultural Adaptation Strategies to Climate Change that Can Reduce Charcoal Production

Great efforts must be exerted to encourage rural dwellers to go back to farming amidst the climate change that has destroyed the natural environment. Various agricultural adaptation strategies must be adopted to manage the soil resources such as mixed cropping. Mixed cropping is the practice of growing two or more crops together in the same field. It was derived from the traditional method of utilizing land particularly where there is shortage of land. For instance, cereals such as maize, sorghum, and legumes (cowpea and groundnuts) can be planted together. Mixed cropping is advantageous in that it varies in the period of maturity such as maize and cowpea, drought tolerance (maize and sorghum), input requirements (cereals and legumes) and final users of the products (e.g., maize as food and castor oil for cash). Hence, farmers should be encouraged to practice mixed cropping to maximize lands. Improved irrigation efficiency is required to make farming a business throughout all the seasons. Achievement in climate change adaptation depends on the access to adequate water in drought-prone areas. Knowing full well that water can be an inhibiting factor, improved irrigation efficiency is a significant adaptation device toward realizing food demands, especially during off seasons. Harvest during the dry season usually attracts good market price compared with that during the rainy season (Orindi and Eriksen 2005). Thus, there is a need for the adoption of soil conservation measures. Soil conservation deals with the proper timing of various farming activities that demand local experiences, burying of crop residues to improve soil fertility, burning of crop wastes to achieve quick release of nutrients, and allowing animals to graze on farmlands after harvesting crops to improve soil organic matter. Mulching is also important for controlling soil temperatures and extreme water loses. In addition, it prevents the emergence of diseases and harmful pests and conserves soil moisture. Before the advent of chemical fertilizers, rural farmers heavily depended on organic farming, which reduces GHG emissions. Planting of trees (afforestation) and agroforestry are mechanisms of soil preservation. Tree planting is the technique of transplanting seedlings for the following

purposes: forestry, land reclamation, and landscaping. Tree planting in silviculture is called reforestation or afforestation, depending on whether the area that is used for planting is or is not recently forested. It involves planting of seedlings over an area of land where trees and plants have been removed by man, fire, or pest and diseases. The free distribution of tree seedlings to farmers to achieve quick afforestation is a method of adapting to climate change (Akinnagbe and Irohibe 2014; Bird et al. 2011). With the reduction in the quantity of available water for crop production, there is a need for crop breeders to provide varieties of crops that are resistant to drought. These crops can be planted in drought-prone areas to lessen their vulnerability to climate change. For example, oat and wheat require fairly less irrigation water compared with dry-season rice. Furthermore, drought resistant crop varieties have been subjected to test by smallholder growers as adaptation methods to climate change in Nigeria, Senegal, Burkina Faso, and Ghana (Ngigi 2009). Furthermore, crop diversification should be encouraged. medium or long time crop production is a possibility in diversification to high-value crops. The diversification of crop planting is an adaptation mechanism prioritized in areas where irrigation is used or not used. Thus, farmers should be encouraged to change the type of crop they plant to curb the risk of low yield from harvest on farm (Orindi and Eriksen 2005; Adger et al. 2003). Crop diversification can be a buffer against variations in rainfall. In addition to the changes in cropping patterns and planting calendars, long-term alterations in rainfall due to climate change can negatively impact crop production. Thus, it is important for extension agents to orient rural farmers. Such an orientation will enable the farmers to familiarize the trend of cropping patterns in their domains. Essentially, shifting from charcoal production to other livelihood activities will prevent our environment from further deterioration. Most rural dwellers consider charcoal production as their last resort to generate income (Eniola 2014). Hence, there is a need to create awareness on other livelihood activities, such beekeeping, mushroom farming, fish farming, and horticultural farming, among others, with special financial support from the government and other non-governmental agencies.

## Conclusion and Recommendations

This chapter concludes that the government in Nigeria needs to exert more effort on climate change adaptation, especially in terms of the eradication or reduction of the threats posed by charcoal production to human health and the environment. Charcoal production cause severe damage to both the environment and humans, thus leading to the reduced number of people engaging in farming activities. Quick actions in ensuring impeding food shortage and rebuilding the forest must be taken so as not to jeopardize the future need of the forests by the coming generation. The country should strictly adhere to the laws, regulations, and policies of the international bodies on climate change adaptation. Alternative means of livelihood, such as fish farming, mushroom production, vegetable production, and other simple and cheap farming activities, should be embraced by farmers. The reduction of the number of rural dwellers involved in charcoal production will go a long way.

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