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Charcoal Production and Energy Resources in Western Nigeria: Issues and Challenges for Sustainable Development

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ABSTRACT

Charcoal is dark grey residue consisting of Carbon and any remaining ash, produced by the slow process of heating wood and other substances in the absence of oxygen, called Pyrolysis. It is a cheap source of fuel to purchase and use but not without some challenges. This paper highlights the significance of charcoal production around the world, its roles in the economy of communities, and major challenges. Ibarapa Region of Oyo State in Western Nigeria is used as a case study. It is in eight major parts: Introduction and the world scene; typicality of Ibarapa Region of Nigeria; predominant methods of production; types and uses of charcoal; challenges to the communities and the nations; the place of Environmental Adult Education for sustainable production, transportation and consumption; and discussion, conclusion, and recommendations. The work uses essentially secondary sources of data and information. Charcoal production at a sub-industrial level is one of the causes of deforestation and environmental degradation. While it is regulated to a great extent in the developed world, it is illegally and nearly absolutely unregulated in the others such as in Brazil and Nigeria where production is largely illegal industry. The consequences have been devastating. Adult Environmental Education may generally take place in formal and non-formal education settings whereby organized learning can take place in many forms.

Keywords: Charcoal production, energy, sustainable development, adult education, Ibarapa, Western Nigeria

INTRODUCTION

Linking environmental and social issues and locating environmental problems within the context of human daily lives and actions are important challenges for adult environmental education. There are no such things as environmental problems; there are just a lot of social problems (Egunyomi, 2008; Forest Stewardship Council, 2013). Presently, adult environmental education is experimenting with different ways to bring about change and initiate action. Such a task goes beyond creating understanding and awareness. They aim at developing skills, creating a sense of commitment and stimulating individual and collective actions. Environmental education has the potential to bring about action at the individual, community and governmental levels. However, environmental activists and educators are becoming aware of the kinds of situation that create barriers to participatory action for the environment, such as: (1) situations where marginal communities face grave economic and social problems; (2) where there is a lack of environmental awareness and of commitment to environmentally friendly policies among governments and industry; and (3) where local initiatives do not achieve their aims because of lack of support from the institutional sector, and because of lack of coordination with other initiatives. Environmental Adult Education, therefore, needs to address all sectors of society: people, communities, public institutions, the private sector, governments, policy-makers, and international organizations.

Charcoal, a lightweight, black residue, consisting of carbon and any remaining ash, obtained by removing water and other volatile constituents from animal and vegetal substances is a source of energy and heat in both developed and developing world. It is usually produced by slow pyrolysis, that is, the heating of wood or other substances in the absence of oxygen. In history, 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 wood on their ends so as to form a conical pile, openings being left at the bottom to admit air, with a central shaft to serve as a chimney. The whole pile is covered with turf or moistened clay mud. The firing starts at the bottom of the flue, and gradually spreads outwards and upwards. The success of the operation depends largely upon the rate of the burning. Under average conditions, 100 parts of wood yield about 60 parts by quantity, or 25 parts by mass, of charcoal; small-scale production on the spot often yields only about 50%, while large-scale became efficient to about 90% even by the seventeenth century (Smith and Voreacos, 2007). According to Dawson (2001) and Ogundele *et al*. (2011), the operation is so delicate that it was generally left to professional charcoal burners. They often lived alone in small huts in order to tend their wood piles. In the Harz Mountain, Germany, the burners lived in conical sheds (huts) they called Koten which are still much in evidence today (Smith and Voreacos, 2007; Dawson, 2001). The name by which it is called varies from community to community but they are of similar concepts and descriptions.

Though charcoal is an old source of energy, it is as well a modern source of energy for making charcoal heat for ironing, cooking, heating and warming house etc among both rural and urban communities. It is in addition, an export commodity in some nations of the world including

Nigeria, with a large market in the Europe, United States of America and Asia (Table 1). The prices range from $170-$300/ton depending on the packaging and "type." Tropical Africa accounts for 70% of the exports and the market is all year round with a usual slight drop between July and September (Food and Agricultural Organization, 2007).

Table 1: Top Wood Charcoal Exporting and Importing Countries

Rank	Country of Export	Percentage Share of Total Wood Charcoal Exports	Country of Import	Percentage Share of Total Wood Charcoal Imports
1	Paraguay	12	Germany	9
2	India	11	China	8
3	Indonesia	11	Malaysia	8
4	Argentina	11	Japan	7
5	Somalia	5	Brazil	6

Source: Forest Stewardship Council. (2013). The Increasing Importance of Forests to the Prosperity of People, FSC Contribution to the World Forests Summit, Stockholm, (March).

Globally, charcoal industry is a multibillion dollar industry. According to The Food and Agricultural Organization (FAO) of the United Nations (2007 and 2010), over 40 million metric tonnes of charcoal are consumed globally and approximately 2.4billion people rely on wood and charcoal for their daily fuel. Nigeria currently ranks second to Brazil in the production of charcoal. The western countries particularly prefer Nigeria's charcoal, as the country is rich in tropical hardwood, which burns slower and hotter. The country (Nigeria) presently exports 380,000 metric tonnes of charcoal annually (Food and Agricultural Organization, 2010). It is a cheap source of fuel to purchase and use. It is also a source of generating income through exportation and local sales. The business involves the sourcing, storage, packaging (in about 5 Kg bags) and transportation of the hardwood charcoal. It has seasonal market, but the season differs from one country to another: In the United Kingdom, Belgium, Holland, France, Germany and Denmark, the sale season is from May through August because that is the summer time for the communities. The Europeans give out their orders from September to May of the following year. But in countries like Israel, Kuwait, Iran and Iraq, and other Asian countries, it is all-year round and the order is placed from January through December. The United Kingdom is one of the largest consumers, though other countries around the world like Holland, France, Netherland, Germany, Spain, Bulgaria and Denmark also consume the product in large quantity (Food and Agricultural Organization, 2010).

The massive production, at its height employing hundreds of thousands, mainly in Alpine and neighbouring forests, was a major cause of deforestation, especially in parts of Central Europe (FAO, 2010; Forest Stewardship Council, 2013). In the United Kingdom, many woods were managed as thickets, which were cut and re-grown cyclically, so that a steady supply of charcoal would be available, in principle, forever; complaints about shortages may relate to the results of temporary over-exploitation or the impossibility of increasing production to match growing demand. The increasing scarcity of easily harvested wood was a major factor behind the switch to vestige fuel equivalents, mainly coal and brown coal for industrial use.

In Scandinavia and Finland, the charcoal was considered the by-product of wood tar production. The best tar came from pine, thus pinewoods were cut down for tar pyrolysis. The residual charcoal was widely used as substitute for metallurgical coke in blast furnace for smelting. Tar production led to massive and rapid deforestation: it has been estimated that all Finnish forests are younger than 300 years (Food and Agricultural Organisation (FAO, 2010). According to the FAO, the end of tar production at the end of the 19th century resulted in rapid re-forestation.
The charcoal briquette was first invented and patented by Ellsworth B. A. Zwoyer of Pennsylvania (USA) in 1897 and was produced by the Zwoyer Fuel Company. The process was further popularized by Henry Ford, who used wood and sawdust byproducts from automobile fabrication as a feedstock. Ford Charcoal progressed to become a huge and popular Kingsford Charcoal Company as it is today.

By and large, the objective of this chapter is to highlight the significance of charcoal production around the world using the Ibarapa Region of Oyo State, Nigeria, as a case study; its roles in the economy of the communities and the nations, and major environmental challenges. The place of Adult Environmental Education is highlighted. It makes suggestions for sustainable charcoal production and environmental sustainability while every effort towards community development may not necessarily be jeopardized. It is in seven major parts: Introduction and the world scene; typicality of Ibarapa Region in Nigeria; predominant methods of charcoal production; major types and uses; challenges of production and usage; the place of Adult Environmental Education; and discussion, conclusion, and recommendations. The work uses essentially solely secondary sources of data and information.

Revisiting Ibarapa Communities in Western Nigeria

Ibarapa region is made up of three Local Government Areas of Oyo State, namely: Ibarapa West, Ibarapa Central, and Ibarapa East with the administrative headquarters at Aiyete, Igbo-Ora and Eruwa respectively. It is occupied by Yoruba group of people located in the Southwestern corner of Oyo State in Nigeria. They are noted for *EgusiIbara* (melon) from where the name Ibarapa was derived (Abimbola, 2006). The community is bounded on the north by Iwajowa and Iseyin Local Government Areas of Oyo State; and by Ido Local Government Area of the state in the east. It is absolutely bounded in the south by the Ogun State of Nigeria. The area is approximately 2,496 km² in ecological size and consists mostly of rolling savannah with forests situated along the southern border and in isolated patches along with river courses. The landmass lies at an elevation ranging between 120 and 200 meters above sea level, but rocky inselbergs and outcrops can be seen rising to 340 meters Among them are Aako, Asamuni, OkeIdere, Asawo, Anko and others.

Precipitation is characterized by a double rainfall maximum, that is, two high rainfall *peaks*, with a short dry season and a longer dry season falling between and after each peak. The natural vegetation was originally rainforest but that has been mostly transformed into a derived type of savanna as a result of several centuries of slashes and burn agricultural practices. What is predominantly observed now is the Guinea Savanna mosaic, but Lophiralaceolata remains a tree that is more resistant to fire (Oderinde *et al*., 2015; Aderogba and Bankole, 2016). The mixture of forest and grassland provide favourable habitat for a range of animal species from large mammals such as African leopad, forest elephants, antelopes, and others. The wetland is rich in birdlife, including fowls, eagles, sparrow, owl, etc. The ecoregion covers a substantial part of the Oyo State including the large guinea savanna of Nigeria. Apart from the administrative headquarters of the Local Government Areas, other major human settlements are Lanlate, Igangan, Tapa and Idere. The adjoining rural communities and farmsteads are Akowe, Alagbaa, Alapala, Apagbo, Elewure, KajolaShipa, Onipede, Adeagbo, Ahoro, Ajegunle, Ajelanwa, Alaparun, Gbelekale, Asunnara, Elegbeda, Idiope, Olokete, Owode, Abule Oba, Abule Okie, Abule-Osun, Aderohunmu, Ago-Ajaala, Aiyegbede, Ameke, Baba Oke, Bamigbose, Dagiloro, Dawodu, Duduyemi, Elepo, Elukotun, Ajebandele, IsabaTemidire, Lawore, Okolo, Olokemeji, Olori, Olorunda, Oluwo, Sango, Temidire-Idiope, Alapa, Igbodudu, Itabo, Akeroro, Sekere, Babalokuta, Obatade, Imeleke, and others. This area has been populated by humans for millennia and very little of it, if any, is formally protected (Abimbola, 2006; Aderogba, 2017).

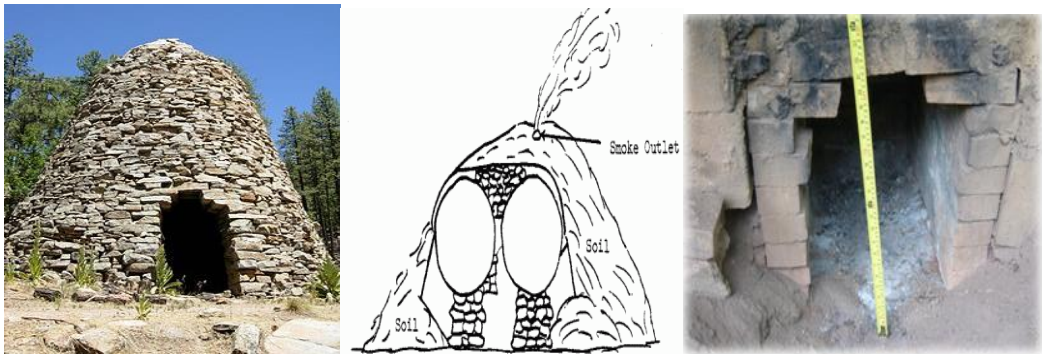
The indigenes are said to have migrated into the area as a fraction from the Old Oyo empire, during the periods of constant internecine warfare between the different Yoruba states, as well as refugees escaping the transatlantic and trans-Saharan the business of the day (Abimbola, 2006). The Tapa segment of the population is said to have been formed by the Jihad ridden Nupe refugees from the northern Niger, who had lost their traditional state to Fulani jihadists. The predominant occupation of the people is farming; their major crops are melon, cassava, maize, yam and vegetable. A substantial part of the crop produced is consumed locally. Cash crops such as cocoa, palm trees are sparingly cultivated. Industrialization is at its lowest web and poverty is in the land (Aderogba and Bankole, 2016).

The region drew its distinctiveness from the aforementioned. There is poverty in the land, but energy is massively required for heating, cooking smelting, etc. Common sources of energy from the national grid, electricity, are not common. It is neither available nor reliable or expensive and scarce in spite of the huge capital outlay and investments by the central government (Aderogba and Bankole, 2016). The commonest sources of energy seem to be bio-fuel (wood and charcoal), petroleum (oil and gas), sun and human power. There are unaffordable limitations of either financial capability or technology on all except the charcoal and wood. The latter are readily available.

Predominant Methods of Charcoal Production

Charcoal the dark grey (and sometimes black substance) residue consisting of Carbon and any remaining ash, produced by the slow process of heating wood and other substances in the absence of oxygen, called Pyrolysis, is an impure form of Carbon, which contains ash. In other words, the black substance which is derived by burning wood slowly in an oven with only a little air is excellent domestic fuel, and it can be made from virtually any organic material like wood, coconut shells, rice husks and bones. Usually, hardwood species like Acacia, Mangroves, Oaks and Prosopis are preferred for its production. It is relatively safer and more economical to use than firewood (Zulu and Richardson, 2013; World Health Organization, 2014).

It has been made by various methods. The traditional method in Britain used a clamp: This is essentially a pile of wooden logs (e.g. seasoned oak) leaning against a chimney - logs are placed in a circle. The chimney consists of 4 wooden stakes held up by some rope. The logs are completely covered with soil and straw allowing no air to enter. It must be lit by introducing some burning fuel into the chimney; the logs burn slowly and transform into charcoal in a period of 5-6 days' burning. If the clay mould covering gets cracked by the fire, additional clay is placed on the cracks. Once the burn is complete, the chimney is plugged to prevent air from entering. The true art of this production method is in managing the sufficient generation of heat by combusting part of the wood material; and its transfer to wood parts in the process of being carbonized. It has a strong disadvantage: There is huge amount of methane emissions (not yet burnt) that are harmful to human health and the environment.



(a) (b) (c)

Fig. 1: (a) An abandoned charcoal kiln near Walker, Arizona, USA; (b) Sketch of a Traditional Kiln for making Charcoal in Brazil; and (c) A Modern Kiln in India.
Sources: Egunyomi, D. A., Aderogba, K. A. and Bankole, M. O. (2016). Unsustainable Exploitation of the Guinea Savannah, South of Sahara: Issues, Policies and Programmes for Sustainability, paper presented at the 2016 Adult Education World Conference, University of Ibadan, Ibadan (July).

As a result of the partial combustion of the wood material, the efficiency of the traditional method is low. However, it is of interest to assert that there are many methods applied as there are many regions of the world producing charcoal. Figure 1 (a) is an abandoned charcoal kiln near Walker, Arizona, United States of America; (b) is a sketch of a traditional Kiln for making charcoal; and (c) is a modern charcoal kiln in India. Modern methods employ retorting technology, in which process heat is recovered from, and solely provided by, the combustion of gas released during carbonization. Yields of retorting are considerably higher than those of kilning, and may reach 35-40% more. Also known types and methods are earth pits, earth moulds, casamance, brick, metal, brick and orange, drum, etc. They all have different efficiency.

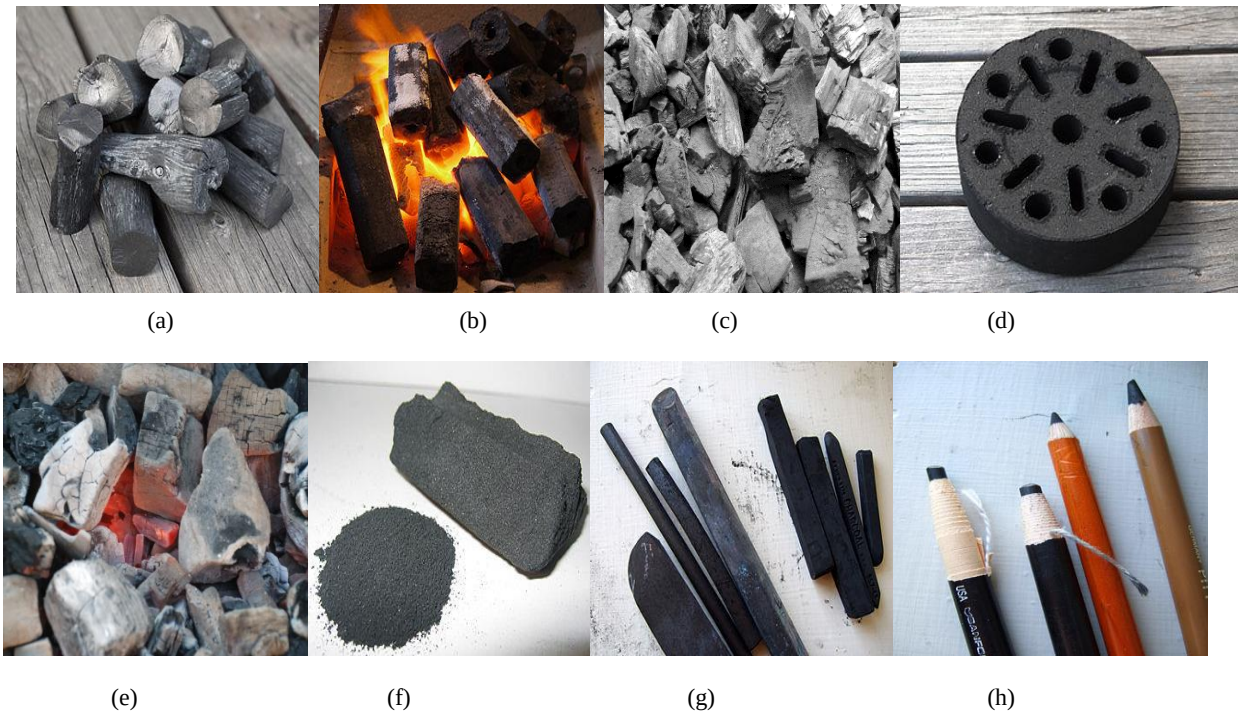
But in response to one of the research questions (What were the major activities involved in charcoal production and transportation out of the community?)in a work of Aderogba (2017) entitled Charcoal Production in Ibarapa Region of Oyo State and Sustainable Development of the Agrarian Community,IyandaOguntade from Igangan, a charcoal producer and transporter gave a summary of all the processes involved in charcoal production and transportation in the region in this way:
We make road [foot path] to the location that we intend to have the kiln and prepare the ground for the kiln, .gather enough wood by cutting down the forest woods [trees] including the branches and the leaves. We use the leaves to wrap it all before setting the fire below. Often, we cut the wood into small, small logs, all through. The pieces are heaped but with a shallow hole beneath, that is, from where we set fire. The heap of wood is covered all round with leaves cut from the branches of the trees fell. When that is not enough, we cut from other trees around - just to get enough for the purpose. The kiln is made of wet mud molded into a cone-shaped all round the heap of wood. When all the pieces of wood might have been well wrapped with leaves and wet mud, we set fire below. Air [oxygen] is virtually not allowed; if it does, we get ashes in place of charcoal. …. It takes more than five to six days before you get the desired results. We quench the resultant coal from receiving air [Oxygen] and pile for loading. The charcoal is loaded into sacks and moved to a coal depot through footpath or through a pick-up van near a motor road before taken the loads to Aiyete [town]. That is what we do a year in year out. All my three children are always with me. My wife also sells charcoal in town.
Not less than three individuals of between 22 and 40 years old are involved in each series of operations. Sometimes, the number could be as many as ten including the drivers of the trucks and the motor boys. It is the only business of some families and they move from one location to another within the forest; and all year round, that is, when the stock gets exhausted from any location. Under this circumstance, the kilns are not permanent, unlike the modern types. In the processes, both plants that were required and those that were not got destroyed and never get replaced by anybody. Individuals and families in the business are increasing by the day, whereas, those in faming activities (individuals and families) are decreasing in number on a daily basis (Food and Agricultural Organization, 2017). It is perceived as a modern *grass root business* that can easily and quickly fetch money for families and individuals.
But, the properties of the charcoal produced depend on the material charred (Zulu and Richardson, 2013). According to them, the charring temperature is also important. It can contain varying amounts of hydrogen and oxygen as well as residue and other impurities that, together with the structure, determine the properties. The approximate composition of charcoal for gun powder is sometimes empirically described as C_7H_4O. To obtain charcoal with high purity, the source material must be free of non-volatile compounds (Kato *et al*., 2004; Zulu and Richardson, 2013).

Foremost Varieties and Uses

Common charcoal is made from peat, coal, wood, coconut shell, or petroleum. Sugar charcoal is obtained from the carbonization of sugar and is particularly pure. It is purified by boiling with acids to remove any mineral matter and is then burned for a long time in a current of chlorine in order to remove the last traces of hydrogen. It was used by Henri Moissan in his attempt to create a synthetic diamond (Dawson, 2001). Activated charcoal is similar to common charcoal but is made particularly for medical use. To produce activated charcoal, manufacturers heat common charcoal in the presence of a gas that causes the charcoal to develop many internal spaces or "pores." These pores help activated charcoal trap chemicals (Smith and Voreacos, 2007). But lump charcoal is traditional charcoal made directly from hardwood material. It usually produces far less ash than briquettes (Zulu and Richardson, 2013; Ackermann *et al*. (2014). This is the common and the only type produced in Ibarapa region and most parts of the guinea forests of Nigeria (Ogunsanwo *et al*., 2007; Ogundele *et al*., 2011; Oderinde *et al*., 2015).

Japanese charcoal has had pyroligneous acid removed during the charcoal making; it, therefore, produces almost no smell or smoke when burned. The traditional charcoal of Japan is classified into two types: White charcoal (Binchotan), which is very hard and produces a metallic sound when struck; and Black charcoal (ja). A more recent type is of factory-made briquettes:

- *Ogatan* made from hardened sawdust, often used in *Izakaya* or *Yakiniku* restaurants;
- *Pillow shaped briquettes* made by compressing charcoal, typically made from sawdust and other wood by-products, with a binder and other additives;
- *Hexagonal sawdust briquette charcoal* made by compressing sawdust without binders or additives, the preferred charcoal in Taiwan, Korea, Greece, and the Middle East; and
- *Extruded charcoal* made by extruding either raw ground wood or carbonized wood into logs without the use of a binder, the heat and pressures of the extruding process hold the charcoal together.



(a) (b) (c) (d)

(e) (f) (g) (h)

Fig. 1: Major types of charcoal: (a) Binchotan, Japanese high grade charcoal *(b) Ogatan*, charcoal briquettes; (c) Dry charcoal; (d) Grill charcoal; (e) burning charcoal; (f) Activated carbon; (g) Four sticks of compressed vine charcoal; and (h) Two charcoal pencils , and two charcoal pencils in wooden sheaths

Source: Dawson, A. (2001). Activated Charcoal: A Spoonful of Sugar, *Australian Prescriber*. NPS Medicine Wise. Retrieved 19 March 2016; Zulu, L. C. and Richardson, R. B. (2013).Charcoal, livelihoods and poverty reduction: evidence from sub-Saharan Africa. *Energy for Sustainable Development*, 17(2): 127-137; and Smith, M. &Voreacos, D. (2007). Brazil: Enslaved workers make charcoal used to make basic steel ingredients, *Seattle Times*, January 21, p.17.

Fig. 1 is major types of charcoal (a) is Binchotan Japanese charcoal; it is of very high grade, made from ubame oak. Ogatan chacoal briquettes are made from sawdust, (b). (c) is dry charcoal made from baoba wood at Igbo-Ora, (Oyo State) in the guinea savanna forest of Nigeria. (d) is griled charcoal made from coconut shell, common in Brazil; and

(e) is burning charcoal in Japan. (f) is activated carbon. The four sticks of vine charcoal and the four sticks of compressed charcoal are Fig. 1 (g). Fig. 1 (h) are two charcoal pencils in paper sheaths that are unwrapped as the pencil is being used and two other charcoal pencils in wooden sheaths (Dawson, 2001; Smith and Voreacos, 2007; Zulu and Richardson, 2013). Charcoal has been used since earliest times for a large range of purposes including art and medicine, but by far its most important use has been as a metallurgical fuel. It is the traditional fuel of the blacksmith's forge and other applications where an intense heat is required. It was also used historically as a source of black pigment by grinding it up. In this form charcoal was important to early chemists and was a constituent of formulas for mixtures such as black powder. Due to its high surface area charcoal can be used as a filter, and as a catalyst or as an adsorbent. It burns at intense temperatures of up to 2,700 °C, but by contrast, the melting point of iron is approximately 1,200 to 1,550 °C. Due to its porosity, it is sensitive to the flow of air and the heat generated can be moderated by controlling the air flow to the fire. This probably explains why charcoal is still widely used by blacksmiths. Charcoal has been used for the production of iron since Roman times and till the modern times where it also provides the necessary carbon.

Like many other sources of carbon, charcoal can be used for the production of various syngas compositions, automobile powered, Black Powder, source of carbon, can be *activated* to increase its effectiveness as a filter, as adsorbs of organic compounds dissolved or suspended in gases and liquids, in industrial processes such as the purification of sucrose from cane sugar, undesirable color, absorb odors and toxins in gases such as air, and filters in some types of gas masks. The medical use of activated charcoal is mainly the absorption of poisons, variety of health-related applications, for example, to reduce discomfort and embarrassment due to excessive gas in the digestive tract.

Charcoal is used in art for drawing, making rough sketches in painting; and it is one of the possible media for making a parse-mage, as a fixative. Artists generally utilize charcoal in three forms: Vine charcoal, created by burning sticks or vines; powdered charcoal, often used to "tone" or cover large sections of drawing surfaces. Drawing over the toned areas darkens it further, but the artist can also lighten (or completely erase) within the toned area to create lighter tones. Compressed charcoal powder mixed with gum blinder compressed into round or square sticks. The amount of binder determines the hardness of the stick. Compressed charcoal is used in charcoal pencils. One additional use of charcoal is in horticulture. Although American gardeners have been using charcoal for a short while, research on Terra preta soil in the Amazon has found the widespread use of biochar by pre-Columbian natives to turn unproductive soil into carbon rich soil (Lehmann, 2009). According to him in the edited work, "the technique may find modern application, both to improve soils and as a means of carbon sequestration."

Charcoal was consumed in the past as dietary supplement for gastric problems in the form of charcoal biscuits. Now it can be consumed in tablet, capsule or powder form, for digestive effects. Research regarding its effectiveness is controversial (Dawson, 2001). To measure the mucociliary transport time the use was introduced by Passali in combination with saccharin.

Red colobus monkeys in Africa have been observed eating charcoal for the purposes of self-medication. Their leafy diets contain high levels of cyanide, which may lead to indigestion. So they learned to consume charcoal, which absorbs the cyanide and relieves indigestion. This knowledge about supplementing their diet is transmitted from mother to infant. This may be a likened to the use of charcoal for preservation of blended cowpea beans among the Yorubas of Oyo State, Nigeria.

Major Challenges in Charcoal Production and Uses

Six to fifteen tonnes of wood are necessary to make one ton of charcoal, accordingly much of the forests, particularly African forests have already been lost due to its charcoal export to Europe and other parts of the world where it is in dear demand. Paraguay loses nearly 40,000 hectares of forest every year due to illegal export of charcoal, and another 12,000 ha for producing barbecue coal for Europe. Furthermore, like in Southwestern Nigeria, the Paraguayan charcoal producers who mostly run small-scale rural units earn little from this trade. On the other hand, compared to the production of kerosene, coal, Liquid Petroleum Gas, fuel wood, and electricity, the production of a Terajoule of energy by charcoal provides employment to over 200 to 350 persons. In India, Thailand, China, Malawi, Nepal, Myanmar, Pakistan, and Philippines, the industry provides employment for up to 6% to 10% of their rural populations (FAO, 2010). But, charcoal production at a sub-industrial level is one of the causes of deforestation (FAO, 2007 and 2010). While it is illegal and regulated to a great extent in the developed world, it is more or less legal and nearly absolutely unregulated in the others such as in Brazil and Nigeria where production and uses are largely legal.

Massive forest destruction has been documented in areas such as Virunga National Park in the Democratic Republic of Congo, and Mau Forest in Kenya (Lynette and Wangwe, 1999; Zulu and Richardson, 2013) where it is considered a primary threat to the survival of the mountain gorillas. Similar threats are found in Zambia. In Malawi, illegal charcoal trade employs over 95,000 workers and is the main source of heat and cooking fuel for about 95% of the national population (FAO, 2007). It causes deforestation, a regulated charcoal industry that required replanting and sustainable use of the forests "would give their people clean efficient energy – and their energy industries a strongcompetitive advantage."And generally, **a**round the globe, it is of interest to note that the material resources for production of charcoal is from the natural environment - wood, coconut husks, etc. They are exhaustible and they get depleted over time and space. Table 4 show the trees that were found natural in Ibarapa Region within the Guinea Savanna of Oyo State, Nigeria, but have drastically got depleted over time (Oderinde *et al.,* 2015). According

to these authors, the likes of Mahogany, Obeche, Irokoetc have been extensively exploited; many of them, namely Baoba, Cashew, Axle wood, Eboy, Gimelina, Mahogany, Mango, Iroko, Teak and Obeche have been "used-up" (Oderinde *et al*., 2015), Table 3. According to their randomly selected respondents, about thirteen of the guinea savanna forest trees were found to have been reduced in number. In the same way, Figures 4 and 5 shows the trends of depletion of the wild and semi-cultivated trees in the region within a period of about 30 years, 1982-2012 only (Egunyomi *et al*., 2016). It is weir; and called for attention.

Table 3: Trees that have reduced in number over time

Item	Scientific Name	Common Name	Local Name	Frequency	Percentage (%)
1	*Adansonia digitata*	Baobab	Oshe	2	2.5
2	*Anacardium occidentale*	Cashew	Kaju	1	1.3
3	*Anogeissus leiocarpus*	Axle wood	Ayin	24	30.0
4	*Ceiba pentandra*	-	Araba	23	28.8
5	*Diospyros celebica*	Ebony	Ige	2	2.5
6	*Gmelina arborea*	Gmelina	Igiisana	1	1.3
7	*Khaya grandifoliola*	Mahogany	Mahogany	1	1.3
8	*Khaya ivoriensis*	-	Oganwo	12	15.0
9	*Mangifera indica*	Mango	Mangoro	2	2.5
10	*Milicia exelsa*	Iroko	Iroko	47	58.8
11	*Nauclea diderichii*	-	Opepe	2	2.5
12	*Tectona grandis*	Teak	Igigedu	15	18.8
13	*Triplochiton scleroxylon*	Obeche	Arere	9	11.3

Source**:** Oderinde *et al.* (2015).

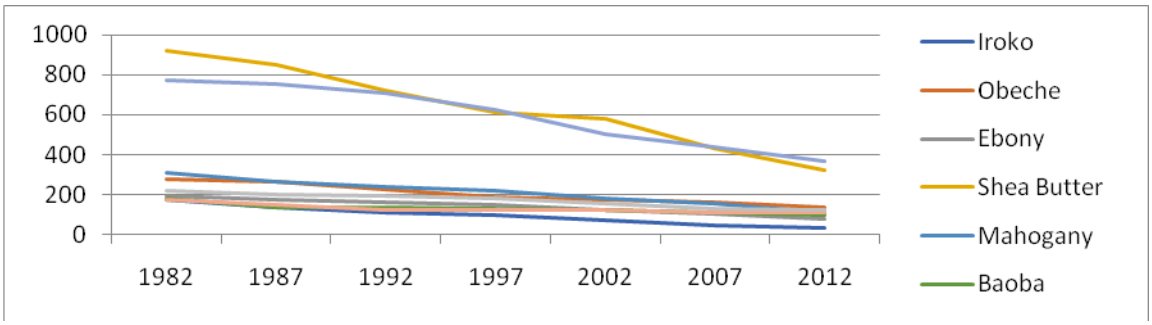


Fig. 2: Trend of Depletion of selected wild Plants
Source: Egunyomi *et al*. (2016).

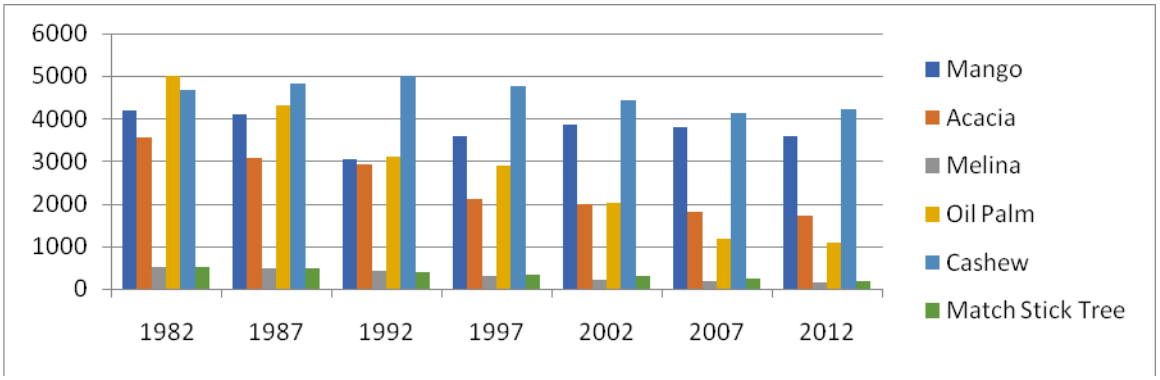


Fig. 3: Trends of Depletion of Selected cultivated and Semi-cultivated Plants
Source: Egunyomi *et al*. (2016).

Aside the depletion of the natural forest resources which leads to other several consequences (environmental degradation, change in ecosystem, climate change and global warming, soil erosion, soil impoverishment, lost of biomass, etc), human and animal wellbeing were not spared (Van der Werf *et al*., 2009; Alamu and Agbaje, 2011; Ogundele *et al*., 2011; Tunde *et al*., 2013; Zulu and Richardson, 2013). Again, Aderogba (2017) in her work

Charcoal Production in Ibarapa Region of Oyo State and Sustainable Development of the Agrarian Community, a respondent to one of her questionnaire items (What are the impact of the charcoal production and transportation out of the region on the natural environment?), SikiruOkunola from AnkoEruwa has this to say when he expressed his views on the impact of charcoal production on the physical environment thus:

Let us be frank with ourselves, the impacts are numerous, severe and enormous; and could be very devastating. Right from the roads we make to the kilns, the grasses and trees that we cut, the sand/mud and pit we made, the smoke and heat created [emanating]; the new environment that emerged, vehicles that we bring in, and all sorts of waste created around and on the way. It is humongous and beyond imagination. We make vehicles to come and load in places where vehicles have never been to. We turn bush to temporary homes. Sometimes, it is new communities of plants and animals that emerge. From Igangan through Idere and Igbo-Ora to Lanlate, it is the same, and ….

Again, these are similar to the findings of Bayode *et al.* (2015) for different parts of Oyo State, Nigeria, and Oderinde *et al.* (2015) for Ibarapa East of the same region; and Lynette and Wangwe (1999) and Alamu and Agbeja (2011) for different regions around the world. The impacts are also similar to those of miming activities as observed by different scholars and organizations (Andrew and Jackson, 1996; Food and Agricultural Organization, 2007). Incidentally often, particularly in those developing nations, Nigeria inclusive, there has never been any policy addressing the issue; and if there had been any, none of the charcoal producers had ever been challenged.

The Place of Adult Education

Charcoal has been receiving great recognition in the economy and livelihood of man in developed and developing countries (Dawson, 2001; FAO, 2017; Aderogba, 2017). The environment has tremendously suffered more of the consequences of the production, transportation and uses of it and its derivates (Ogundele *et al.*, 2011; Tunde *et al.*, 2013). To engender sustainability, Adult Environmental Education is thus of paramount importance (Andrew and Jackson, 1996; Myers, 1994; Belanger, 1999; Haugen, 2006; Environmental Education, 2008). As the "hybrid outgrowth of the environmental movement and adult education, combining an ecological orientation with a learning paradigm to provide a vigorous educational approach to environmental concerns" (Sumner, 2003) must be of great concern and immediate focus. Concerted efforts are required in the teaching of environmental issues on how individuals and businesses of charcoal production, transportation and use can be managed or changed, and the lifestyles modified and or adjusted; and so also the ecosystems to live sustainably. The overarching goal of this would be to educate global societies to live more sustainably.

According to the United Nations Environmental Programme (UNEP) (2008), "though the environmental adult education is a relatively new and unique field of study and practice, it is a community-based method in which educators listen and respect the input of learners, and all participants are considered essential." The educators would have to consider environmental problems with a holistic approach that combines social, political and environmental concerns into the community dilemmas.

Participatory methods would deliberately and inadvertently allow all stakeholders to make connections between social issues and environmental problems. This connection will make the charcoal producers, transporters and users in particular to understand the core causes of major environmental issues and the resulting problems. In this way, educators will be opportune to stress the importance of instilling environmental awareness so that communities do not forget their relationship with the natural world. In summary, the methods and content of the programme should include:

- a fair knowledge of the environment in which the industrialist (charcoal producers and transporters) dwell;
- a knowledge of the environmental problems and their causes;
- the skills to engage in social activism to combat those problems;
- the attitude of respect and connection to the natural environment; and
- a desire to change current practices to protect the Earth.

The environmental adult education may generally take place in a non-formal educational setting. This means that the organized learning can take place in many forms including vocational education, literacy education and on the farms like the nomadic education in the northern parts of Nigeria.

DISCUSSION

The fore going has highlighted that there were huge production, transportation and uses of charcoal that have been going on, all year round; and for years now and in the Ibarapa communities of Oyo State, Nigeria. The activities have enormous negative impacts on the physical environment. Suffice to say that trees such as Baoba(*Adansonia digitata*), Axile wood (*Anogeissus leiocarpus*), Bamboo(*Bambusa vulgaris*), Ebony(*Diospyros celebica)*, Gmelina(*Gmelina arborea*),Mahogany(*Khaya grandifolia*),Mango(*Mangifera indica*),Iroko(*Milicia excelsa*),Locust Beans (*Parkia biglobosa*), Teak (*Tectona grandis*), Obeche (*Triplochiton scleroxylon*),and Shea Butter (*Vitellaria paradoxa*) and many others in Ibarapa Region, for instance, have been massively depleted. Some have gone to extinction. The use of the charcoal is enormous too: It is medicinal, used in industrial manufacturing, on the farms, domestically and others. It is the only source of energy, income, and means of livelihood and occupation of many.

However, and more significantly, there were positive and negative impacts on community development. This work is unable to discuss other causes of forest degradation nor do the chemistry and physical reaction in the production of charcoal, but, for the fact that the charcoal production activities support the community livelihood suggest that

any attempt to impede charcoal production must be with care. In those regions, where charcoal is being extraordinarily produced, additional uses, for example, pencil and artist tools, drawing pencils, medicine etc may be further researched into and refined, thus used as raw materials. Research institutes and industrialists must invest extraordinarily into refinement and use of charcoal those new ways.

All levels of governments, nationally, internationally and regionally, must work with concerted efforts and collaboratively to educate all and sundry on specific aspects of Environmental Adult Education, through Community Educators, on tree felling, and charcoal production; and conservation laws that must also be enforced. There must be alternatives to use of charcoal; jobs for charcoal producers, alternative forms of energy - wind, solar, hydro etc.

Unconditional attention must be given to environmental gentrification: Forest conservation and reserves should be encouraged so as to preserve plant and animal life forms. In the township and in the forest, there must be substantial planting of trees; and the recently fell trees and shrubs must be replaced with high breed type of trees.

REFERENCES

Abimbola, K. (2006). *Yoruba Culture: A Philosophical Account, Ibadan, Nigeria: Iroko Academy, p. 40.*

Ackermann, K., Kirtz, L., Andriamanantseheno, C. and Sepp, S. (2014). The "green charcoal chain".*RURAL*, 21: 01.

Aderogba, K. A. and Bankole, M. O. (2016). Unsustainable Exploitation of the Guinea Savannah, South of Sahara: Issues, Policies and Programs for Sustainability, Paper Presented at the Faculty of Social Sciences Conference, Obafemi Awolowo University, Ile-Ife, (March).

Aderogba, K. A. (2017). Charcoal Production in Ibarapa Region of Oyo State, Nigeria and Sustainable Development of the Agrarian Community. Paper presented at the International Conference on Education, Development and Innovation (INCEDI), Methodist University College, Accra, Ghana, August 28-39.

Alamu, L. O. and Agbeja, B. O. (2011). Deforestation and endangered indigenous tree species in South-West Nigeria.*International Journal of Biodiversity and Conservation*. 3(7): 291-297.

Andrew, R. W. J. and Jackson, J. M. (1996).*Environmental Science: The Natural Environment and Human Impact,* Harlow: Longman Group Limited, p. 243.

Bayode, T. J., Adeleke, B. M., Abiodun, O. D. and Ayangbile, O. A. (2015). Degradation and depletion of forest resources case study: Oyo State, Nigeria in O. Y. Balogun and K. A. Aderogba (eds.) *Environment, Risks and Management,* Department of Geography and Environmental Management, Tai Solarin University of Education, Ijagun, Ijebu-Ode, pp. 371-388.

Dawson, A. (2001). Activated Charcoal: A Spoonful of Sugar, *Australian Prescriber*. NPS Medicine Wise.Retrieved 19 March 2016.

Egunyomi, D. A. (2008). Continuing Education for Environmental Sustainability in the 21st century Nigeria: Issues and Perspective. *Pakistan Journal of Social Sciences*, Faisalabad, Pakistan, Vol. 3, No. 3, p. 240-244.

Egunyomi, D. A., Aderogba, K. A. and Bankole, M. O. (2016). Unsustainable Exploitation of the Guinea Savannah, South of Sahara: Issues, Policies and Programmes for Sustainability, paper presented at the 2016 Adult Education World Conference, University of Ibadan, Ibadan (July).

Food and Agriculture Organization (2007).Manual on Deforestation, Degradation and Fragmentation using Remote Sensing and GIS.MAR-SFM Working Paper 5 / 2007.

Food and Agriculture Organization (2010).Global Forest Resources Assessment 2010, Country Report, Nigeria.

Food and Agricultural Organization (FAO). (2017). *The charcoal transition: greening the charcoal value chain to mitigate climate change and improve local livelihoods*, by J. van Dam. Rome, Food and Agriculture Organization of the United Nations.

Forest Stewardship Council. (2013). The Increasing Importance of Forests to the Prosperity of People, FSC Contribution to the World Forests Summit, Stockholm, (March).

Lehmann, J. Ed. (2009).*Biochar for Environmental Management: Science and Technology.* London: Stephen Joseph. Earthscan.

Kato, M., DeMarini, D. M., Carvalho, A. B., Rego, M. A. V., Andrade1, A. V., Bonfim, A. S. V and Loomis, D. (2004). *World at Work: Charcoal producing industries in northeastern Brazil.*

Lynette, O. and Wangwe, J. B. (1999).*The Underlying Causes of Deforestation and Forest Degradation*: The Case Study of Mau Forest in Kenya, Forest Action Network (FAN).

Smith, M. and Voreacos, D. (2007). Brazil: Enslaved workers make charcoal used to make basic steel ingredients, *Seattle Times*, January 21, p.17.

Myers, N. 1. (1994). Tropical Deforestation: Rates and Patterns In The Causes of Tropical Deforestation: *The Economic and Statistical Analysis of Factors Giving Rise to the Loss Of Tropical Forests,* (Eds.) K. Brown and D. Pearce, UCL Press, pp. 27-40.

Oderinde, F. O., Eludoyin, O. S. and Ogundele, A. T. (2015). Charcoal production and forest degradation in Ibarapa East Local Government

Area, Oyo State, Nigeria in O. Y. Balogun and K. A. Aderogba (eds.) *Environment, Risks and Management*, Department of Geography and Environmental Management, Tai Solarin University of Education, Ijagun, Ijebu-Ode, pp. 389-415.

Ogundele, A.T., Eludoyin, O. S. and Oladapo, O. S. (2011). Assessment of Impact of Charcoal Production on Soil Properties in the Derived Savanna, Oyo State, Nigeria, *Journal of Soil Science and Environmental Management*, 2 (5):142-146.

Ogunsanwo, O. Y., A. A. Aiyeloja and C. Uzo (2007). Production Technique and the Influence of Wood Species on the Properties of Charcoal in Nigeria, A Case Study of Oyo State, *Agricultural Journal* 2 (1): 131-133.

Tunde, A. M., Adeleke, E. A. and Adeniyi, E. E. (2013).Impact of Charcoal Production on the Sustainable Development of Asa Local Government Area, Kwara State, Nigeria.*African Journal Review*, Vol. 7 (2), 1-15.

Van der Werf, G. R., Morton, D. C., Defries, R. S., Olivier, J. G., Kasibhatha, R. B. Jackson, G. J. Collatz and Randerson, J. T. (2009). CO2 Emissions from Forest Loss, *Nature Geoscience*, Vol. 2, 737-738.

Environmental Education (2008). The Modern Impetus for EE: The Tibilisi Declaration (1977). Retrieved September 27, 2008, from the Global Development Research Center Web site: http://www.gdrc.org/uem/ee/1-4.html

Haugen, C. S. (2006). Environmental Adult Education Theory and Adult Learning Principles: Implications for Training. M.A. Thesis, American University, in Proquest Digital Dissertations

Sumner, J. (2003). Environmental adult education and community sustainability. New directions for adult and continuing education, Fall (99), 39-45.

United Nations Environmental Programme (2008). The Belgrade Charter adopted at the International Workshop on Environmental Education in 1975. Retrieved September 27, 2008, from United Nations Environment Programme Web site: http://portal.unesco.org/education/en/ev.php-URL_ID=33037&URL_DO=DO_TOPIC&URL_SECTION=201.html

World Health Organization (2014). The Significance of Charcoal fire to Health, Washington DC.: World Health Organization

Zulu, L. C. and Richardson, R. B. (2013).Charcoal, livelihoods and poverty reduction: evidence from sub-Saharan Africa. *Energy for Sustainable Development*, 17(2): 127- 137.

