Implications of Biomass Energy Production and Utilization on Sustainable Forest Management in Ibarapa Region of Oyo State, Nigeria

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Abstract

The paper attempts an evaluation of the impact biomass energy production and utilization has on the sustainable forest management in Ibarapa region of Oyo State, Nigeria. Three hundred and fifty respondents randomly sampled from the seven major towns in the region were used for the study. Administration of questionnaire, field observation and oral interview were adopted for data collection. Data collected were analyzed using tables, pictures, model and simple percentage. The study revealed massive production and utilization of biomass energy, mostly fuel wood and charcoal in the study area. The adoptions of these energy types were mainly due to the high cost of fossil fuels and epileptic electric power supply. Negative impact of biomass energy production and utilization on the forest management in the area were manifested in massive deforestation, loss of biodiversity, soil degradation among others. Improvement in power supply, availability of affordable alternative energy sources, afforestation and legislative policies were recommended as mitigating measures against unsustainable forest management caused by biomass energy production and utilization.

Keyword: *biomass energy, deforestation, biodiversity, charcoal, fuel wood, forest.*

Introduction

The continuous increase in the prices of fossil fuels such as kerosene and gas has been a persistent national problem, this coupled with epileptic electricity supply and their attendants hike in tariffs have made biomass energy the popular alternative energy source. According to a UNDP (2004) estimate, 2.5 billion people in the world lack access to modern energy services. Hence, they rely on traditional biomass sources such as fuel wood, agricultural residues, animal dung and charcoal to meet their basic energy needs (WHO 2006). Arms (2008), posited that biomass energy especially fuelwood and

charcoal are the most important sources of energy in the developing countries. However, while the use of fuelwood is predominantly rural affairs, charcoal utilization assumes considerable importance among low income earners in urban centres.

Delmas et al (1991), observed that the total amount of biomass energy utilization in Tropical Africa is estimated at 230 million tons of dry matter per year. Charcoal alone was said to have taken about 11 million tons. The growth of towns and cities in most developing countries of Africa has necessitated the need for more biomass energy burning. The estimation therefore is that for 1% increase in urbanization, there is 14% increase in biomass energy especially charcoal consumption. With persistent poverty in the developing countries occasioned by unemployment and low per capita income, biomass energy production and marketing thus become a mean of livelihood. Hence, many rural dwellers in Tropical Africa have taken to charcoal production and fire wood marketing at alarming proportion as their means of economic emancipation. Similarly, urban dwellers adopt charcoal as alternative to expensive kerosene and liquefied petroleum gas. The heightened and growing demand for biomass energy in Nigerian urban centres, consequent upon the gradual withdrawal of the petroleum subsidy by the government and bourgeoning urban population fuelled by rural-urban migration underscore the need to examine the effects of biomass energy production on the ecosystem especially the forests.

Forests are essential for human survival and wellbeing. They harbour two thirds of all terrestrial animal and plant species. They provide us with food, oxygen, shelter, recreation and spiritual sustenance, and they are the sources for over 5,000 commercially traded products ranging from pharmaceutical to timber and clothing. It is estimated that approximately 60 million indigenous people are almost wholly dependent on forests, 350 million people depend on forests for a high degree for subsistence and income and about 1.2 billion people rely on agro forestry farming system (WHO, 2004). Ecologically intact forests store and purify drinking water, they can mitigate natural disasters such as droughts and floods, they help store carbon and regulate the climate. The health of forests and the provision of these and other forest ecosystem services however depend on the diversity between species, the genetic diversity within species, the diversity of forest types and above all human cautious utilization of forest products. However, it has been observed that utilization of forest resources especially in Africa seriously hinder its ability to effectively perform these roles.

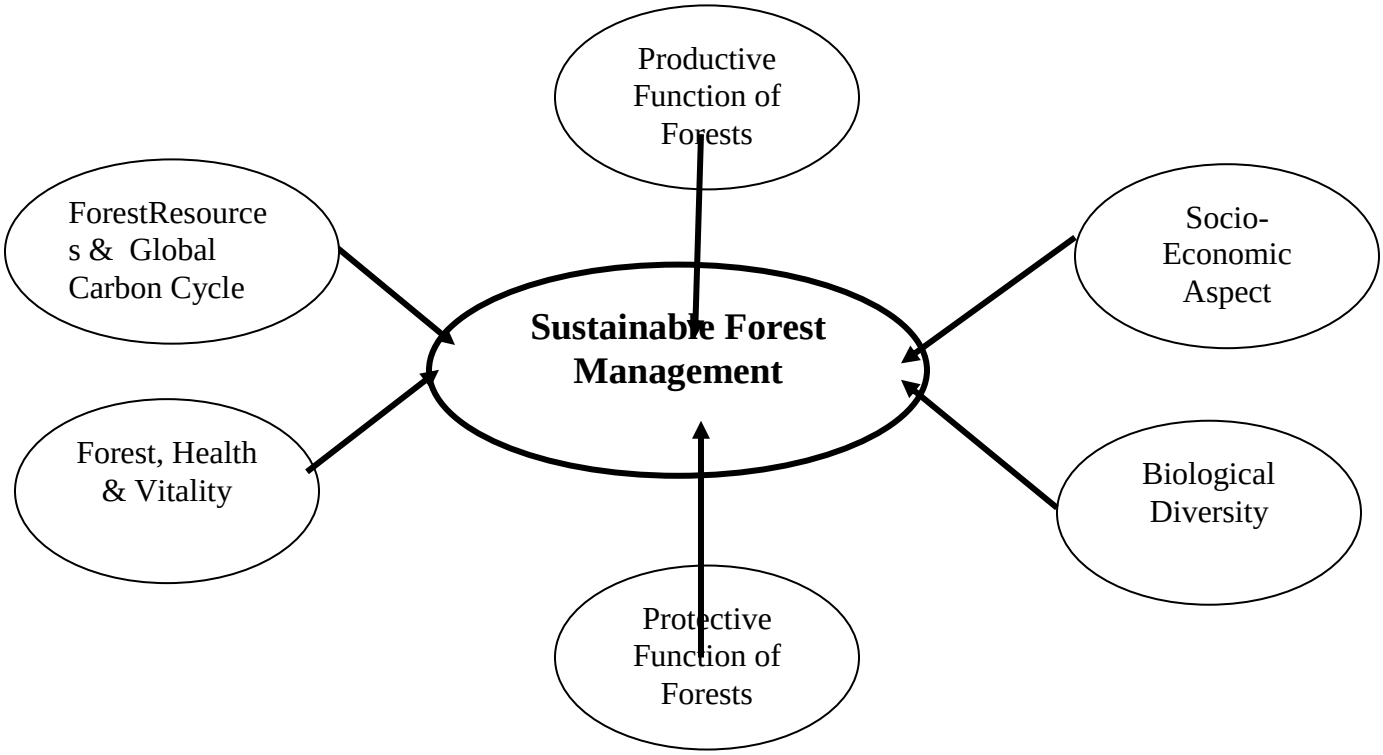
According to FAO (1993) forest area in Africa is decreasing annually at an alarming rate, while the demand for the resources continues to increase. The West African rainforests are especially being depleted. FAO therefore predicted that if the present trend continues the tropical rainforest could completely disappear by the year 2020 due to deforestation induced by fuel wood charcoal production and conversion of forest to other uses. To forestall such calamity, attempt has been made to inculcate sustainable forest management in environmental policies of most African countries.

Sustainable forest management is the process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent value and future productivity and without undue undesirable effect on the physical and social environment (Babalola and Ajayi 2002).

Broadly, sustainable forest management can be defined as the stewardship and use of forests and forest land in a way and at a rate, and maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill now and in the future, relevant ecological, economic and social functions at local, national and global levels and does not cause change to other ecosystems (Ministerial Conference on the Protection of Forests in Europe,2003).

Sustainable forest management integrates five main goals- environment, health, economic profitability, social and economic equity (Figure 1). Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their needs. Therefore, stewardship of national and human resources include consideration of social responsibilities such as quality of populace, the needs of rural communities both in the present and the future. Stewardship of resources involves maintaining and enhancing the vital resources base for the long term.

Figure 1: Criteria and Example Indicator for Sustainable Forest Management



Adapted from Ministerial Conference on the Protection of Forests in Europe, (2003)

Nigeria has developed comprehensive conservation programmes since independence. These range from individual species protection through ecosystem conservation to the wider present day concept of sustainable development of the total environment. (Babalola and Ajayi 2002). The post-independence period has seen a vigorous attempt by the government to promote the ideals of conservation by gazetting a number of reserves and signing a number of international treaties aimed at protecting the environment. Unfortunately, these efforts are been hindered by certain human activities.

Large areas of tropical forest, irrespective of whether protected or controlled by communities are still being harvested unsustainably, if not illegally, through logging, hunting or collection of non-timber forest products. Hence, sustainable development is yet to be achieved. Nigeria has one of the world's highest rate of deforestation of primary forest, (FAO 2004). The consequences of deforestation were so massive that between 1990 and 2005 Nigeria has lost a staggering 79% of its old growth forests (Rainforest Mangaby, 2007). This paper therefore attempts an evaluation of impacts of biomass energy production and utilization on sustainable forest management in Ibarapa region of Oyo State which is noted for massive charcoal productions and fuelwood collection (Ogundele 2012).

Objectives of the Study

The basic tenet of this study is to examine the impact of biomass energy production and utilization on sustainable forest management in the study area. The paper also examines the major biomass energy sources in the area. Methods of biomass energy production and the perception of the inhabitants on the impacts the production processes and utilization have on the forest were also examined. Measures to mitigate the adverse effects of biomass energy production and utilization on the forest management were suggested

Methodology

The Study Area

Ibarapa region is located approximately within Latitude 70^0 20^1 and 70^0 50^1 and Longitude 30^0 00^1 and 30^0 40^1 E. The region comprises of three local government areas namely Ibarapa East with headquarters at Eruwa,; Ibarapa Central with headquarters at Igboora and Ibarapa North with headquarters at Ayete. These three local government areas headquarters with four other settlements (Lanlate, Idere, Tapa and Igangan) constitute the seven major towns in Ibarapa land. The major towns are the administrative, social and commercial nerve centres for numerous smaller settlements. The region as at 2006 has a population of 322, 297 and landmass of about 279, 160 hectares (NPC 2006). Ibarapa region is bounded in the North by Iseyin, Kajola and Iwajowal Local Government Areas, in the East by Ido Local Government Area, in the West and the South by Ogun State (Fig 1)

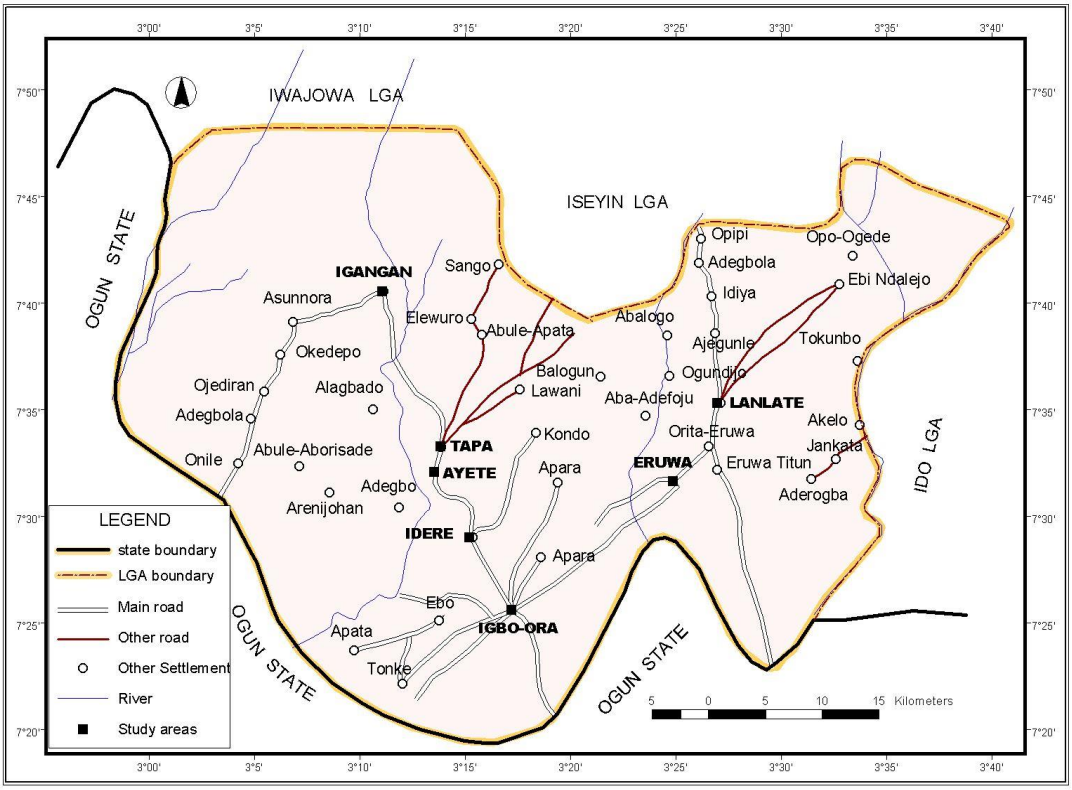


Figure 2: Map of Ibarapa Region showing the sampled Settlements

The climate is of the tropical continental type characterized by high temperature, high humidity and heavy rainfall. Rainfall is of double maxima with two distinct seasons. The climatic features encourage growth of abundant trees especially in the Southern part that share borders with the rainforest, there are also abundant thick undergrowth and luxurious grasses (Ogundele, Aderounmu and Agboola, 2008). The abundant tree species account for vast biomass energy utilization in the area. Felling of trees for agriculture, charcoal production, fuel wood gathering, lumbering, seasonal bushfire and grazing are the major factors of deforestation in the region.

The region is that of undulating highlands with a pocket of undulating plains running into valleys, hills, ridges, inselbergs and rock outcrops of varying height: Major hills include Agasa, Akolu among others. Ibarapa region is mainly drained by major rivers such as Ogun, Ofiki and the most prominent Opeki, other minor rivers are tributaries of these major rivers. The soils of the study area are ferruginous tropical soils. The parent materials are schist and quartzite. Hence, the main soil consists of brown sandy loam overlaying red brown sand-clay.

Farming remains the major occupation of the area due to vast expanse of plain fertile land. Subsistence farming combined with biomass energy production is prominent features in the area. Commercial agriculture is practiced with the establishment of commercial farms which include Obasanjo, Aderupoko Sotionye, Global West and Zartech. Secondary and Tertiary activities within the region include black smithing, block making carpentry/woodwork, textile/cloth weaving, hotel services, teaching, banking,

health services, trading is enhanced by the presence of periodic market, which include Maya, Okolo, Owode, Alapa, Alabi ,Towobowo among others.

Sources of Data and Technique of Data Collection

Data for this study were derived from both primary and secondary sources. The primary data collection instruments included questionnaire administration, oral interview and field observation, the study was limited to the entire major seven towns in Ibarapa region i.e. Lanlate, Eruwa, Igboora, Idere, Ayete, Tapa and Igangan (Figure 1). In each town, fifty respondents were randomly selected making a total of 350 respondents. Oral interviews were conducted for biomass energy merchants, consumers and forest officers. Field observation was very important for this work because it affords on site assessment of the impact biomass energy production and utilization has on the vegetation of the area. Secondary data sources include printed materials, internet and materials obtained from the local government secretariats. The questionnaire was designed in such a way as to elicit enough information based on the objectives of the study. Analysis of the result was mainly through percentages, cross tabulation, pictures and model.

Result and Discussion

Bio Features of the Respondents

Table 1: Bio data of the respondents

Features	**F**	**%**	**Features**	**F**	**%**
Sex			**Educational qualification**		
Male	182	52	Non formal	102	29.14
Female	168	48	Primary	91	26
			Secondary	85	24.57
			NCE/BSc	71	20.29
			MSc	-	-
Total	**350**	**100**	**Total**	**350**	**100**
Age			**Occupation**		
Above 70	-	-	Farming	121	34.57
60 – 69	25	**7.**14	Trading	88	25.14
50 – 59	77	22	Artisan	61	17.43
40 – 49	105	30	Civil servant	80	22.86
30 – 39	65	18.57			
20 – 29	78	22.20			
Below 20	-	-			
Total	**350**	**100**	**Total**	**350**	**100**

Source: Field survey 2015

The socio-spatial and demographic characteristics of the respondents were depicted in table 1 above. Out of the 350 respondents sampled, a total of 182 representing 52% were males while 48% or 168 were females.

Neither of the respondents was below the age of 20 nor above 70, 22. 20% are within ages 20 – 29, 18.57% within ages 30 – 39, 30% within ages 40 – 49, 22% within ages 50 – 59, while 7.14% are within ages 60-69.

The highest educational qualification was NCE/BSc with 20.29%. The highest percentage was 29.14% and represented that without formal education, others are primary education 26%, secondary 24.57%, none of the respondents has master's degree. Larger percentage of the respondents are farmers (34.57%). Traders (25.14%), artisan (17.43%) and civil servant (22.86%).

The above data showed that males are more than females, the respondents were mostly in economic active age and farming remains the most popular economic activities (Ogundele 2012, Ogundele and Ogunjimi 2013).

Biomass Energy Types in Ibarapa Region

Table 2: Biomass Energy Types

Energy sources	**F**	**%**
Palm kernel	90	10.04
Crop residues (Maize husks)	127	14.17
Saw dust	127	13.51
Firewood	230	25.67
Charcoal	328	36.61
Total	**896**	**100**

Source: Field survey 2015

Multiple responses

Table 2 showed the major types of biomass energy produced and utilized in the study area. It was discovered that charcoal and firewood are the most prominent biomass energy types in the area. They constitute 36.61% and 25.67% energy consumed respectively. Others are crop residue 14.17%, saw dust 13.51% and palm kernel 10.04%. Evidences of charcoal and fuel wood production and marketing were visible in the area. Sites of charcoal production with piles of trees cut into wood and stacked into a kiln and kiln burning slowly (Plate 1) are common sight. Similarly, bags of charcoal stores in charcoal depots (Plate 2) , fuel wood lining main roads awaiting buyers (Plate 3) and fuel wood deposited for use at Garri industries (Plate 4) depicted the level of acceptability of biomass energy in the area.

Plate 1: Kiln burning slowly

Plate2: Fuel wood lining the main road for buyers

Plate 3: Charcoal depot

Plate 4: A typical garri industry with fuel wood used in production

Basis of Biomass Energy Production and Consumption

Table 3: Reasons for Biomass Energy Production and Consumption

Factors	**F**	**%**
1. Demand is high	320	16.69
2. Readily available	318	16.59
3. Ready-made market	326	17.06
4. Unemployment	195	10.17
5. Generation of additional income	200	10.43
6. It is cheap	350	18.26
7. High energy density	208	10.85
Total	**1917**	**100**

Source: Field survey 2015
Multiple responses

Table 3 above showed the factors encouraging the production and consumption of biomass energy in the area. It was discovered that charcoal was a very cheap energy source compared to other fossil fuels like kerosene and gas, where a litter of kerosene was being sold for #120, and 3kg of gas for #900 a bag of charcoal is sold for #600 and a bunch of fuel wood starts from #50 depending on size. 18.26% of the respondents agreed that the low prize of charcoal and fuel wood accounted for their popularity as energy sources in the area.

Apart from this, the materials needed for the production of biomass energy were in abundant in the area, with enormous forests resources there is little hindrance to charcoal production and fuel wood collection, 16.59% of the respondents said biomass energy was popular because it is readily available, 17.01% were of the opinion that the availability of market for biomass energy greatly contributed to its production and utilization, Aside household consumption of fuel wood, small scale industries such as

Garri industries seriously demanded for it. (Plate 4) Apart from those who are involved in retail marketing, most periodic markets in the study area had sections dedicated to charcoal trading (Ogundele 2012). In addition operators of charcoal depots (Plate 3) revealed that apart from selling their product at cities in Nigeria, substantial part of their products are being exported to middle East, Asia, America and Europe.

Furthermore, the higher density of biomass energy sources especially charcoal which is more than other fossil fuels was said to accounted for its popularity in the area (10.85%).In addition to this it can be easily stored, has excellent cooking properties burns evenly for a long time and can be easily extinguished and re-heated (Ogundele 2012).

The study also revealed that most people involved in the production and marketing of charcoal and firewood sited unemployment (10.17%) as the major reason for their involvement. As a result of the parlous state of the Nigeria economy which is characterized by high rate of unemployment people in the rural area see biomass energy production as a mean of livelihood. Interview conducted for marketers revealed that apart from agriculture and marketing food products, charcoal marketing remain one of the lucrative business ventures in both rural and urban centres in the area.

Similarly, others (10.43%) agreed that biomass energy production also complement the income they obtain from their major occupations especially farming which is subsistence in nature (Ogundele 2012). In addition artisans who required electricity for their works have embraced biomass energy production to supplement their insufficient income as a result of epileptic power supply.

Biomass Energy Production

Table 4: Methods of Production of Biomass Energy Types

Energy types	**F**	**%**
(a) Charcoal		
i. Earth pit kiln	35	10
ii. Earth mound kiln	315	90
iii. Others (Casamance, brick kiln)	-	-
Total	**350**	**100**
(b) Fuelwood		
i. Felling of trees with cutlass	285	81.43
ii. cutting with chain saw	65	18.57
Total	**350**	**100**

Source: Field survey 2015

Table 4 showed the methods adopted in production of biomass energy. The two major sources of biomass energy were examined. Traditional methods of charcoal production like the earth pit kiln and the mound kiln are widely used in the study area. This is similar to the founding of Ogundele (2012). Of all the two methods, the earth mound was the most popular with 90%. Other efficient methods of charcoal production such as casamance, brick kiln, metal chimney and Adam retort were not used in the area.

Similarly, fuel wood production involved the use of cutlasses and chain saw to gather woods which in most cases are fresh woods which are sun dry on the field. Felling of trees with cutlasses was common with 81.43%. The use of chain saw (18.57%) was less popular this may be probably because of the cost of the machine.

Field observation showed that the major raw materials for both biomass energy types are trees (which are of different species). The first step in both energy productions involved the felling of trees. This was done manually by the use of cutlasses and axes only few of the producers agreed to the use of chain saws. In most cases trees are cut to the surface of the ground, this coupled with lack of selective cutting seriously reduce chances of vegetation regeneration. Gathering of woods is followed by drying in case of fuel wood production (where fresh woods were involved) while in the case of charcoal production stalking of wood in kiln and carbonization followed wood gathering. After harvesting fuel wood and charcoal are sold to consumers.

Table 5: Impact of Biomass Energy Production and Utilization on Forest Development

Impact	**F**	**%**
1. Deforestation	350	22.71
2. Loss of biodiversity	350	22.71
3. Increase in temperature	185	12.01
4. Atmospheric pollution	297	19.27
5. Depletion of soil	205	13.30
6. Loss of watershed protection	154	10.00
Total	**1541**	**100.00**

Source: Field survey 2015

Multiple responses

The impacts of biomass energy production and utilization on forest development are depicted in table 5 and figure 2. It should be noted that while most of the impacts such as deforestation, loss of biodiversity and depletion of soil have direct influence on vegetation development others have combined effects (both direct and indirect) on vegetation (CBD, 2010; Chidumayo, 2011; Ogundele 2012).

The impact of biomass energy production and utilization on forest management in the study area was mostly felt in terms of deforestation and loss of biodiversity each factor received the support of 22.71% of the respondents.

Personal observation and responses from the respondents (22.71%) revealed that deforestation in the area was mainly due to production of biomass energy most especially charcoal and fuel wood. The methods adopted in production of charcoal and fuel wood was not environmental friendly. The manual cutting of tree species for fuel wood and charcoal was mostly used in the area. Trees are cut to the surface of the ground and there was no selective cutting of trees. Even forbs, herbs and thick undergrowth that serve as protective shield for the soil are not spared as they are cleared and used as combustible materials during charcoal making. Prominent forest reserves such as Igangan and Otuma in Ibarapa East Local Government Area and Ibarapa North Local Government Area respectively were not spared of this human intrusion. Heavy off take of wood for fuel and

charcoal has converted once closed forest and open forest to scrubland or savanna (Ogundele, 2012). It was also observed that grasses on which cattle grazed are been seriously depleted.

Consequences of these deforestation activities is the loss of biodiversity (22.71%) several plant and animal species have been depleted, plant especially with edible seed, nuts and kernels are becoming extinct in the area. Trees such as shear butter and locust bean which are mostly used in charcoal production are been depleted at alarming proportion. Similarly, animals especially rodents,, rabbit, grass cutters which are common to the area are been endangered through habitat destruction. Crops and plant species such as algae, and mushrooms which are edible are now aliens to the younger generation in the area, so also is the cultural values associating with forest resources eroded, for instance medicinal herbs, wild fruits and honey which are sources of live hood for some people are drastically reduced if not eliminated. Ogundele 2012 associated persistent poverty in the area to these conditions.

Another in direct impact of biomass energy production and utilization on forest is the depletion of soil, (13.30%) this was manifested in soil erosion and degradation of topsoil as a result of land exposure after tree clearing for fuel wood and charcoal. The loss of forest cover has been cited as one of the major reasons for soil erosion (Anantha 1996; Ogundele 2012). The surface and the earth pit kiln system of charcoal production, as well as the annual cutting of trees to the surface without replacement adopted in the area exposes the soil to agents of denudation and at the same time damaged the topsoil. The carbonization processes involved in charcoal production have been caused serious alteration of the physical, chemical and biological properties of the soil (Ogundele, Eludoyin and Oladapo, 2011). In addition rainfall runs-off soil that have been hardened by exposure much faster than before, the most fertile top layer of soil that can support forest regeneration is therefore greatly reduced and this may persist for so many years since rapidly eroded soil is not replaced within a human generation.

Atmospheric pollution (19.27%) and increase in temperature were also identified by the respondents to have negative impacts on the forest management in the area. Charcoal production and utilization of fuel wood involved carbonization which results into emission of gases like carbon monoxide (CO) methane, carbondioxide (CO_2) among others. These situations have been accredited with global climate change and global warming. Ogundele 2012 was of the opinion that the fact that there was no data to quantify the extent of these gasses in Ibarapa region does not mean they are in-existence or negligible. Evidence from the field survey revealed pollution of the environment through charcoal production and fuel wood consumption. Kiln sites visited are still emitting smoke (Plate 1) while charcoal particles are carried by wind several kilometers. This was noticed around charcoal depots and warehouse (Plate 2). The incidence of temperature increment or global warming and climate change have contributed severally to forest loss in sub-Sahara Africa and all over the world. 10% of the respondents agreed that loss of watershed protection can also be attributed to the production and consumption of biomass energy. According to Anantha (1996), forest especially tropical forest serve as important water catchments areas, and loss of forest cover affect the hydrological cycle. For example Salati (1985) estimates that as much as 75% of the yearly rainfall in the Amazon Basin is returned from the forest to the atmosphere and loss of this forest cover could reduce future rainfall. Though, the actual relationship between forest cover and

rainfall is yet to be determined in Ibarapa region, the global impacts removal of forest cover have on hydrological cycle and the impact of reduce rainfall amount on vegetation has been documented by researchers. (Mfon et al 2014; Sioli, 1985; Akachuku ,2007).

Mitigating Measures against Biomass Energy Production and Consumption Induced Forest Degradation

Table 6: How to Reduce Forest Encroachment Cause by Biomass Energy Production and Consumption

Item	F	%
1. Reduction in prizes of convectional fuels	350	23.49
2. Creation of more forest reserves	185	12.42
3. Legislation	320	21.48
4. Afforestation programmes	350	23.49
5. Rain forest management	285	19.12
Total	**1490**	**100.00**

Source: Field survey 2015

Multiple responses

Table 6 showed the suggestions offered by the respondents as mitigating steps against the forest degradation induced by biomass energy production and utilization. Reduction in prices of fossil fuels such as kerosene and cooking gas (23.49%) was acknowledged by all the respondents as a major mean through which biomass energy consumption and its attendant negative impact on the environment can be reduced. In addition to this, is the needs to ensure regular power supply, this will not only lead to the increase in generation of cooking energy through electric cooker but also encourage utilization of eco-friendly energy.

Furthermore, afforestation programmes were also suggested to be a major factor in reducing negative impact of biomass energy consumption on forest resources. Such programmes include tree planting campaign, establishment of forest plantations to provide fuel wood and sawn timber.

Though forest reserves abound in Ibarapa region, those reserves are been encroached by the residents. 12.42% of the respondents believed establishment of more forest reserves would prevent degradation of forest by the residents.

Government policies especially in area of regulations of people interaction with forest are in operation in Nigeria. It has been established that most of these policies especially legislation against forest encroachment were not adequately enforced. If these regulations could be enforced with all seriousness its required there is no doubt that sustainable forest management would be achieved.

Forest management (19.12%) methods include enrichment planting, tropical shelter wood system, taungya system, malayan system among others were also suggested to ensure sustainable forest management in the area.

Conclusion

Energy is essential for socio- economic, human and technological development in the study area. Fuel and charcoal remain the dominant energy source for most households as it is locally available. However, this has had grievous consequence on sustainable forest management in the area. Finally, it's important to point out that reaching toward

the global goal of sustainable forest management is the responsibility of all actors in the system, including foresters, farmers, policy makers, researchers, consumers and marketers. Each group has its own parts to play in strengthening of sustainable forest community.

Recommendations

1. The private sector and NGO's should be encouraged to participate in biodiversity conservation through grants and tax rebates
2. Agro forestry should be encouraged and sponsored in the area, this will not only increase wood supply for charcoal production but will also prevent indiscriminate cutting of trees and hereby ensuring conservation of trees on sustainable yield basis
3. There is need to minimize biomass energy utilization rates through the development of alternative energy sources most especially fossil fuels (Kerosene and gas) as well as electric supply
4. Researches should be embarked upon by foresters with the view to developing fast growing tree species as well as those resistant to fire outbreak
5. Environment rehabilitation programmes such as erosion control, biodiversity resaves, soil conservation, and tree planting should be given priorities by governments.
6. Environmental laws including forest utilization regulation rules should be fully enforced and implemented in order to serve deterrent to defaulters
7. More forestry personnel should be employed and properly trained to police the forest in order to reduce deforestation.

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