

# Analysis of Forest Waste Management and Recycling Potential in Nigeria

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## Abstract

Forest wastes are renewable resources that can serve as sources of energy for heat and electricity generation. How these materials are managed in order to reduce their contribution to the release of greenhouse gases, reduce subsequent climate change challenges and their potential use in bio-energy production has remained a myth in Nigeria. In this paper, extensive review of the literature was carried out to arrive at the findings. More than 93% of all wood processing industries in Nigeria are sawmills. In addition to sawmills there are the plywood mills, furniture processing industries, and particleboard mills. Sawdust is the major waste generated from wood processing in the various processing units. Currently, the most popular waste management practice in Nigeria is burning. Dumping in open spaces, riverbanks, and water bodies is also obtainable. There is no record of wood waste recycling for bio-fuel production at the moment. Wood wastes are reused for agricultural production (mulching, manure) and as firewood. These actions contribute to the release of greenhouse gases and subsequently contribute to global warming. There are policies and agencies put in place to address this menace but implementation is a problem. An increase in proper waste management education and awareness, and aid from developed countries in terms of providing the technology needed for recycling and incineration, will go a long way in ensuring the safety (from climate change and consequences) of the local people, the environment, and the world at large.

## Keywords

Forest Waste, Nigeria, Bio-Fuel, Waste Management, Wood, Biomass, Bio-Energy, Climate Change, Global Warming

## 1. Introduction

Nigeria has a land area of 356,669 mi<sup>2</sup>, about 34,907 mi<sup>2</sup> are covered by natural forests [1]. According to Global Forest Research, Nigeria lost 3,776 mi<sup>2</sup> of her natural forest in 2020, a loss equivalent to 59.5 mt CO<sub>2</sub> emissions [2]. Forest wastes from this huge loss in living natural forest in Nigeria have not been accounted for over the years. Forest waste in this study includes; forest residues such as logging residues, thinning from forest and timberland, residues from processing mills and urban forest wood wastes. Logging residues are made up of tops, cut branches, dead trees, small trees, non-commercial trees, rough or rotten trees. Prior to this age, forest wastes such as logging residues were discarded, presently, these materials are sourced and utilized as feed-stock for bio-energy production. Forest wastes may have some functions in the forest. Functions which are definitely not economical but have ecological advantage. Some dead woody wastes are left on forestland purposely for the above reason [3]. Organisms such as mosses, fungi, bacteria, liverworts, ferns, regenerative plants, reptiles, amphibians, birds use the materials as their habitat. Wood wastes decay and contribute to improvement of soil structure and texture. Dead logs act as nursery for seed germination and stand establishment. Additionally, forest wastes enhance nitrogen fixation and add nutrients to the soil when cycled. Due to the ecological benefits of woody residues, some states in the United States of America advocate for some percentage of logging residues to be left onsite. In Maine, Minnesota, Pennsylvania, Missouri, the recommended retention rate is 20%, 20%, 15% - 30% and 33% respectively [3]. In urban forests, forest wastes may include the municipal solid wastes (MSW) generated by humans who visit the park for aesthetic or recreational purposes. In Nigeria, it is estimated that largest cities such as Lagos, generate about 295,650 tons of wood waste annually, 489,100 tons per year in Abeokuta, Ogun State, and generally 250,640 tons of wastes per day. Indiscriminate deforestation, poor policy implementation may be the reasons for these amount of wastes released per day. This has resulted in open burning, dumping in water bodies, or dumping in open locations, all of which pollute the environment [4]. Wood wastes generate green house gases, expose humans to various health risks, endanger both lives on land and in water and render the ecosystem unsustainable. Wood chips left to dry naturally emits 136 kg CO<sub>2</sub> equivalent per tonne in half a year [5]. The need for proper management strategies and efforts to mitigate these risks through recycling are therefore essential. This study used available literature to examine the strategy employed in forest waste management in Nigeria and as well describes the recycling potential of the wastes for bio-energy production. Information was retrieved from journals, reports, books for the review-research study. The objective of this study was to ascertain forest waste management practices in Nigeria.

## 2. Literature Review

Wood serves various functions, it is praised as the most multipurpose raw ma-

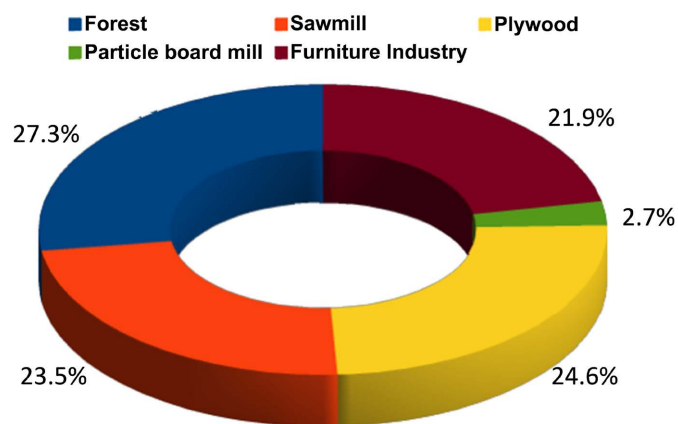
material in the world [5]. It contributes to the achievement of most of human basic needs-food, shelter, electricity generation. Being multipurpose makes waste generation in large amount possible. Wastes lead to loss of aesthetic, environmental degradation through emissions and keep the atmospheric air saturated with unpleasant odour. Any material that has been utilized and is no longer required because the valuable or useful element has been taken is considered waste [5]. Some wastes from the wood industry are solid, whereas others are soluble or solvent. Waste refers to resources that are left over from the manufacturing process that are deemed unusable for a major purpose. Forest and wood wastes obtainable in Nigeria include branches, leaves, stumps, roots, low-grade and decayed wood, bark, sawdust, trimmings, split wood, planer shavings, sander dust, screening fines, panel trim, wood pallet, and furniture wastes.

### 2.1. Sources of Forest Waste

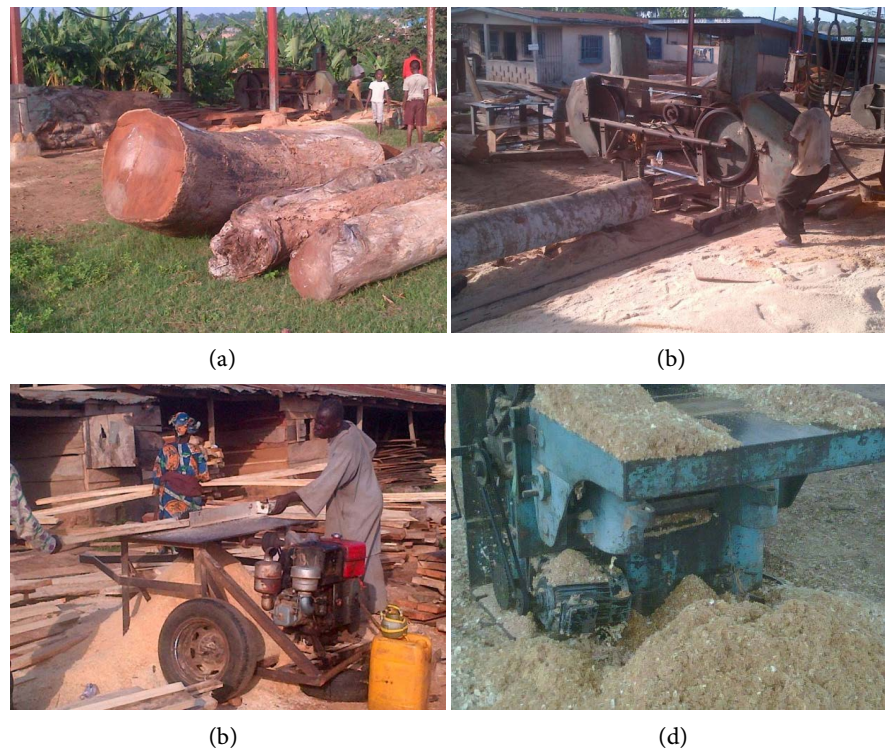
Wood wastes are wood fragments and particles produced by industrial or small-scale wood processing industries, construction and demolition activities, and decomposed wood products. Bark, scrap lumber, sawdust, building and demolition wastes, off-cuts, ash from the burning of wood wastes, and broken furniture are all examples of common wood wastes [6]. During the processing of wood, waste is generated in several sectors. This includes sawmill waste, furniture waste, and plywood waste, as these industries are directly involved with the use and conversion of timber into consumer-oriented products. **Figure 1** shows the various sources of forest waste and the average percentage amount generated by each sector.

Round-woods which serve as feed-stock for industries are mostly sourced from Edo, Cross River, Ogun, Ekiti, Osun, Oyo, Ondo and Osun states, all in the southern part of the country [7].

In the sawmill sector, wood must be turned into a variety of sizes in order to maximize profit while also meeting the needs of the public. **Figure 2** below, shows a small-scale workshop usually called “timber shade” where wood products and wastes are generated from logs of wood in Nigeria.



**Figure 1.** Sources of forest wastes; modified from [8].



**Figure 2.** Wood processing and wood waste generation in a timber shed. Photo credit: [9].

The first pit-sawing facility was established in Nigeria in 1782 [8]. As the need for lumber (sawn wood) continues to rise, more sawmills have been built since then. It may be agreed that areas with high forest reserve and hence vulnerable to logging contribute greatly to forest waste generation. The graph below (**Figure 3**) shows the amount of wood waste production per day from cities in south western Nigeria. The vast majority of forest in Nigeria is seen in this region. The southeast has been reported to have total forest cover lower than the recommended for every region by FAO [10].

Aside wastes from processing, other forest wastes seen in Nigerian forests include branches, leaves, stumps, roots, low grade and decayed wood, slashing, bark, yard trimmings. Unlike the assertion of [12] about urban forest waste being a term used to collectively refer to logs, brushes and chips produced/generated during arboricultural activities in the urban areas, forest waste in this paper is used to refer to wastes generated in the forest (naturally—branch fall, decaying trees), logs, chips, yard trimmings as well as wastes from forest resource processing (sawdust, wood shaving etc). This is because the idea of urban forestry is new in Nigeria and literally does not differ from the typical forest to an average citizen.

## 2.2. Classification of Forest Wastes

Forest waste (urban) can be classified based on the quality of the waste material into Higher quality waste (Hqw) and Lower quality waste (Lqw) [12]. Sorting



**Figure 3.** Wood wastes generated in Southwestern Nigeria, data adopted from [9] [11].

into these categories will ensure efficiency and lead to production of best materials from each category during recycling. Forest waste characterization examines various waste components and is an essential component of any waste management program. In order to fully treat wastes and put them to efficient use, waste technology developers must examine the quality of the wastes [13]. Thus, Hqw produce higher quality products and as such Lqw produce lower quality products. Higher quality products generated from Hqw (logs) include veneer, furniture, cabinetry, art works; lumber, pallets, packaging crates and firewood from Medium quality (logs) wastes while mulch, compost, biomass and pellets are products of Lqw (chips and brushes).

In terms of wood waste, there are clean wood waste and contaminated wood waste as explained in [4]. Scrap lumber, sawmill ends, plywood, and wood used in concrete with fewer than 2-inch diameter residual concrete chunks on it are examples of clean wood waste. Nails, bolts, and screws can be found in large amounts in clean wood. Telephone poles, treated wood, and wood with tar are not considered clean wood waste, as they include paint, oil, or Styrofoam. Note that paint and other pollutants in wood debris can be recycled as construction and demolition waste. Wood that has been painted or coated, wood from building, furniture, are examples of contaminated wood waste.

### 2.3. Forest Waste Management Practices in Nigeria

The USDA Department of Forest Service employs incineration, landfills, composting and recycling in the management of solid wastes [14]. Both wood and yard trimmings are classified as solid waste by the US Environmental Protection Agency [14]. In the state of Virginia, from 2010 till date only 8% of yard trimmings went to landfills the rest were composted. However, the most popular forest waste management practice in Nigeria is burning [5]. Wood wastes are collected and used as fuel for cooking (firewood) and for heat production in many Nigerian homes. Farmers living close to sawmills collect sawdust and wood shavings for use as bedding in their poultry farms (Figure 4); [6]. Crop farmers make use of wood chips and wood shavings for mulching. The above strategies are seen as disposal method rather than management practices [8].



**Figure 4.** Wood waste collection by residents. Photo credit: [6].

A large amount of the waste that wasn't utilized or collected by farmers and residents are burnt in an open space in order to make space for fresh wastes. Closely following burning is dumping. Wood wastes are dumped in open spaces, river banks and in water bodies (**Figures 5(a)-(d)**) [15]. This unequivocally shows the extent of concern for environmentally friendly practices and the extent of the awareness of climate change impacts arising from this sector. All the management practices obtainable in Nigeria contribute adversely to human health (respiratory issues) and the ecosystem (unfavourable climate, loss of biodiversity) and hence do not ensure sustainability.

## **2.4. Major Constraints in the Participation of Stakeholders in Forest Waste Management**

### **2.4.1. The Attitude and Behaviour Gap**

This includes the perception of people in relation to waste and waste management. Some people, such as waste pickers, see “waste” as a resource or a source of income in a job market that is otherwise scarce [16]. On the other hand, in the developing world, majority of people regard waste as a burden and a problem that must be addressed [17]. Convenience, social norms, lack of public participation, and a lack of education and awareness of effective waste management techniques are all factors that contribute to this attitude-behavior gap [17].

### **2.4.2. Lack of Education and Awareness**

Another major constraint seen in developing countries is a lack of education and awareness about effective waste management practices. Even though citizens in Nigeria may be aware of recycling and other sustainable waste-management techniques, this does not always translate into participation in pro-environmental activities such as recycling initiatives. They appear to have not embraced waste management reforms amid their knowledge of such activities. Therefore, knowledge of waste management practices does not translate to practice.



**Figure 5.** (a-d) Wood waste-wood shavings (a), sawdust (b & c) dumpsites and, off cuts, wood chips, bark (d) in a sawmill. Photo credit: (a & b) in [14], (c & d) [6].

#### 2.4.3. Financial Constraints

Budgetary constraints are common in underdeveloped countries where resources are scarce and expenditures are distributed inefficiently. Due to financial constraints, many towns are struggling to attain appropriate service quality and coverage.

#### 2.4.4. Inadequate Service and Operational Inefficiencies

Another important set of issues towns have in providing proper waste management practices is insufficient service coverage and operational inefficiencies of services, which include inexperienced workforce. In cities in the developing worlds, municipal solid waste as well as forest waste collection operations typically serve only a small portion of the population. Low-income earners living in urban and rural regions are most likely to be without waste collection services [7]. One of the key reasons is a lack of financial resources to deal with the growing volume of waste generated by urbanization.

#### 2.4.5. Limited Utilization of Waste Reduction Facilities

Here, the constraint is infrastructure. Limited recycling program usage is frequently cited by researchers as a major infrastructural challenge in sustainable waste management. The absence of “visible” recycling centers and receptacles was found to impede participation in recycling activities in research conducted

in Botswana. Lack of access to recycling facilities was identified as a primary reason why households in poor nations do not recycle [7].

#### **2.4.6. Lack of Policy Enforcement and Responsibility**

The issue is often not the environmental regulation itself; some developing countries have more refined legislature than developed countries. However, the absence of enforcement is the true obstacle to long-term waste management [18]. The failure to enforce regulations and laws is a fundamental institutional problem that contributes significantly to the mismanagement of solid waste in underdeveloped countries. Kenya is a good example; while having adequate waste management legislation, local governments lack the capacity to apply it [18].

### **2.5. Forest Waste Management Policies in Nigeria**

Forest waste management has become a global issue that every government in the twenty-first century has demonstrated uncommon determination to address particularly when it comes to public health and environmental laws [16]. This is owing to ongoing economic growth, urbanization, and industrialization, which has resulted in a rapid increase in the volume and types of solid and hazardous wastes [16]. The Federal Environmental Protection Agency (FEPA) was established in 1988 to address Nigeria's growing concern about municipal and forest waste management. FEPA's vision for 2010 was to address environmental issues in the country in order to achieve sustainable development while the goal for solid waste management is to "achieve at least 80% successful management of the volume of urban solid waste produced at all levels and guarantee ecologically stable management" [19]. The Niger Delta Development Commission (NDDC), the Ministry of Environment, and the Federal Environmental Protection Agency (FEPA) are among the institutions in charge of environmental management in the country. Environmental agencies at the state level include the State Environmental Protection Agency (SEPA) and the Ministry of Agriculture and Natural Resources, while environmental agencies at the local level include the Department of Community Development and the Department of Agriculture and Forestry. Often, these government institutions have admirable objectives and initiatives, but many of them fail due to financial and management issues [20]. Apart from Lagos State, which has commercialized waste management strategy, other states operate at a lower level. Source of income from wood wastes is insignificant, many of the processing industries urge villagers to pick wood waste for free or pay a certain small amount just to get rid of the wastes and their inconveniences. Other states, on the other hand, continue to consider waste management as a social service, and as a result, rather than earning cash for the state, the state spends a large portion of its revenue on waste management [19]. Given the negative health consequences of improper waste management, legislative measures that promote proper waste management could be beneficial to city residents. Reduced infectious illness rates and mortality, as well as a better qual-



ity of life and attitude to life, are all possible benefits of a clean environment [21]. In Nigeria today, waste generation and its possible implications on human and environmental health, as well as the urban landscape, have become a perennial theme [21]. All parties concerned with the safety and aesthetics of our environment must be aware of the harmful repercussions of nucleated solid wastes, which can be found in residential areas and many other parts of cities. In our urban environment, these solid wastes have become commonplace. The fact that Nigerian cities are overwhelmed with both municipal solid and forest waste is no longer news [22].

## **2.6. Nigerian Population in Relation to Effective Waste Management**

The rate at which resources are exploited is determined by the human population and the level of technology available. As environmental raw resources are mined using various methods and industrially turned into various sorts of finished products used by humans, a slew of harmful by-products are created, degrading the quality of man's surroundings. Population-dependent rates of exploitation, production, and consumption necessarily dictate the rate of generation of environmental externalities in the form of toxic compounds that damage the environment—the air, water, and land [23]. This material is eventually disposed of in municipal landfills, which, due to poor and incompetent management, have become sources of environmental and health hazards. One of the main aspects of concern is the pollution caused to the earth; be it land, air and water [24].

## **2.7. Forest Wastes and Its Effect on Quality of Life Includes the Following**

### **2.7.1. Environmental Effects**

Air pollution, which includes odour, smoke, noise, dust, and other factors, is one of the most significant environmental consequences of the anthropocene era. Flooding and land damage can result from improper waste disposal due to clogged drains. In many places in Nigeria, flooding is a common occurrence. Floods are typically caused by severe, high-intensity rainfall combined with poor watershed management. Flooding can be caused by human activities such as unplanned rapid development, improper waste disposal, land use change for agricultural purposes, inadequate dam construction, and deforestation, among others.

### **2.7.2. Health Effects**

Decaying wastes attract disease carrying insects. Flies carry pathogens on their bodies and legs and expel them on food and damp surfaces. Mosquitoes breed in stagnant water in clogged sewers, as well as cans, tyres, and other rainwater collection containers. Rats spread diseases like typhus, salmonella, and leptospirosis. Glass, razor blades, nails as well as tissue damage or infection via inhalation, ingestion, or skin contact, and parasite infestation and infected cuts from skin

contact with wastes, are among the hazards that refuse workers encounter. Inhalation of gases or carbon released during burning of wastes can cause respiratory tract damage, asthma and weakening of immune system.

### **3. Methodology**

Nigeria is a country in West Africa popularly referred to as the giant of Africa with a population size of over 200 million and a land area of about 351,650 sq. Miles [1]. The northern part of the country is dry however the southern part receives annual rainfall amount of between 1500 - 2000 mm [25]. The climate ranges from humid, sub-humid to semi-arid from south to north. The abundance rainfall in the south creates an enabling environment for engagement in forestry and agricultural activities by the populace. Forestland in the country is estimated to cover 11.1 million hectares while other wooded land measure up to 5.5 million hectares [26]. This study uses existing literature to examine forest management practices in Nigeria and estimate bio-energy production potential of forest wastes.

### **4. Result and Discussion**

#### **4.1. Effective Forest Waste Management and Sustainable Development**

Landfill is the cheapest and most straightforward method of waste disposal. It is one of the major waste management methods in the United States. Sustainable development is defined as development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs [27]. The benefits of sustainable waste management practices cannot be overemphasized. To dispose off urban solid waste originating from forests, a variety of ways are employed. Some of the procedures used include land-filling, incineration, composting, anaerobic digestion, and recycling [28]. Although incineration is rarely used in Nigeria, open dumping in any available open space is the current practice of urban or municipal waste management. Incineration is occasionally employed in Nigerian hospitals to burn pharmaceutical waste on a small scale [28]. Waste disposal in a landfill is the cheapest and most straightforward option. Some of the primary issues confronting and militating against effective waste collection and disposal management and development in various parts of Nigeria include, but are not limited to: 1) Population growth. 2) People's waste disposal habits 3) Work attitude of those rested with the responsibility of collecting and disposing wastes 4) Inadequate equipment, plant, and other tools required 5) Corruption. Other setbacks in effective waste management of environmental initiatives include variety of bureaucratic bottlenecks, a lack of political will, and a lack of continuity of programs and policies [27].

#### **4.2. Resource Recovery and Recycling**

Incineration and conversion of waste to energy is not yet practiced in Nigeria

[29]. In Lagos, MSW gotten from forest is not treated but transported straight to the ultimate dumpsites for disposal [30]. There are two incinerators located along Oshodi-Apapa Express Way and at Ebute-Meta which have never been used, leading to the treatment of MSW by open mass burning at the dumpsites as a volume reduction measure [30]. The situation is the same in Abuja as collected MSW is transported straight to the disposal sites. In Port Harcourt, the only form of treatment done on MSW is open air burning at the final disposal site in order to reduce volume [27]. The situation is the same in Bauchi where MSW treatment is predominantly by open burning at the dumpsite. Similarly, there is no form of treatment for collected MSW in Enugu. Across the country, burning of forest wastes at dumpsites for volume reduction; and refuse burning at individual homes of confidential documents, old furniture, and firewood is a common practice. This open burning has adverse effects on the environment however, little progress is being made to tackle the root cause of the problem. Considering the high percentage of organic matter component of municipal and forest waste in Nigeria, a private company, Earth Care Nigeria Ltd, set up a composting facility in Odugunya, Lagos State to produce compost from waste for agricultural use [30]. In addition, an integrated waste recycling and treatment plant has been established in Akure, Ondo State. The sorted recyclables are processed, sorted organic fraction of MSW is composted (aerobic decomposition) to produce compost—a stabilized organic fertilizer; sorted plastics are shredded to smaller particles and are converted to pellets and the pellets sold out to companies in Lagos, Anambra and Oyo for use as secondary raw materials. Additionally, sorted scrap metals are melted in a furnace and used to produce manhole and pipe couplings cast-iron products.

### **4.3. Waste Ultimate Disposal**

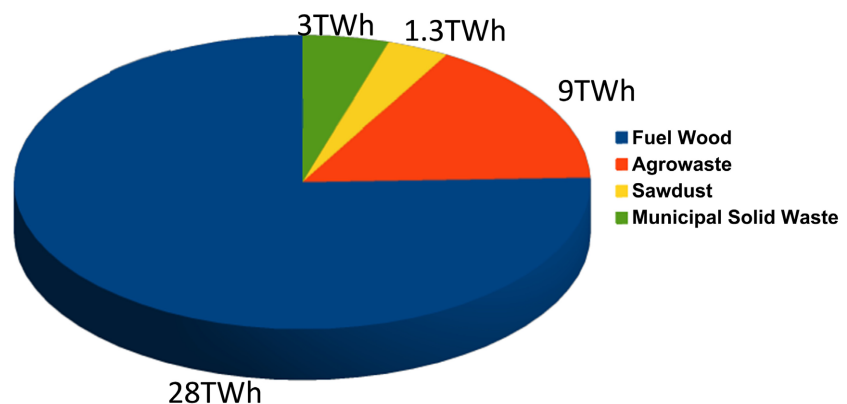
In Nigeria, wastes are typically disposed off in open dumps or uncontrolled landfills, as in most underdeveloped countries. Dumpsites can be found alongside or next to major highways [28]. There are no sanitary landfills for waste disposal in Abuja, the Federal Capital Territory. Wastes are collected formally from Abuja's central districts and carried to dumpsites at Mpape, Suka, and Guzape. The ultimate disposal of wastes at these dumpsites is the responsibility of private companies, while dumpsite maintenance is the duty of the government. There are eight dump sites in Lagos [28], including Oloshosun, Agege (operational), and Iyana-Iba (no longer in use).

### **4.4. Biofuel Production Potential from Wood Waste**

Due to the abundance of biomass resources in Nigeria, the potential production of bio-fuel from these resources has been estimated to be feasible and at same time high [15]. Nigeria like other developing countries faces the issue of poor electricity supply. Oil contributes greatly to the GDP of the country. However, with the rising interest and advocacy for climate change mitigation strategy and

sustainable development, climate friendly actions and in a bid to reduce inconveniences and risks posed by these wastes, there's been a shift to green energy hence bio-fuel stands as a potential remedy. Of the four biomass resources (fuel wood, agro-waste, sawdust and municipal solid waste) abundant in the country, forest resources (fuel wood, agro-waste) have the highest bio-energy generation potential (**Figure 6**).

**Bioenergy/Biofuel Generation Potential in Nigeria According to Biomass**



**Figure 6.** Bio-energy generation potential in Nigeria, data adopted from [9].

Nigeria has a total estimated value of 7 million tons per year of wastes from sawdust and other forest wastes. Interestingly [15] has speculated that 1.8 million tonnes of the total estimated waste which is comprised of sawdust can generate a whopping 1.3 TWh (Trillion Watt hour) of electricity.

## 5. Conclusion

Many countries have finally recognized and understood the impact of poor forest waste management practices on the natural environment in recent years. In these countries, approaches to developing sustainable forest waste management, particularly those that integrate social, economic, and environmental systems, are gaining traction. In developing countries, particularly Nigeria, forest waste management is rarely integrated, and there is often no clear assignment of responsibilities for tasks and schedules among the organizations involved. There is often no umbrella organization to coordinate overlapping responsibilities for waste management that involve more than one agency. This situation not only hinders the effective implementation of forest waste management operations, but also produces confusion in relation to technical cooperation and the development of projects among stakeholders.

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### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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