IMPACT OF BIOENERGY IN ILORIN SOUTH LOCAL GOVERNMENT AREA OF KWARA STATE, NIGERIA

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Abstract
This study investigated sustainable bioenergy production from wood biomass in Ilorin South Local Government Area of Kwara State, Nigeria, focusing on available biomass resources, awareness levels, and perceived challenges to utilization. A descriptive survey research design was adopted. The population of 126 respondents, comprising 39 sawmill workers and 87 carpenters registered under the Ilorin South Carpentry Association. Data were collected using a structured instrument developed by the researcher. The questionnaire was organized into four sections and measured on a four-point Likert scale (Strongly Agree to Strongly Disagree). The validity of the instrument was ensured through experts in Vocational and Technical Education and Test and Measurement. The reliability of the instrument was determined by Cronbach Alpha and yielded coefficient of 0.84. Data collection involved on-site visits to sawmills and carpentry workshops, with verbal consent obtained from all participants. Descriptive statistics such as frequency counts, and percentages were employed to answer the research questions. Findings revealed that wood biomass is abundant in the area and holds strong potential for sustainable bioenergy production, but utilization is hindered by high equipment costs, inadequate technical knowledge, poor government support, and limited access to efficient technologies. The study concluded that wood biomass possesses significant potential as a renewable energy source, however, its utilization is constrained by several challenges whereby when efforts are integrated by the government and other stakeholders, in providing solutions will unlock the economic and environmental benefits of wood biomass. The study recommended targeted capacity building, policy incentives, and investment in biomass conversion technologies to enhance sustainable bioenergy adoption in the region.

Keywords: Bioenergy, wood biomass, sawmill workers, carpenters, Ilorin South, Kwara State.

Introduction

The global shift towards renewable energy sources has placed biomass, particularly wood biomass, at the forefront of sustainable energy discussions. According to Fatma et al. (2018), wood biomass refers to the woody, lignocellulosic parts of plant material such as tree stems, branches, forestry residues, and wood-processing by-products rich in the structural polymers cellulose, hemicellulose, and lignin. It is commonly used as a renewable feedstock in bioenergy and biofuel production. Accordingly, lignocellulosic biomass from wood is a highly abundant and renewable feedstock with significant potential for sustainable bioenergy generation due to its carbon-neutral nature and wide availability. In regions where forestry and sawmilling are common, wood residues form a substantial portion of the biomass resource base. This makes them a viable

for renewable energy production that aligns with climate change mitigation strategies. The sustainable utilization of wood biomass requires a clear understanding of both its availability and the technologies needed for efficient conversion, which has led researchers to investigate regional case studies such as Ilorin South in Kwara State.

Ilorin South, one of the sixteen Local Government Areas in Kwara State, is characterized by a mix of urban and semi-rural settlements, with economic activities that include agriculture, small-scale manufacturing, and wood-based industries. The area hosts several sawmills and timber-processing workshops, generating substantial quantities of wood residues. Despite this potential. It is observed that wood residues from sawmilling and timber processing remain particularly underutilized in Nigeria, leading to environmental pollution and economic waste. Alhassan et al. (2019) estimated the volume of wood residues generated from sawmilling activities in Kwara State and highlighted their untapped energy potential for electricity generation and thermal applications. This implies that, if those wood residues are properly harnessed, wood residues could provide a reliable and sustainable energy source for local communities. The real challenge, however, lies in developing sustainable production systems that convert these residues into bioenergy efficiently.

Bioenergy is a form of renewable energy derived from biological materials known as biomass such as plants, agricultural residues, forestry waste, and organic municipal waste. These materials store energy through the process of photosynthesis, and when they are converted (through combustion, fermentation, gasification, or other technologies), the stored chemical energy is released in the form of heat, electricity, or biofuels. Bioenergy, according to Abdul Hamid and Abdull Razis (2023), refers to energy derived from wood waste specifically lignocellulosic biomass converted into bioethanol through pretreatment technologies. This process enables the sustainable production of second-generation biofuels, positioning wood waste as an eco-friendly and renewable energy resource. Sustainable bioenergy production involves not only tapping into available biomass resources but also adopting environmentally friendly conversion technologies. Abdul Hamid and Abdull Razis (2023) emphasized that pretreatment technologies, such as torrefaction, pyrolysis, and fermentation, enhance the efficiency of bioethanol production from wood waste, making the process both sustainable and economically viable. This focus on process optimization links directly to the broader discussion on how wood biomass can be leveraged for sustainable energy development in Nigeria.

Harnessing Nigeria's abundant renewable resources demands more than just technological availability; it requires deliberate strategic planning. Oyedepo et al. (2019) emphasize that Nigeria's bioenergy sector must prioritize coordinated efforts in knowledge advancement, infrastructure investment, and capacity building. This is because achieving these elements would strengthen the sector's ability to contribute effectively to Sustainable Development Goal 7, which focuses on ensuring access to affordable and clean energy for all. This highlights that without strong technical skills, proper facilities, and human resource development, the sector may not reach its full potential in supporting sustainable energy goals. Building on this perspective, Okoro et al.

(2024) stressed that without such integrated strategies, Nigeria risks lagging in the global transition to renewable energy systems. In Kwara State, Olaoye et al. (2022) points out that adopting innovations such as improved biomass stoves and efficient conversion equipment is essential. These technologies not only enhance energy efficiency but also reduce environmental pollution, thereby maximizing the benefits of wood biomass utilization. This means that Nigeria's ability to remain competitive in the global energy market depends on implementing comprehensive and forward-looking policies that align with international energy trends. Expanding on the national picture, Aworunse et al. (2023) present the shift towards bioenergy as part of Nigeria's broader movement into a post-oil bioeconomy. They argue that sustainable bioenergy production can serve as a catalyst for rural economic growth, creating jobs, stimulating small enterprises, and supporting community livelihoods. This growing recognition of bioenergy's economic and environmental value is also evident internationally, where different regions have integrated it into their renewable energy strategies, offering Nigeria a useful model for aligning national goals with global best practices.

Bioenergy from forest biomass plays a significant role in renewable energy strategies, especially in the European Union where Kożuch et al. (2024) note its importance amidst changing geopolitical conditions. In Nigeria, this global trend is mirrored in the rising interest in local bioenergy development, supported by the availability of raw materials such as wood residues in areas like Ilorin South. Thiffault et al. (2023) further emphasize that integrating wood residue utilization into energy planning can aid in the transition to a sustainable bioenergy future. Therefore, assessing the potential, sustainability, and economic viability of wood biomass in Ilorin South becomes a critical step in contributing to Nigeria's renewable energy portfolio. This study, therefore, aims to investigate the sustainable production of bioenergy from wood biomass in Ilorin South LGA of Kwara State, focusing on its availability, conversion potential, environmental benefits, and socio-economic implications. By drawing from both local and international literature, the research situates Ilorin South within the broader discourse on sustainable energy transitions, providing evidence-based insights that could guide policy, technology adoption, and rural development initiatives.

Statement of the Problem

Energy demand in Nigeria continues to rise, while access to clean and affordable energy remains a major challenge, especially at the local level. In many urban and semi-urban communities like Ilorin South Local Government Area of Kwara State, traditional energy sources such as firewood and charcoal are still widely used for cooking and small-scale heating. Large amounts of wood waste from sawmills, carpentry workshops, and furniture industries are generated daily, often left unused or improperly disposed. It is not clearly known whether these abundant wood residues are being effectively harnessed as a sustainable source of bioenergy. The extent to which stakeholders in Ilorin South are aware of or capable of utilizing wood biomass for clean energy production has not been fully established. The environmental, economic, and social viability of bioenergy production from wood waste

in the area remains uncertain. Without sufficient empirical data on the availability, awareness, and utilization of wood biomass for energy purposes, it becomes difficult to determine its actual potential as a sustainable solution to local energy needs. This study, therefore, seeks to explore the availability, current usage, and feasibility of sustainable bioenergy production from wood biomass in Ilorin South LGA, with the aim of bridging the knowledge gap and informing policy and practice on renewable energy alternatives.

Purpose of the Study

The main purpose of this study is to examine the impact of Bioenergy in Ilorin South Local Government Area of Kwara State, Nigeria. Specifically, the study aims to:

1. examine the availability of wood waste for sustainable bioenergy production in Ilorin South local Government Area of Kwara State.
2. assess the level of awareness of wood biomass for sustainable bioenergy production in Ilorin South Local Government Area.
3. examine the challenges of utilizing wood biomass for sustainable bioenergy production in Ilorin South Local Government Area

Research Questions

The following research questions were raised to guide the study

1. What types of wood biomass are available for bioenergy production in Ilorin South LGA?
2. What is the level of awareness among woodworkers and other local users regarding energy production from wood waste?
3. What are the perceived challenges of utilizing wood biomass for sustainable bioenergy in the area?

Methodology

This study adopted a descriptive survey research design to examine sustainable bioenergy production from wood biomass in Ilorin South Local Government Area of Kwara State. The population of the study comprised 39 sawmill workers and 87 carpenters registered under the Ilorin South Carpentry Association, giving a total population of 126 respondents. The entire population was used as the sample for the study through a census sampling technique due to its manageable size.

A structured questionnaire was developed by the researcher as the main instrument for data collection. The questionnaire was divided into four sections using a four linket scale (SA for Strongly Agree, A for Agree, D for Disagree and SD for Strongly Disagree). Section A comprised demographic information of the respondents, section B entails information on the types of wood biomass, section C consist of information on the level of awareness among woodworkers and section D entails information on the challenges of utilizing wood biomass. The instrument was validated by three experts, two from the Vocational and Technical Education Department and one from Test and Measurements Department in Ekiti State University, Ado-Ekiti, to ensure content and face validity. A pilot test was conducted with twenty respondents outside the study area, and the reliability of the instrument was determined using Cronbach's Alpha, yielding a reliability coefficient of 0.84, indicating high internal consistency.

Data collection was carried out through on-site visits to sawmills and carpentry workshops within Ilorin South LGA, with the assistance of two trained research assistants. Respondents were

given adequate time to complete the questionnaire, and verbal consent was obtained prior to participation. Data collected were coded and analyzed using descriptive statistics such as frequency counts and percentages.

Results

Research Question 1: What types of wood biomass are available for bioenergy production in Ilorin South LGA?

Table 1: Types of wood waste available for sustainable bioenergy production

Types of wood waste	Frequency	Percentage (%)
Sawdust	32	25.40
Wood shavings	21	16.60
Tree bark	18	14.30
Broken wood pieces	55	43.60

Table 1 indicates that broken wood pieces is the most common type of wood waste available with a percentage of 43.6%, followed by sawdust with a percentage of 25.4%, wood shavings (16.7%), and tree bark (14.3%). This variety of biomass materials suggests multiple potential feedstocks for bioenergy production.

Research Question 2: What is the level of awareness among woodworkers and other local users regarding energy production from wood waste?

Table 2: Level of Awareness Among Woodworkers and Other Local Users Regarding Energy Production

Items	SA (%)	A (%)	D (%)	SD (%)
I understand the basic processes involved in producing energy from wood waste.	50(39.7)	38(30.2)	38(30.2)	0(0.0)
I have received training or information on bioenergy production from wood biomass.	40(31.7)	20(15.9)	48(38.1)	18(14.3)
I can identify the benefits of using wood waste for energy production.	48(38.1)	23(18.3)	55(43.7)	0(0.0)
I know of local projects or initiatives that use wood waste for bioenergy production.	33 (26.2)	40 (31.7)	25 (19.8)	28 (22.2)

The results indicate that 70% of respondents understand the basic processes involved in producing energy from wood waste, showing a generally good awareness level. Only 47.6% of respondents have received training or information related to bioenergy production, indicating a gap in formal education or exposure. About 56.4% could identify the benefits of wood waste for energy production, but awareness of local projects or initiatives remains limited, with only 57.9% acknowledging knowledge of such efforts, showing room for improvement in community-level engagement.

Research Question 3: What are the perceived challenges of utilizing wood biomass for sustainable bioenergy in the area?

Table 3: challenges of utilizing wood biomass for sustainable bioenergy

Items	SA (%)	A (%)	D (%)	SD (%)
High cost of bioenergy production equipment discourages use of wood biomass	60(47.6)	40(31.7)	15(11.9)	11(8.7)
Lack of technical knowledge limits utilization of wood biomass	65(51.59)	42(33.33)	10(7.94)	9(7.14)
Inadequate government support hinders wood biomass energy projects	70(55.56)	35(27.78)	12(9.52)	9(7.14)
Poor access to efficient wood biomass conversion technology is a challenge	68(53.97)	40(31.75)	11(8.73)	7(5.56)
Traditional preferences for other energy sources reduce interest	45(35.70)	38(30.20)	22(17.50)	21(16.70)

Table 3 above revealed the major challenges affecting the utilization of wood biomass for sustainable bioenergy production. The results show that a majority of respondents agreed that the high cost of bioenergy production equipment discourages the use of wood biomass, with a percentage of 79.3%, indicating a high level of agreement. Similarly, the statement that a lack of technical knowledge limits the utilization of wood biomass for bioenergy recorded 84.92%, further suggesting that inadequate expertise remains a significant constraint. Inadequate government support was also identified as a challenge, with a percentage of 83.34%, showing general agreement among respondents. Poor access to efficient wood biomass conversion technology was highlighted, with a percentage of 85.72%, underscoring the technology gap in the sector. Lastly, traditional preferences for other energy sources were acknowledged as a limiting factor, with 67.9%, indicating that socio-cultural influences also play a role in reducing the adoption of wood biomass utilization. These findings suggest that overcoming economic, technical, policy, and traditional barriers is essential to promoting the adoption of wood biomass for sustainable energy production.

Discussion of Findings

The findings of the study revealed that sawdust, wood shavings, tree bark, and broken wood pieces were the major types of wood biomass available in Ilorin South LGA for potential bioenergy production. This aligns with the report by Alhassan et al. (2019), who observed that sawmilling activities in Kwara State generate significant quantities of wood residues with substantial energy potential. Similarly, Adeleke et al. (2023) emphasized that Nigeria's biomass resources, including wood waste, are underutilized despite their abundance. The availability of these biomass types in the study area underscores the possibility of establishing a steady feedstock supply chain for bioenergy production. However, as Fatma et al. (2018) note, effective utilization requires proper classification, collection, and processing to ensure efficiency in bioenergy conversion. This availability naturally raises the question of whether local users have the knowledge to harness these materials effectively.

The outcome of the study showed a moderate to high level of awareness among woodworkers and other local users about converting wood waste into usable energy, though gaps in training and practical knowledge were evident. Many respondents agreed they

understood the basic processes and benefits, yet fewer had received formal training or knew of local bioenergy initiatives. These findings are consistent with Okoro et al. (2024), who highlighted that while awareness of bioenergy potential in Nigeria is growing, practical knowledge and technical capacity remain insufficient. Ezealigo et al. (2021) also observed that without structured training programs, biomass resources risk being wasted due to poor valorization practices. The study by Olaoye et al. (2022) in Kwara State further supports this, noting that targeted sensitization and skill development significantly increase adoption of biomass-based technologies. Nonetheless, awareness alone is not enough, as practical barriers may still limit adoption an issue.

The findings revealed that the perceived challenges to utilizing wood biomass for sustainable bioenergy were found to be predominantly economic, technical, and policy-related. High equipment costs, inadequate technical knowledge, poor government support, and limited access to efficient conversion technologies were major concerns. These findings correspond with Adeleke et al. (2023), who identified similar barriers in Nigeria's biomass sector, particularly the financial constraints faced by small-scale producers. Aworunse et al. (2023) linked these limitations to Nigeria's slow transition towards a bioeconomy, noting that policy gaps and insufficient infrastructure compound the problem. Abdul Hamid and Abdull Razis (2023) stress that appropriate pretreatment technologies can enhance efficiency, but these require investments that are often out of reach for local operators. Furthermore, cultural preferences for traditional energy sources, as found in this study, mirror the observations of Edeh and Okpo (2023), who argued that social acceptance is as critical as technical feasibility in bioenergy adoption. The study's findings indicate that while Ilorin South LGA has abundant wood biomass resources and a reasonable level of awareness among local users, significant challenges hinder full-scale adoption of sustainable bioenergy production. Addressing these constraints will require integrated approaches that combine resource mobilization, technical training, financial support, and policy reforms.

Conclusion

The study on Sustainable Bioenergy Production from Wood Biomass in Ilorin South LGA, Kwara State revealed that wood biomass possesses significant potential as a renewable energy source in the area. However, its utilization is constrained by several key challenges, including the high cost of bioenergy production equipment, limited technical knowledge among stakeholders, inadequate government support, poor access to efficient biomass conversion technologies, and cultural preferences for alternative energy sources. Despite these constraints, the findings indicate that with appropriate policy support, technological advancement, and community sensitization, wood biomass can serve as a viable and sustainable solution to meeting local energy demands while reducing environmental degradation and dependence on fossil fuels. The study underscores the need for integrated efforts from government, private sector, and community members to unlock the economic and environmental benefits of wood biomass utilization.

Recommendations

Based on the findings, the following recommendations are made:

1. Government and development agencies should provide subsidies, grants, or low-interest loans for the acquisition of bioenergy production equipment to reduce the financial burden on investors and small-scale producers. This can be achieved when government and agencies allocate budgets or partner with financial institutions to offer incentives to small-scale producers
2. Organize training workshops for farmers, entrepreneurs, and energy stakeholders to enhance technical skills in biomass processing, conversion, and maintenance of bioenergy systems. By partnering with experts and organizations to conduct capacity-building sessions.
3. Formulate and implement policies that promote renewable energy development, including incentives for private sector investment in wood biomass energy projects and stricter regulations to encourage cleaner energy alternatives. This can be achieved by establishing clear renewable energy targets and incentives by the government.
4 Facilitate the importation, local fabrication, and distribution of cost-effective and efficient biomass conversion technologies to improve production efficiency and reduce operational costs.
5 Conduct awareness programmes to sensitize communities on the environmental and economic benefits of wood biomass energy, while addressing traditional biases against its use, by collaborating with community leaders and influencers to promote benefits.

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