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Research Article

AN OVERVIEW OF SAWDUST UTILIZATION AS ECO-SUSTAINABLE RAW MATERIALS IN INDUSTRY, AGRICULTURE, CONSTRUCTION, AND ENERGY GENERATION

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Abstract

Growing concerns over environmental degradation, unsustainable waste disposal, and rising unemployment necessitate the exploration of innovative approaches to waste-to-wealth conversion. This paper gave the overview application of sawdust an abundant by-product of timber processing as an eco-sustainable raw material across key sectors such as agriculture, construction, industry, and energy generation. Assessing its potential for wealth creation, the study highlights sawdust transformation from a neglected pollutant into a resource that fosters economic empowerment, job opportunities, and environmental sustainability. Areas examined include its physical and chemical properties, conversion techniques, and real-world adoption in low- and high-income economies. Systemic analysis were made to identify economic, environmental, and social outcomes, with particular attention to green technology innovations. The results demonstrate that sawdust can significantly reduce environmental pollution when diverted from open burning and landfill disposal. In construction, it enhances low-cost composite materials while, it improves soil fertility and livestock bedding in agriculture. It serves as an efficient biomass fuel in bioenergy, and in industry, it acts as a filler and absorbent. These applications directly contribute to circular economy models, wealth creation, and youth employment. Harnessing sawdust as a sustainable raw material offers governments, entrepreneurs, and local communities viable opportunities for green enterprise development, rural industrialization, and climate change mitigation. This paper underscores the transformative potential of sawdust within waste-to-wealth frameworks, offering practical pathways for policy implementation, sustainable industry, and future bioeconomy expansion.

Keywords: Sawdust, waste-to-wealth, sustainable materials, circular economy, bioenergy.

1.0 Introduction

Sawdust, the fine particulate waste generated during sawing, milling, sanding, and other wood-processing operations, has traditionally been perceived as a nuisance or waste material. For decades, the majority of sawdust produced worldwide was disposed of through open burning, indiscriminate dumping, or landfilling, all of which contributed to environmental degradation, greenhouse gas emissions, and loss of potentially valuable resources (Aina et al., 2019; Gupta et al., 2021). However, contemporary research has highlighted that sawdust is not merely a byproduct but a versatile and renewable raw material with broad industrial, agricultural, constructional, and energy applications. Between 2017 and 2025, there has been growing recognition of the significant role that sawdust can play in promoting sustainability, circular economy principles, and wealth creation (Okorie et al., 2022). The global shift towards eco-friendly materials and renewable resources has created an urgent need to rethink waste management systems. Sawdust, being rich in cellulose, hemicellulose, lignin, and trace minerals, is biodegradable, renewable, and abundantly available, especially in developing nations where sawmills operate at relatively low efficiency (Odeyemi et al., 2020; Chukwudi et al., 2024). The valorization of sawdust into productive uses across diverse sectors therefore represents not only an environmental necessity but also an economic opportunity. This paper introduces the multi-sectoral significance of sawdust and emphasizes its contributions to sustainable development and wealth creation.

Sawdust as a fine particulate residue generated during woodworking operations such as sawing, milling, sanding, and drilling, is one of the most abundant wood-processing byproducts worldwide. Estimates suggest that sawdust constitutes between 10–15% of total wood input in sawmills, depending on machine efficiency and the type of wood being processed (Aina et al., 2019). In regions where sawmilling is an important industry such as sub-Saharan Africa, South Asia, and Latin America, the amount of sawdust generated annually runs into millions of tons. This vast quantity of residue is often discarded through uncontrolled burning or landfilling. However, with advances in waste management technology and sustainable practices, sawdust is increasingly being recognized as a valuable raw material rather than waste (Oladele et al., 2021). Chemically, sawdust is largely composed of cellulose, hemicellulose, and lignin, which are naturally biodegradable polymers. These constituents provide structural strength to wood and make sawdust versatile for multiple industrial uses (Okorie et al., 2022). Cellulose in sawdust is processed into composites, bio-adsorbents, or even biofuels, while lignin provides thermal stability and aromatic precursors for industrial resins. Such biochemical richness positions sawdust as a renewable material with applications across diverse fields including construction, agriculture, industrial processing, energy generation, and even domestic use (Wang et al., 2021; Lottermoser, 2010; Yuan et al., 2022; Samolada & Zabaniotou, 2014).

Valorization of sawdust is highly significant and economical. The global shift toward circular economy models emphasizes resource efficiency, recycling, and waste minimization. Sawdust aligns with this vision because it transforms a ubiquitous waste stream into a source of revenue and livelihood (Singh et al., 2023). A small-scale enterprises (in many developing countries) use sawdust to produce briquettes and pellets, which serve as affordable cooking and heating fuels (Onyegiri et al., 2023). Some construction companies are experimenting with sawdust as a partial replacement for cement or fine aggregates in concrete, leading to cost reductions, thermal insulation, and reduced carbon emissions. These initiatives demonstrate how sawdust can simultaneously drive economic growth and environmental sustainability. Sawdust-based industries require manpower (job creation) for collection, sorting, transportation, processing, and marketing. Entrepreneurs and start-ups focusing on sawdust applications such as briquette making, composite boards, particleboard production, and soil amendment processing, create jobs for both skilled and unskilled labour (Ibrahim et al., 2022). In communities where sawmilling is widespread, the development of sawdust-utilizing enterprises has shown reduction in unemployment and stimulate local economies. Thus, sawdust utilization is not only an environmental solution but also a socio-economic strategy for inclusive development.

The environmental impact of sawdust utilization cannot be overstated. When dumped in landfills, sawdust undergoes slow decomposition, releasing methane, a potent greenhouse gas. Open burning of sawdust contributes to air pollution and respiratory health problems. Repurposing sawdust into sustainable products therefore reduces environmental hazards while generating value. The adoption of sawdust utilization practices contributes directly to several United Nations Sustainable Development Goals (SDGs), including SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production) (Yusuf et al., 2024). Sawdust represents an untapped natural asset with high potential to transform waste into wealth. Its applications cut across industry, agriculture, construction, and energy generation, making it a cornerstone of sustainable development as presented in this study. This paper explored the potentials, properties, challenges, applications, and socio-economic implications of sawdust utilization between 2017 and 2025, highlighting its role as a sustainable raw material for wealth and job creation (Kumar et al., 2021; Hoornweg & Bhada-Tata, 2012; Lu & Yuan, 2017).

2.0 Sources of Sawdust

Sawdust is generated in large volumes from several sources. The volume of sawdust generated globally is estimated at over 90 million tons annually, with Africa and Asia contributing significantly due to high wood consumption and less efficient milling practices (Singh et al., 2023).

i. **Sawmills**: Primary source are cutting, trimming, and planing of logs that generates millions of tons annually.
ii. **Furniture and Carpentry Workshops**: Sawing, sanding, and drilling produce medium to fine sawdust.
iii. **Wood-based Industries**: Plywood, particleboard, veneer, and MDF factories generate fine sawdust.
iv. **Timber Markets**: On-site wood cutting and shaping produce both coarse and fine sawdust.
v. **Domestic Activities**: Small-scale carpentry, handicrafts, and household repairs contribute to localized sawdust generation (Aina et al., 2019; Okafor et al., 2023).

3.0 Waste Technology as Sustainable Source of Wealth and Job Creation

Waste convertion into wealth has gained momentum in the last decade, with various technologies employed to recover value from agricultural, industrial, and municipal wastes (Adaramola et al., 2020). Sawdust occupies a special place within this paradigm because of its chemical versatility and physical adaptability. Waste valorization technologies such as pyrolysis, briquetting, composting, and composite manufacturing have made it possible to transform sawdust into biofuels, soil amendments, construction materials, and industrial adsorbents (Singh et al., 2023). Waste-to-wealth initiatives create jobs in collection, processing, and downstream industries in regions like sub-Saharan Africa and South Asia where unemployment among youths is high, sawdust briquette production has provided a low-cost entry point for small-scale entrepreneurs (Ibrahim et al., 2022). Beyond direct employment, sawdust-based industries stimulate auxiliary businesses such as transport, packaging, and distribution. Sawdust exemplifies sustainable waste management, serve as both an environmental safeguard and a driver of inclusive economic growth (Okafor et al., 2023).

4.0 Sawdust as Sustainable Raw Material

Sawdust exemplifies circular economy principles where waste is transformed into a valuable input for new processes (Figure 1). Its renewable nature, biodegradability, and abundance make it a strategic raw material for the future (UNEP, 2023). By displacing fossil-based materials in energy, cement, plastics, and fertilizers, sawdust helps reduce the carbon footprint of industries while simultaneously generating wealth. It thus embodies both ecological and economic sustainability.

Figure 1: Ssawdusts

5.0 Sawdust Characterisation

Sawdust is described as a fine, powdery or flaky material composed of small wood particles produced during sawing, sanding, drilling, or routing operations (Figure 2). It is often light brown to dark brown in color, depending on the type of wood. The size and texture of sawdust vary from coarse shavings to fine powder, with particle sizes ranging from a few microns to several millimeters (Okorie et al., 2022). Sawdust is lightweight, porous, and organic in nature, making it both biodegradable and combustible. These properties account for its versatility in multiple applications. Its high porosity and surface area enhance its ability to absorb liquids, which explains its frequent use in animal bedding, oil spill absorbents, and industrial adsorbents (Wang et al., 2021). Its fibrous composition makes it compatible with cementitious and polymer matrices, enabling its integration into composite construction materials.

Figure 2: Sawdust description

5.1 Sawdust Production Sizes

The size of sawdust particles depends largely on the type of wood, the machinery used, and the processing technique. Sawmills using modern, high-efficiency equipment generate finer, more uniform sawdust, while traditional mills often produce coarser, irregular particles (Aina et al., 2019). Different particle sizes determine the suitability of sawdust for various applications**.** The adaptability of sawdust particle size is one reason for its wide industrial relevance. Proper grading and processing enhance its value and make it fit for targeted end-use applications.

i. Fine sawdust (≤1 mm): It is highly absorbent and is often used in composting, mulching, particleboards, and as adsorbents in industrial wastewater treatment (Figure 3).

Figure 3: Fine sawdust

ii. Medium sawdust (1–5 mm): It finds application in briquette and pellet production due to its balance of density and binding ability (Figure 4).

Figure 4: Medium sawdust

iii. Coarse sawdust (>5 mm): It is more suitable for livestock bedding, landscaping, and as filler (Figure 5) in lightweight construction blocks (Onyegiri et al., 2023).

Figure 5: Coarse sawdust

5.2 Physical and Chemical Composition and Properties of Sawdust

Sawdust is primarily composed of three biopolymers via (Huang et al., 2019; Okorie et al., 2022);

i. Cellulose (35–60%), which gives structural strength.
ii. Hemicellulose (15–35%), which is amorphous and provides flexibility.
iii. Lignin (15–30%), which binds fibers together and provides resistance to microbial attack.

The elemental composition of sawdust (Figure 6) typically includes carbon (≈45%), hydrogen (≈6%), oxygen (≈45%), with small amounts of nitrogen, sulfur, and trace minerals (Chukwudi et al., 2024). The calorific value of sawdust ranges from 16–21 MJ/kg, making it a viable biomass fuel. Physically, sawdust is porous, lightweight, and has a large surface area, which enhances its water absorption and adsorption capabilities. Its thermal conductivity is low, which explains its usefulness as an insulator in construction materials (Onyegiri et al., 2023). The pH of sawdust varies with wood species, influencing its suitability in soil amendment and composting. These properties collectively explain why sawdust can be applied in construction (as aggregate substitute), in energy (as biofuel), in agriculture (as soil conditioner), and in industry (as adsorbent and filler) (Huang et al., 2019; Yusuf et al., 2024). (Wang et al., 2021). (UNEP, 2023; Chukwudi et al., 2024). Key physical properties are as stated.

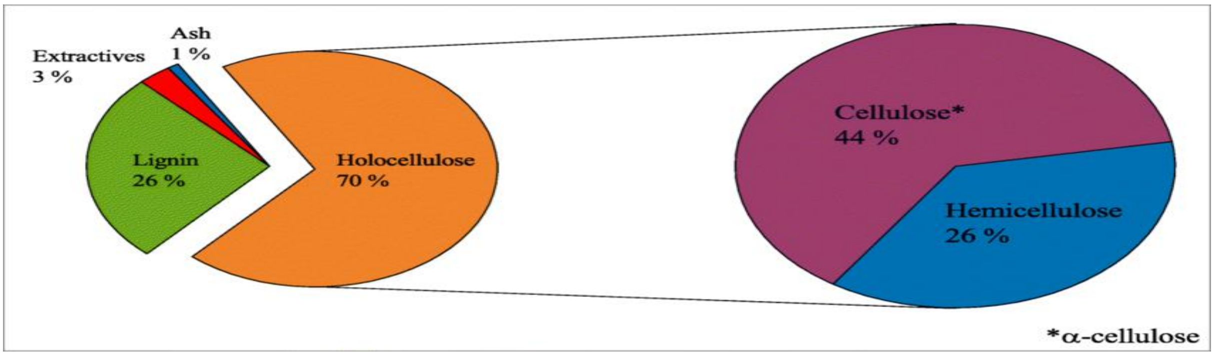

Figure 6: Chemical properties of sawdusts

i. **Absorbent:** Sawdust readily absorbs liquids, making it useful in various applications.

ii. **Bulky:** Its loose, granular form makes it bulky, which is beneficial for uses like insulation.

iii. **Fibrous:** The natural structure of wood fibers contributes to its overall fibrous texture.

iv. **Non-conductive:** Sawdust is a poor conductor of heat and electricity.

v. **Water Retention:** It exhibits significant water retention properties, influencing its behavior as a growth medium or absorbent.

Other key properties and applications are as stated:

i. **Structural Strength:** The presence of cellulose provides inherent strength and durability when used in composites like particleboard.

ii. **Flexibility and Binding:** Hemicellulose and lignin provide flexibility and hold the fibers together, contributing to the material's integrity.

iii. **Bio-resource:** Sawdust is recognized as a waste product with value for energy generation (combustion, gasification), agricultural use, and as a precursor for biopolymer production.

6.0 Applications of Sawdust

Sawdust's versatility as a renewable resource enables its use across multiple sectors, including construction, agriculture, energy, industry, and domestic applications. Its physical and chemical properties, such as high cellulose content, porosity, and biodegradability, make it suitable for diverse applications that promote sustainability and economic value (Okorie et al., 2022).

6.1 Construction and Building

Sawdust is increasingly utilized in construction as a partial substitute for traditional materials, reducing costs and enhancing eco-friendly properties such as thermal and acoustic insulation. Recent studies indicate that incorporating 5–17% sawdust into concrete mixtures can achieve compressive strengths above 20 Mpa, suitable for lightweight, non-load-bearing structures (Ahmed et al., 2021). Sawdust is also used in manufacturing particleboards, fiberboards, acoustic panels, and insulation boards, which reduce reliance on virgin materials and lower the carbon footprint of construction projects (Onyegiri et al., 2023). In Nigeria, researchers developed sawdust-based lightweight concrete blocks using sawdust from local Gmelina arborea wood, achieving a 30% cost reduction compared to conventional sand-based blocks while maintaining adequate strength for residential partitions (Ahmed et al., 2021). Similarly, in India, sawdust from teak wood has been combined with resin to produce particleboards used in low-cost housing, offering improved thermal insulation for tropical climates (Onyegiri et al., 2023).

6.2 Agriculture and Gardening

Sawdust serves as an effective soil amendment, mulch, and composting material in agriculture, enhancing soil fertility, water retention, and erosion control. When composted with animal manure, sawdust improves soil organic content, while its use as mulch helps conserve moisture and suppress weeds. Treated sawdust can also adsorb pesticides and heavy metals, mitigating soil contamination (Mbagwu et al., 2022). In Kenya, smallholder farmers in the Rift Valley have used sawdust from pine sawmills as mulch in maize fields, reducing soil erosion by 25% and improving water retention by 15% compared to bare soil, as reported in local agricultural extension studies (Mbagwu et al., 2022). In Ghana, sawdust composted with poultry manure has been applied to cocoa plantations, increasing soil organic carbon by 10% and boosting crop yields (Abioye et al., 2018).

6.3 Energy and Fuel Production

Sawdust briquettes and pellets offer renewable, affordable alternatives to fossil fuels, with calorific values of 18–21 MJ/kg. These biomass fuels reduce greenhouse gas emissions and support energy access in rural areas, particularly in developing countries where firewood and coal dominate (Yusuf et al., 2024). Pyrolysis and gasification technologies further enable sawdust conversion into biochar and syngas, enhancing its energy applications (Huang et al., 2019). In Uganda, the Green Bio Energy initiative has produced sawdust briquettes from local sawmills in Kampala, distributing them to rural households as a cleaner alternative to charcoal. These briquettes, with a calorific value of 19 MJ/kg, have reduced household carbon emissions by 40% compared to traditional wood fuels (Yusuf et al., 2024). In China, sawdust from poplar wood has been pyrolyzed to produce biochar for industrial heating, achieving a 50% reduction in coal dependency in small-scale factories (Huang et al., 2019).

6.4 Industrial Uses

Activated sawdust, due to its porous structure and abundant functional groups, is highly effective in wastewater treatment, particularly for removing heavy metals like lead and cadmium. It is also used as a filler in plastics, adhesives, and resins, enhancing product sustainability by replacing synthetic materials (Wang et al., 2021). In South Africa, sawdust from eucalyptus wood has been activated into carbon for treating mining wastewater, removing 95% of copper and zinc ions in pilot-scale trials conducted in Johannesburg (Wang et al., 2021). In Brazil, sawdust from pine sawmills has been incorporated as a filler in biodegradable plastic packaging, reducing production costs by 20% and improving material degradability (Okorie et al., 2022).

6.5 Domestic Applications

Sawdust is widely used in households for animal bedding, litter boxes, spill absorbents, and fuel for cooking stoves. Its high absorbency and low cost make it ideal for these applications, particularly in rural settings where access to commercial alternatives is limited. In India, sawdust from local carpentry workshops is used as bedding for dairy cattle in Uttar Pradesh, absorbing 30% more moisture than straw and reducing odor in livestock sheds (Wang et al., 2021). In Nigeria, sawdust from iroko wood is used in traditional fish smoking in Lagos markets, providing consistent heat and enhancing flavor while reducing reliance on expensive charcoal (Abioye et al., 2018; Mbagwu et al., 2022) (Ahmed et al., 2021; Onyegiri et al., 2023)

6.6 Job Creation

Sawdust-based enterprises, such as briquetting, particleboard production, and composting, generate significant employment opportunities, particularly in developing regions. These industries absorb both skilled and unskilled labour, addressing unemployment challenges in communities near sawmills (Okafor et al., 2023). In Ghana, the Sawdust-to-Wealth cooperative in Kumasi has employed over 500 youths in sawdust briquette production, creating 200 direct jobs and 300 indirect jobs in collection and distribution since 2020 (Okafor et al., 2023). In Ethiopia, small-scale particleboard factories using sawdust from Addis Ababa sawmills have provided jobs for 150 local workers, including women and unskilled laborers, boosting community incomes by 25%.

6.7 Wealth Creation

Transforming sawdust into marketable products, industries contribute to GDP growth and economic diversification. Government incentives, such as tax rebates or grants, further encourage entrepreneurship and exports in sawdust-based value chains, promoting sustainable industrialization (Singh et al., 2023). In India, sawdust briquette exports from Tamil Nadu to Southeast Asia generated $2 million in revenue in 2022, supporting 50 small enterprises and contributing to local GDP (Singh et al., 2023). In Nigeria, sawdust-based particleboard production in Ogun State has attracted government grants, enabling 10 startups to scale operations and create a $500,000 market for construction materials in 2023 (Okafor et al., 2023).

6.8 Other Applications

Recent innovations have expanded sawdust's applications into bio-phenolic resins, porous carbon electrodes for batteries, and biodegradable packaging materials. These emerging uses highlight sawdust's potential in high-tech and sustainable product development (Chukwudi et al., 2024). In Malaysia, researchers at University of Teknology Malaysia developed bio-phenolic resins from sawdust-derived lignin, used in eco-friendly furniture adhesives, reducing formaldehyde emissions by 60% compared to conventional resins (Chukwudi et al., 2024). In Germany, sawdust from spruce wood has been processed into porous carbon electrodes for lithium-ion batteries, improving energy storage capacity by 15% in experimental prototypes (Okorie et al., 2022).

7.0 Challenges Associated with Sawdust

Despite its economic and environmental potential, sawdust remains grossly underutilized in many regions. A significant portion of sawdust generated from sawmills, carpentry workshops, and furniture industries is discarded as waste, often dumped in open fields or landfills without proper management (Aina et al., 2019). This neglect has environmental, social, and economic consequences. One of the most common disposal practices is landfilling, where sawdust accumulates in dumpsites. Over time, the material undergoes anaerobic decomposition, producing methane gas, a greenhouse gas 28 times more potent than carbon dioxide in trapping heat in the atmosphere (Gupta et al., 2021). This contributes to global warming and climate change. Additionally, leachates from decomposing sawdust can contaminate soil and groundwater, introducing organic compounds and potential toxins into natural ecosystems (Chukwudi et al., 2024). Open burning of sawdust, a practice prevalent in regions where landfill space is limited is a major challenge. While burning appears to be a quick disposal method, it releases large amounts of carbon monoxide, carbon dioxide, particulate matter, and polycyclic aromatic hydrocarbons into the atmosphere (Odeyemi et al., 2020). These emissions contribute to air pollution and pose serious health risks such as respiratory diseases, eye irritation, and cardiovascular problems. The International Agency for Research on Cancer (IARC) classifies wood dust (including sawdust) as a Group 1 human carcinogen when inhaled in occupational environments (Wang et al., 2021).

Besides environmental and health issues, the economic neglect of sawdust represents a lost opportunity.Communities forfeit potential revenue streams and employment opportunities by failing to utilize sawdust for energy, construction materials, or soil amendments,. In many developing countries, where unemployment rates remain high, the inability to harness sawdust effectively perpetuates poverty and waste (Ibrahim et al., 2022). While sawdust holds significant promise as a sustainable raw material, its current mismanagement through landfill disposal, open burning, and general neglect, remains a barrier that must be addressed through policy reforms, technological innovation, and public awareness campaigns.

8.0 Conclusion

Sawdust, though often considered waste, is an untapped resource with significant potential. Sawdust utilization creates value chains that employ both skilled and unskilled labour, while it reduces the pressure on landfills and mitigates greenhouse emissions from open burning. The outcomes illustrate that sawdust is a viable pathway toward circular economy and sustainable wealth generation. Its multi-sectoral applications demonstrate how waste materials can be reintegrated into productive economic cycles, thereby fostering sustainability. Effective policies, investments in technology, and awareness creation are necessary to unlock its full potential for wealth creation and environmental protection. Large-scale adoption can create green jobs, stimulate rural and urban economies, and contribute to national GDP through the establishment of sawdust-based industries. It reduces reliance on non-renewable resources positions sawdust as a strategic material for achieving net-zero emissions goals. Investing in sawdust utilization aligns with both climate action strategies and socio-economic development plans, making it a critical resource for the future. The following summarizes sawdust applications.

i. In construction, sawdust has been successfully incorporated into lightweight concrete, blocks, and particleboards, reducing costs and enhancing thermal and acoustic insulation properties.
ii. In agriculture, it has been applied as mulch, compost, and soil amendment to enhance water retention and organic content of soils.

iii. In energy generation, sawdust briquettes and pellets have emerged as affordable, renewable alternatives to fossil fuels, reducing greenhouse gas emissions and supporting energy security.
iv. In industry, activated sawdust has shown high efficiency in wastewater treatment and heavy-metal adsorption due to its porous structure and abundant functional groups.
v. Households uses sawdust as animal bedding, absorbents, and fuel demonstrating its versatility in everyday life.

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