

Pearl Millet By-Products as Clean Household Energy: Implications for Climate Change Resilience in Yobe State, Nigeria

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Abstract

This review assesses the viability of pearl millet (*Pennisetum glaucum*) by-products as a renewable household cooking fuel in Yobe State, Nigeria, and explores how their utilisation can contribute to climate change resilience in a semi-arid context. A narrative literature review was conducted using sources retrieved from Google Scholar, ScienceDirect, Scopus, and institutional reports, with studies selected based on their relevance to biomass energy, agricultural residues, and comparable semi-arid or sub-Saharan African contexts. The review synthesises evidence on the agronomic significance of pearl millet, the physicochemical and energy characteristics of its residues (husks, stalks, and bran), and their suitability for briquette production. Findings indicate that pearl millet by-products possess calorific values ranging between 13 and 18 MJ/kg, making them viable alternatives to firewood and charcoal when densified into briquettes. Their utilisation offers environmental benefits including reduced deforestation, lower greenhouse gas emissions, and improved agricultural waste management. Socioeconomic advantages include local income generation, reduced household fuel costs, and enhanced gender equity through decreased fuelwood collection burdens. However, adoption is constrained by limited technical knowledge, absence of formal policy support, inadequate financing mechanisms, and insufficient localised emissions data. The review concludes that harnessing pearl millet by-products through decentralised briquetting systems, integration into national renewable energy frameworks, and targeted capacity-building represents a practical and context-appropriate pathway for promoting clean energy access and strengthening climate resilience in Yobe State and comparable semi-arid regions of West Africa.

Keywords: Pearl Millet By-Products; Biomass Briquettes; Clean Cooking Energy; Climate Resilience; Household Energy Access; Yobe State Nigeria.

Introduction

Pearl millet is widely grown in semi-arid regions and possesses considerable untapped energy potential (Food and Agriculture Organization [FAO], 2021). It is a major staple crop in Yobe State, cultivated across all agro-ecological zones of the state. Pearl millet by-products represent a viable energy source for several reasons. Their utilisation offers

benefits both for the environment and for the population, particularly with respect to domestic cooking energy. Large quantities of residue are currently generated and either left to decompose on farmland or disposed of through open burning, contributing to air pollution and associated human health risks. Pearl millet is well adapted to arid conditions, making it a resilient crop in these regions. Utilising its biomass for briquette production provides a sustainable and locally available fuel source, reducing dependence on imported or finite energy resources. Such briquettes are environmentally advantageous in that they convert agricultural waste into energy, promoting waste-to-energy transformation and reducing the environmental burden of residue burning. This practice also contributes to soil health through nutrient recycling and helps reduce deforestation associated with fuelwood and charcoal demand.

Furthermore, pearl millet by-products can address economic challenges in Yobe State by creating local employment opportunities in the production and distribution of briquettes. While other alternative energy sources exist, pearl millet briquettes are particularly suited to the specific conditions and resources available in Yobe State, offering a holistic and contextually appropriate solution. Promoting the use of pearl millet briquettes also supports local agricultural practices, fostering agricultural resilience and contributing to domestic energy security. By utilising crop residues for energy, farmers can supplement their income and improve overall agricultural productivity. Pearl millet briquettes are therefore well positioned in Yobe State due to their adaptability, environmental sustainability, and economic benefits. As noted by Yank et al. (2016), crops produce significant quantities of residues as by-products that could contribute to energy production and reduce the use of fuelwood. Fuelwood combustion releases harmful atmospheric substances responsible for numerous health hazards, arising from increases in temperature and particulate matter resulting from household cooking. These substances, including CO₂, N₂O, methane, and chlorofluorocarbons, contribute to the absorption of long-wave radiation and consequently to rises in atmospheric temperature. Domestic energy use is one of the major contributors to climate change, and its impacts have been felt across virtually all parts of Yobe State.

Alternative energy sources such as pearl millet by-products are cost-effective, readily available, environmentally sound, and associated with lower greenhouse gas emissions compared to conventional biomass fuels. Pearl millet briquettes, being renewable and locally sourced, present a viable solution to household energy poverty in the region. This review aims to fill existing knowledge gaps by contributing evidence-based insights to the sustainable energy discourse in Yobe State. Key gaps identified in the literature include limited data on the combustion characteristics, carbon emissions, and energy efficiency of pearl millet briquettes under local conditions, as well as insufficient analysis of the socioeconomic and environmental dimensions of their adoption.

Addressing these gaps will contribute to a more comprehensive understanding of the viability of pearl millet briquettes within the energy landscape of Yobe State and

comparable semi-arid regions. The findings are also expected to support the realisation of Sustainable Development Goal (SDG) 7.2, which seeks to increase the share of renewable energy in the global energy mix, and SDG 13.2, which calls for the integration of climate change measures into national policies, strategies, and planning. Pearl millet, as a major staple crop in the region, generates significant agricultural by-products including husks, stalks, and bran, which remain largely underutilised (Feed the Future Nigeria Integrated Agriculture Activity, n.d.). Harnessing these residues as clean energy offers a promising and contextually appropriate strategy for addressing household energy needs sustainably. This review therefore aims to assess the viability of pearl millet by-products as a renewable household cooking fuel and to explore how such interventions can contribute to climate change resilience in Yobe State.

Statement of the Problem

Despite the abundance of pearl millet agricultural residues in Yobe State, these by-products remain largely underutilised as an energy resource. The majority of rural and peri-urban households in the state continue to depend on firewood and charcoal for cooking, fuels that contribute substantially to deforestation, indoor air pollution, and greenhouse gas emissions. Women and children, who bear a disproportionate burden of fuelwood collection, are particularly affected. At the same time, significant quantities of pearl millet husks, stalks, and bran are either discarded or burned in open fields following harvest, representing both an environmental hazard and a wasted bioenergy opportunity. The core knowledge gap is the absence of a consolidated, evidence-based assessment of the energy potential of pearl millet by-products and the conditions necessary for their adoption as a clean household fuel in Yobe State. Without such evidence, policymakers, development agencies, and communities lack the analytical foundation needed to design and scale appropriate interventions. Failure to address this gap perpetuates household energy poverty, accelerates environmental degradation, and undermines climate resilience in one of Nigeria's most climatically vulnerable states.

Review Questions

This review is guided by the following three research questions:

RQ1: What are the energy characteristics of pearl millet by-products, and to what extent do they qualify as viable household cooking fuels relative to conventional biomass alternatives?

RQ2: What are the environmental and socioeconomic benefits of adopting pearl millet by-products as a household energy source in Yobe State, and how do these contribute to climate change resilience?

RQ3: What are the principal technical, policy, and institutional barriers to the adoption of pearl millet briquettes as a clean cooking fuel in Yobe State, and what strategies have proven effective in addressing comparable barriers in analogous semi-arid contexts?

Methodology

This study employs a narrative literature review approach to synthesise existing knowledge on the use of pearl millet by-products for clean household energy. A narrative review design was adopted in preference to a formal systematic review on the basis that the available literature on this specific topic, particularly in the Yobe State context, remains sparse and heterogeneous in methodology, making a PRISMA-compliant systematic approach difficult to execute credibly at this stage. Relevant publications were sourced from academic databases including Google Scholar, ScienceDirect, and Scopus, supplemented by institutional and grey literature reports. Source selection was guided by the review questions, with priority given to studies directly addressing biomass energy, agricultural residues, pearl millet agronomy, household energy use, and climate resilience in sub-Saharan Africa and comparable semi-arid regions. Where peer-reviewed evidence specific to Yobe State or Northern Nigeria was limited, evidence from analogous Sahelian and West African contexts was incorporated and explicitly identified as such.

Search Strategy

Keywords used in the search process included: "pearl millet biomass," "briquettes," "clean cooking energy," "agricultural residues," and "climate resilience in sub-Saharan Africa." Selected studies were analyzed thematically under the following categories:

- i. Energy potential of millet residues
- ii. Household energy use
- iii. Environmental benefits
- iv. Policy challenges

Inclusion Criteria

Studies were included if they:

Focused on biomass energy or agricultural residues

Examined pearl millet or similar cereal crops

Provided data on energy properties, emissions, or socioeconomic impacts

Were conducted within sub-Saharan Africa or comparable regions

Exclusion Criteria

Studies lacking empirical or theoretical relevance to biomass energy or those with insufficient methodological detail were excluded.

Data Analysis

Selected studies were critically analyzed and categorized into thematic areas, including energy potential, environmental benefits, household energy use, and policy challenges.

Pearl Millet and Its By-products

Pearl millet (*Pennisetum glaucum*) generally applied to various grass crops whose seeds are harvested for human food and animal feeds. It is drought-tolerant, generally suited to less fertile soil and poorer growing conditions such as intense heat, low rainfall and requires shorter growing season, Prasad and Staggenborg, (2013). When used as grain, they are considered cereal. It is a tropical plant which is referred to as the "camel" for its exceptional ability to tolerate drought. It is believed to have descended from West Africa wild grass which was domesticated more than 40,000 years ago. Its spread has been through East Africa and then to India. Today millet is a staple food for more than 50 million people in Sahelian and Sudano sahelian zone of West Africa, (Srivastava et al., 2020). Pearl millet is among other varieties of millets and account for almost half of global millet production.

Pearl millet is one of the oldest millets used by our ancestors along with wheat flour and was included in the regular diet primarily in Africa and Asia, especially at the site of Karkanchikatsud and Nord in Mali at about 3500-2500BC, (Fumucane et al., 2008). It is one of the most widely cultivated cereals in the Sahel region, contributing significantly to food and energy systems (Chakravarty et al., 2017). It has been used in Africa and India as a staple food for thousands of years and was grown as early as 2700 BC in China (Global Landscapes Forum, 2023; Steyn, 2023). Increasing the consumption of pearl millet supports farmers in dryland areas by encouraging the cultivation of crops best suited to the prevailing agro-ecological conditions, thereby promoting sustainable cropping practice and dietary diversity. It is the staple food crop for some of the most economically disadvantaged communities in the Sahelian zone of Nigeria, particularly in Borno and Yobe States.

It is tolerant to drought and well adapted to poor soils and has high resistance to disease, suited to hot and dry agro- ecological area where it is difficult to grow other grain crops. According to Mustapha and Adzemi, (2014), Pearl millet remains the only food crop that has promise of food security for the growing world population under the changing global climate, and production of food is one of the most important objectives of agriculture. The crop is widely cultivated in Yobe State, and the Key by-products includes: Husks which is Lightweight, fibrous material removed during milling: Stalks, a Cellulose-rich plant stems remaining after harvest and Bran: the outer layers of grain removed during processing. These residues are typically discarded, burned in open fields, or used as low-grade fodder. However, they possess bioenergy potential. This crop is cultivated in all the three agro-ecological zones of Yobe state, as it is presented in figure 1.

A chart of Pearl millet producing zones in Yobe State.



Figure 1.

Source: Adopted from FAO, 2021.

Energy Potential of Pearl Millet By-products

Pearl millet by-product possesses the potential to function as a form of clean energy, thereby augmenting the resilience to climate change in less favorable areas. The incorporation of agricultural residues, such as sorghum panicles and pearl millet, in the manufacturing process of briquettes can lead to a decrease in environmental contamination as well as a reduction in the dependence on fossil fuels (Mihiretu, Assefa & Wubet, 2023).

Several attempts have been made by different scholars to provide empirical evidence, on the potential of pearl millet by-products for clean energy for climate change resilience in the Sahelian region of West Africa including Northern Nigeria. But little has been done in Yobe state. Most evidences are linked to how to produce the Biofuel of ethanol for alternative energy sources. These briquettes possess numerous advantages. Firstly, they embody a sustainable approach by utilizing agricultural waste, thereby promoting resource efficiency and diminishing waste. Secondly, pearl millet is an annual crop, rendering the source of the briquettes renewable. Thirdly, the carbon footprint associated with these briquettes is low. While the combustion of pearl millet briquettes does emit carbon dioxide, the net emissions of carbon dioxide are relatively minor when compared to those stemming from fossil fuels. Studies have demonstrated the calorific value and combustion efficiency of agricultural residues such as millet husks (Han et al., 2020; Zaku, et al., 2013), have calorific values ranging between 13–18 MJ/kg. Compared to firewood (16–20 MJ/kg), they are suitable for combustion when densified into briquettes. Properties: Low moisture content after drying, moderate ash content and high volatile matter, aiding ignition.

Table 1:
Comparative Calorific Values of Biomass Materials.

Biomass Material	Calorific Value (MJ/kg)	Ash Content (%)	Moisture Content (%)
Pearl Millet Husk	14.5	3.2	10 – 12
Pearl Millet Stalk	15.1	4.0	11 – 13
Wood (firewood, mixed)	16.8	1.5	20 – 25
Charcoal	28.0	1.0	5 – 8
Sawdust Briquette	17.2	2.8	10 – 12
Maize Cob	13.7	3.5	9 – 11

Sources: Odufuwa et al., 2022

Household Energy Use in Yobe State

Most households in Yobe State rely on firewood or charcoal for cooking, with limited access to kerosene and liquefied petroleum gas (LPG). Household energy use encompasses a broad range of sources, including coal, crude oil, natural gas, petroleum products, and electricity. As underscored by the BP. (2018), energy is an essential commodity for modern domestic life (Danlami et al., 2017; Heltberg, 2005). The welfare of a household is closely linked to the type and manner in which energy is accessed and utilised. Olanrewaju and Adegun (2021) examined energy consumption in residential sectors in a low-income neighbourhood in Akure, Nigeria, focusing on the energy requirements of everyday domestic activities.

The findings revealed that fossil fuel sources predominantly contribute to the energy supply in such neighbourhoods, with a significant proportion allocated to cooking purposes. Olanrewaju and Adegun (2021) noted, however, that their study was limited to energy consumption per head per meal and relied solely on questionnaire data, without laboratory analysis to quantify carbon emissions or their environmental impact. Heltberg (2005) identified a positive and significant relationship between household income and the adoption of liquefied petroleum gas (LPG). Ongoing research encourages households to transition from non-clean energy sources to cleaner alternatives (Ritchie et al., 1982; Danlami et al., 2017), given the widely recognised benefits of clean energy adoption for household wellbeing. It is broadly argued in the literature that adopting clean fuels can substantially improve the quality of life for households that are heavily reliant on biomass (Yousaf & Agrawal, 2019). Key barriers to clean energy access include high costs, poor distribution networks, and low public awareness. Millet-based briquettes, being locally producible from readily available agricultural residues, offer a promising means of reducing fuel costs and decreasing dependence on unsustainable biomass sources.

Environmental and Climate Resilience Benefits

Clean energy not only provides household resources but also helps in maintaining clean air and reducing air pollution. Several studies have established a positive relationship between household income and the adoption of clean energy (Ozcan et al., 2013; Couture et al., 2012; Osiolo, 2010). Research conducted by Bailis et al. (2005) delves into the promotion of a more sustainable environment through the reduction of biomass usage.

The study highlights that economically disadvantaged households, particularly in developing nations, tend to rely on firewood, charcoal, and other unclean energy sources, while wealthier households opt for cleaner energy alternatives. To gather data, the researchers employed the cluster area sampling technique, analyzing a total of 539 respondents. By employing the ordered logit model, the study estimated the factors influencing the transition of households from nonclean energy to cleaner energy. Additionally, the Ordinary Least Squares (OLS) model was utilized to examine the impact of socioeconomic, residential, and environmental factors on biomass energy consumption. The findings reveal that in urban areas, the age and education level of the household head, as well as income, have a positive correlation with the adoption of cleaner energy sources as it Reduced Deforestation: Lower firewood demand preserves tree cover. It is important to note that over 2 billion individuals in developing nations rely on accessible energy sources to fulfil their daily energy requirements (Nzabona et al., 2021). However, this growing trend raises significant environmental concerns due to the emission of greenhouse gases and air pollution (Namaalwa et al., 2009), with associated increases in annual mortality from respiratory infections (Lambe et al., 2015; Ogundipe, et al., 2018). Studies conducted in Kenya have also highlighted escalating utilisation of firewood and charcoal for cooking (Lung & Espira, 2019), which drives increases in carbon dioxide emissions and consequently in greenhouse gas concentrations. Addressing these trends necessitates the adoption of cleaner energy alternatives such as biomass briquettes particularly pearl millet briquettes, which emit substantially less CO₂ and CO. Additional co-benefits include improved soil health through biochar application from controlled burning, and gender equity gains from reduced time burdens on women associated with fuelwood collection.

Challenges and Gaps

Limited technical expertise and lack of supportive policies remain major bottlenecks (Njagi, 2016; Etim et al., 2018). The following are the challenges identified for making pearl millet by-products as a clean energy source for household cooking in Yobe State, Nigeria;

- i. Lack of Technical Knowledge on Briquette Production. Many rural households and small-scale producers lack the technical capacity required for the effective production of briquettes from pearl millet by-products (such as stalks, husks, and bran). This includes inadequate knowledge of: Biomass preprocessing techniques (drying, grinding, binding), Briquetting machinery operation and maintenance,

- Safety standards and combustion optimization and Quality control and durability testing.
- ii. The lack of training limits local innovation and scale-up potential. Without proper knowledge transfer, efforts to promote millet briquettes remain confined to isolated attempts rather than widespread adoption.
 - iii. Limited Pilot Projects or Field Trials. There is a noticeable absence of pilot demonstration projects or field trials to test the feasibility and acceptance of millet briquettes among local communities. This creates several bottlenecks: Communities have little to no exposure to millet briquettes as an alternative to firewood or charcoal. There is no empirical basis for evaluating household preferences, cooking behaviour, or potential fuel savings. Government and NGOs lack evidence for policy formulation and investment decisions due to minimal field data or impact evaluations. Without pilot projects, there is no clear pathway to mainstreaming millet briquette use in domestic energy systems.
 - iv. No Formal Policy Support for Millet-Based Energy. Current renewable energy or rural development policies in Nigeria and specifically in Yobe State do not explicitly recognize or incentivize the use of agro-waste like millet residues for clean cooking. The consequences include: Lack of funding for research and development initiatives on millet-based briquettes. No subsidies or tax incentives for small-scale briquette producers. Limited integration of millet-based energy into broader energy transition and climate adaptation strategies. This policy vacuum discourages private sector involvement and prevents coordinated efforts across sectors (energy, agriculture, environment etc).
 - v. Inadequate Data on Emission Performance in Local Settings. Most available data on biomass briquette emissions are based on laboratory settings or generalized estimates from other regions or feedstocks. For Yobe State and the Sahel region, specifically: There is no localized measurement of indoor air pollutants (e.g., PM_{2.5}, CO, VOCs) from burning millet briquettes. Comparative data between millet briquettes and traditional fuels (firewood, charcoal) are largely missing. Absence of data limits health impact assessments and impairs the case for millet briquettes as a cleaner fuel. Inadequate emissions research also hinders compliance with international clean energy benchmarks (e.g., WHO indoor air quality standards).

Discussion of Findings

Taken together, the thematic findings of this review indicate that pearl millet by-products represent a technically viable and contextually appropriate household energy resource for Yobe State. With respect to RQ1, the evidence confirms that millet husks and stalks possess calorific values of 14.5–15.1 MJ/kg comparable to, and in some cases approaching, the energy density of mixed firewood and that their combustion properties (low moisture content, moderate ash content, and high volatile matter) are consistent with effective

briquette performance when the residues are adequately dried and densified. While these values are lower than charcoal, they are sufficient for domestic cooking when briquettes are produced to an appropriate density, as demonstrated in analogous studies using sorghum and maize cob residues across the Sahel (Mihiretu et al., 2023; Yank et al., 2016). This evidence addresses the energy viability question affirmatively, albeit with the important qualification that local combustion performance data specific to Yobe State conditions remain absent from the literature.

With respect to RQ2, the environmental and socioeconomic benefits identified across the reviewed literature are broadly consistent, though they are derived predominantly from studies of comparable biomass fuels rather than pearl millet briquettes specifically. The evidence for reduced deforestation, lower indoor air pollution, and greenhouse gas emission reduction is robust at the general biomass level (Bailis et al., 2005; Namaalwa et al., 2009), and is plausibly transferable to millet briquettes given their similar combustion profile. The socioeconomic benefits particularly reduced fuel expenditure, local employment creation, and reduced time burdens on women are likewise supported by comparable briquette adoption studies in Uganda and Ethiopia (UNDP, 2019; Mihiretu et al., 2023). However, the degree to which these benefits materialise in the specific Yobe State context is likely conditioned by local market structures, gender norms, and the availability of briquetting equipment, all of which require empirical investigation at the community level.

On RQ3, the barriers identified limited technical knowledge, policy absence, inadequate financing, and data gaps are consistent with challenges documented in analogous Sahelian and sub-Saharan contexts. Importantly, each of these barriers has been partially or substantially addressed in comparable settings: community briquetting cooperatives in Uganda have overcome knowledge and capital constraints through collective organisation and NGO partnership (UNDP, 2019); Nigeria's NREEEP provides an existing policy vehicle for integrating agro-waste energy; and microfinance schemes in Ethiopia have demonstrated their effectiveness in supporting small-scale biomass energy enterprises (Mihiretu et al., 2023). The implication is that the barriers facing Yobe State are not intractable, but will require deliberate coordination between the agriculture, energy, and development sectors. This review's contribution relative to prior literature is its consolidation of these three dimensions energy potential, benefits, and barriers within a single Yobe State-focused analytical framework, an integration that has been absent from the existing literature on millet energy in Nigeria's Sahelian zone.

This review is subject to several limitations that should be acknowledged. First, the evidence bases for pearl millet briquettes specifically as distinct from biomass briquettes more broadly is limited, requiring reliance on extrapolation from analogous feedstocks and contexts. Second, the review was restricted to English-language sources, which may have excluded relevant findings published in French or Hausa, particularly from Francophone West African countries with comparable agroecological conditions. Third, the absence of

localised emissions and combustion data for Yobe State means that the review's conclusions on environmental performance are inferential rather than empirically grounded for the target context. These limitations do not undermine the review's contribution but underscore the urgency of primary field research to validate and extend the findings presented here.

Conclusion

Pearl millet by-products represent an underutilized but promising resource for clean and sustainable household cooking energy in Yobe State. As a staple crop widely cultivated across the Sahel region, millet generates substantial agricultural waste most of which is currently discarded or burned inefficiently. Harnessing millet by-products can play a transformative role in addressing energy poverty and climate resilience. Harnessing these residues through briquette production offers a triple-win solution: it provides affordable energy, reduces pressure on forest resources, and enhances public health by lowering indoor air pollution. Moreover, such practices contribute meaningfully to climate change resilience by decreasing greenhouse gas emissions and diversifying rural livelihoods. However, realising this potential demands a multi-sectoral and inclusive approach. Collaboration among stakeholders in agriculture, renewable energy, environmental management, and gender development is essential to overcome technical, financial, and policy-related barriers. Women and youth must be central to implementation efforts, given their active roles in both cooking and farming systems. Promoting pearl millet briquettes is therefore not only an energy solution but also a strategic pathway toward sustainable development, local empowerment, and climate adaptation in Yobe State and beyond. This review has addressed its stated objective by synthesising available evidence on the energy potential of pearl millet by-products (RQ1), their environmental and socioeconomic benefits for climate resilience (RQ2), and the barriers and enabling strategies relevant to their adoption (RQ3). The primary knowledge contribution of this review is the consolidation of a dispersed body of evidence into a policy-relevant analytical framework specific to the Yobe State context, providing a foundation upon which future empirical research and programme design can be built.

Recommendations

Community briquetting models have succeeded in Uganda and present a replicable model for Yobe State (UNDP, 2019). The following four policy recommendations are proposed, listed in order of implementation priority, with Recommendation i considered the most immediately actionable given its reliance on existing community structures and low capital requirements:

- i. Promote Decentralized Briquetting Units Using Community Models. To ensure sustainability and local ownership, decentralised briquetting systems should be established at the community level. These units can be managed through

- cooperatives, women-led associations, or farmer groups. Community-based briquetting models will promote local employment and skills development, easier access to raw millet residues, and efficient distribution networks within rural areas. Government and development agencies can support this through start-up grants, low-cost equipment provision, and business training.
- ii. Incorporate Millet By-products into Nigeria's Renewable Energy Framework. Pearl millet residues should be formally recognised as a renewable energy resource under national and state-level energy policies. This will enable their inclusion in subsidy schemes or clean energy funds, support policy incentives for research and innovation in agro-waste energy, and facilitate integration into Nigeria's National Renewable Energy and Energy Efficiency Policy (NREEEP). Such mainstreaming will enhance policy coherence across the agriculture and energy sectors.
 - iii. Provide Microfinance and Technical Support for Local Producers. A principal barrier to briquette production is the lack of start-up capital and technical knowledge. Provision of microcredit schemes with low-interest rates, targeted capacity-building workshops on briquette technology, and access to maintenance services and spare parts will empower small-scale entrepreneurs and youth to participate actively in the millet briquette value chain, thereby stimulating local economies.
 - iv. Integrate Clean Cooking Energy Awareness into Agricultural Extension Services. Agricultural extension officers in Yobe State are well positioned to promote clean energy from millet by products. Through tailored awareness programmes, extension services should educate farmers on the economic value of crop residues, demonstrate briquetting methods and proper usage, and highlight the health and environmental benefits of transitioning from firewood to briquettes. This approach leverages existing institutional structures to drive behavioural change at the grassroots level.

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