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The Potential for Biomass Energy Derived from Agricultural Residues in Somalia

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Abstract

The aim of this study is to evaluate the potential for biomass energy derived from agricultural residues in Somalia. Somalia, a country characterized by agrarian practices and substantial agricultural output, holds promising potential for biomass energy generation from agricultural residues. This study explores the feasibility and capacity of utilizing crop residues, such as maize stalks, sorghum stalks, and other agricultural by-products, for energy production. Through field surveys, biomass characterisation, and feasibility assessments, the study evaluates the availability of agricultural residues and their energy conversion potential using technology like biomass. Factors such as resource availability and economic viability are considered to determine the practicality of scaling biomass energy initiatives in Somalia. The findings underscore the significant role that biomass energy can play in enhancing energy security, rural development, and environmental sustainability in the region. The annual volume of agricultural residues generated by crops in Somalia, measured in tons of dry material, was assessed using agricultural production data from the Food and Agriculture Organization Statistical Database of the United Nations (FAOSTAT) for the year 2021. The total yearly potential of agricultural residues was determined based on the residue-to-product ratio (RPR). The estimated total amount of agricultural residues in Somalia, including annual crop residues, is approximately 2.9 kilotons (kt). The primary crops contributing to this total are sorghum (68.33%), maize (20.18%), and dry beans (10.72%). Somalia possesses a significant amount of raw materials that can be used for energy production from agricultural residues. The estimated total energy potential of these residues for the 2021 production period is approximately 41.4 terajoules (TJ).

Somali'de Tarımsal Artıklardan Elde Edilen Biyokütle Enerjisi Potansiyeli

Özet

Bu çalışmanın amacı, Somali'de tarımsal artıklardan elde edilen biyokütle enerjisi potansiyelini değerlendirmektir. Tarımsal uygulamalar ve önemli tarımsal çıktı ile karakterize edilen bir ülke olan Somali, tarımsal artıklardan biyokütle enerjisi üretimi için umut verici bir potansiyele sahiptir. Bu çalışma, mısır sapları, sorgum sapları ve diğer tarımsal yan ürünler gibi ürün artıklarının enerji üretimi için kullanılmasının fizibilitesini ve kapasitesini araştırmaktadır. Saha araştırmaları, biyokütle karakterizasyonu ve fizibilite değerlendirmelerinin bir kombinasyonu yoluyla çalışma, tarımsal artıkların mevcudiyetini ve biyokütle gibi teknolojiler kullanılarak enerji dönüştürme potansiyellerini değerlendirmektedir. Somali'de biyokütle enerjisi girişimlerinin ölçeklendirilmesinin pratikliğini belirlemek için kaynak mevcudiyeti ve ekonomik uygulanabilirlik gibi faktörler dikkate alınmaktadır. Bulgular, biyokütle enerjisinin bölgede enerji güvenliğini, kırsal kalkınmayı ve çevresel sürdürülebilirliği artırmada oynayabileceği önemli rolün altını çizmektedir. Somali'de mahsullerden kaynaklanan yıllık tarımsal atık miktarı, kuru madde olarak ifade edildiğinde, Birleşmiş Milletler Gıda ve Tarım Örgütü İstatistik Veritabanı'ndan (FAOSTAT) alınan 2021 yılı tarımsal üretim verileri kullanılarak değerlendirilmiştir. Tarımsal atıkların toplam yıllık potansiyeli, atık-ürün oranına (RPR) göre hesaplanmıştır. Yıllık mahsul artıkları dahil olmak üzere Somali'deki toplam tarımsal atık miktarının yaklaşık 2.9 kiloton (kt) olduğu tahmin edilmektedir. Somali'deki toplam atık miktarına katkıda bulunan birincil ürünler sorgum (%68.33), mısır (%20.18) ve kuru fasulyedir (%10.72). Somali, tarımsal atıklardan enerji üretimi için önemli miktarda hammadde tedarik etmektedir. Bu atıkların toplam enerji potansiyelinin Somali'deki 2021 üretim dönemi için yaklaşık 41.4 TJ olduğu tahmin edilmektedir.

1. INTRODUCTION

The growing trends in urbanization, population expansion, economic progress, and technological innovations have significantly amplified the global demand for energy (Samatar et al., 2023). Energy is a key driver of economic development, with a clear correlation between energy consumption and living standards (Karaca, 2015). Energy sources are typically categorized into three main groups: fossil fuels, renewable sources, and nuclear sources (Karaca, 2017). In numerous countries, including Somalia, heavy dependence on fossil fuels is a significant issue. The ongoing preference for obtaining relatively inexpensive energy primarily through coal combustion often outweighs the commitment to preserving a healthy environment (Samatar et al., 2023). Fossil fuel resources are depleting steadily, and nuclear energy continues to face security concerns. Therefore, the optimal approach is to prioritize renewable energy sources, which are abundantly available everywhere and every day (Demirel et al., 2019).

A key element in achieving sustainable development is the need for clean and dependable energy. Renewable energy systems capture energy from renewable sources and transform it into usable forms (Ayik et al., 2020). Renewable energy plays a crucial role in achieving sustainable economic and social development, particularly in alleviating poverty and shifting towards sustainable patterns of production and consumption. It is closely linked to efforts aimed at preserving and protecting resources in support of sustainable development goals. One of its primary benefits is environmental protection, which has motivated many countries to prioritize the development of renewable energy sources (Aicha, 2024).

Renewable energy represents a sustainable form of energy production that does not face the risk of resource depletion. Common types of renewable energy include wind, hydropower, power, geothermal energy, solar energy, tidal energy and biomass energy (Abdalla & Qarmout, 2023). The utilization of renewable energy sources for electricity generation has garnered significant attention due to several advantages. These include favourable environmental effects, affordability, reliability, and the ability to be renewed and reused (Ladu et al., 2022).

Biomass energy includes agricultural residues, household waste, fuelwood, animal waste, and other fuels derived from biological sources (Karaca, 2017). Biomass resources are widely recognized worldwide as a sustainable alternative energy source due to their abundance, renewability, and carbon-neutral properties (Djimtoingar et al., 2022). The successful use of biomass for energy needs has been demonstrated across various economies. Biomass energy is among the many clean energy sources that have seen rapid development. The rise in global energy demand, depletion of fossil fuels, and concerns about global warming have prompted many countries to conduct short, medium, and long-term prospective studies to explore measures focused on energy conservation and sustainable development (Saiah & Stambouli, 2017).

This study aims to assess the potential for biomass energy production from agricultural residues in Somalia. It involves evaluating the availability and types of agricultural residues, estimating the energy yield that can be obtained from these materials, and examining the feasibility and sustainability of utilizing these resources for energy generation. The study seeks to provide insights into how agricultural residues can contribute to Somalia's energy mix, promote energy security, and support sustainable development.

2. MATERIAL AND METHOD

2.1. Agriculture in Somalia

Somalia covers a total area of 637,540 Km2, with 30% of this land being desert, unsuitable for agriculture. Rangelands, which are suitable for livestock grazing, account for 45% of the land. Forests and woodlands make up 14%, while the remaining 11% is arable land. Agriculture is a key employment sector and the primary foundation of Somalia's economy, contributing 60.1% to the country's GDP (Ali Abdulahi, 2022). In Somalia, the agriculture sector is the backbone of the economy, contributing approximately 75% to the GDP and 93% to the country's total export earnings. However, the development of a robust agricultural sector is impeded by various political, economic, and environmental factors (Amare, 2021).

Agricultural production in Somalia has stagnated since the 1960s. This stagnation can be attributed to a lack of technological advancements, political instability, and a deficiency in the human capital necessary for enhancing agricultural output (Warsame et al., 2023). Climate change presents a major threat to sustainable global food security. Shifts in temperature and rainfall patterns negatively impact crop production, especially in many developing nations that depend heavily on agriculture (Ali Warsame & Hassan Abdi, 2023).

The primary source of risk for sustaining global food security has increasingly become the unpredictable climatic conditions. Multiple factors, including shifts in rainfall patterns, increasing temperatures, variations in soil moisture, alterations in the hydrologic cycle, and changes in evapotranspiration, influence the types of crops cultivated and impact the timing of planting and harvesting. Climate change has significantly impacted Somalia's primary food crops, such as maize, sorghum, rice, wheat, and beans, leading to declining productivity in recent years. This trend underscores the transformative influence of climate change on the productivity of Somalia's essential crops and poses a threat to its efforts towards achieving food security (Abdi et al., 2024).

2.2. Assessment of Biomass Energy

Conducting a thorough inventory and assessment of available agricultural residues. This involves measuring the types and quantities of residues produced annually from major crops like maize, rice, sorghum, and other agricultural by-products. The key challenges in utilizing biomass for energy production include the logistics of collection and transportation, along with its seasonal availability. These factors lead to considerable fluctuations in biomass supply, occasionally making it an unreliable energy source (Karaca, 2017).

The annual amount of agricultural residues generated by crops in Somalia, expressed in tons of dry material, was assessed using agricultural production data from the Food and Agriculture Organization Statistical Database of the United Nations (FAOSTAT) for the year 2021. The total yearly potential of agricultural residues was determined based on the residue-to-product ratio.

The residual net potential was assessed by accounting for the availability of residues, which includes the unused and completely wasted portion of the residues. The achievable potential of agricultural residues in Somalia was computed using Equation (1) (Karaca, 2015).

$$(AAR)_i = (ACP)_i \text{ x } (RPR)_i \text{ x } (A)_i \qquad (1)$$

where, $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in ton; $(ACP)_i$ is the amount of crop production in tons; $(RPR)_i$ is the residue-to product ratio of the i^{th} crop and $(A)_i$ is the availability of residues.

Table 1. The residue-to-product ratio, availability, and calorific value of different field crop residues (Demirel et al., 2019, Karaca, 2015, Karaca et al., 2017, Karaca, 2017).

Field Crops	Residues	Residue to Product	Availability (%)	Calorific Value (LHV) $(MJ.kg^{-1})$
Beans, dry	Stalk	0.029	40	19.4
Maize (corn)	Stalk	0.013	60	17.95
Rice	Straw	0.019	60	14.92
Sorghum	Stalk	0.033	60	12.38
Wheat	Straw	0.021	15	18.20

Agricultural residues encompass materials that remain in fields after agricultural activities. While some residues are reused domestically for purposes such as heating, animal feed, and bedding, a significant portion of residues from industrial agricultural practices often remain unused in the fields. These residues may consist of cotton stalks, maize stalks, sunflower stalks, cereal straw, and other similar materials.

To determine the energy potential of residues, the calorific values of specific agricultural residues, as outlined in Table 1, were multiplied by the quantities of available residues, using Equation (2) (Karaca, 2015).

$$(EP)_i = (AAR)_i \text{ x } (LHV)_i \qquad (2)$$

where $(EP)_i$ the energy potential of agricultural residues of i^{th} crop in GJ, $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in tons and $(LHV)_i$ lower heating value of air dry residues of i^{th} crop in $MJ.kg^{-1}$.

Assess existing infrastructure and logistical constraints related to biomass collection, storage, transportation, and processing. Identify gaps and opportunities for improvement to optimise biomass utilisation.

3. RESULTS AND DISCUSSION

Table 2. The total agricultural production and crop residues in Somalia were evaluated using FAOSTAT data from 2021 (FAOSTAT, 2021).

Field Crops	Amount of Crop Production (Ton)	Residues	Total Potential of Residues (Ton)
Beans, dry	26789.94	Stalk	788.9
Maize (corn)	75000	Stalk	981.8
Rice	1632.35	Straw	30.3
Sorghum	100000	Stalk	3252.7
Wheat	1053.08	Straw	22.5
Total	**204475.37**	**Residues**	**5076.2**

Somalia possesses a substantial supply of raw materials for energy production from agricultural residues. The total energy potential of these residues for the 2021 production period was estimated to be approximately 41.4 terajoules (TJ). Table 3 presents the heating values of agricultural residues along with the corresponding available quantities calculated for each individual product.

Table 3. The total energy potential and the corresponding amount of available agricultural residues in Somalia.

Field Crops	Residues	AAR	Total energy potential (EP) (GJ/kg)
Beans, dry	Stalk	310.8	6029.5
Maize (corn)	Stalk	585	10500.8
Rice	Straw	18.6	277.5
Sorghum	Stalk	1980	24512.4
Wheat	Straw	3.3	60.1
Total	**Residues**	**2897.7**	**41380.3**

The total quantity of agricultural residues in Somalia, including annual crop residues, was estimated to be around 2.9 kilotons (kt).

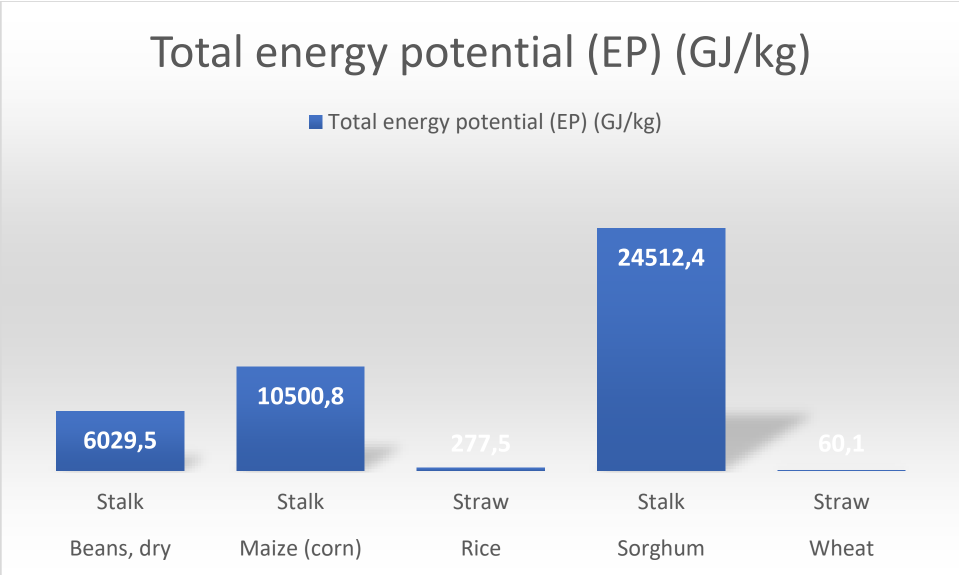

Figure 1. Total energy potential for different crop residues in Somalia

The main crops contributing to the total amount of agricultural residues in Somalia are sorghum (68.33%), maize (20.18%), and dry beans (10.72%).

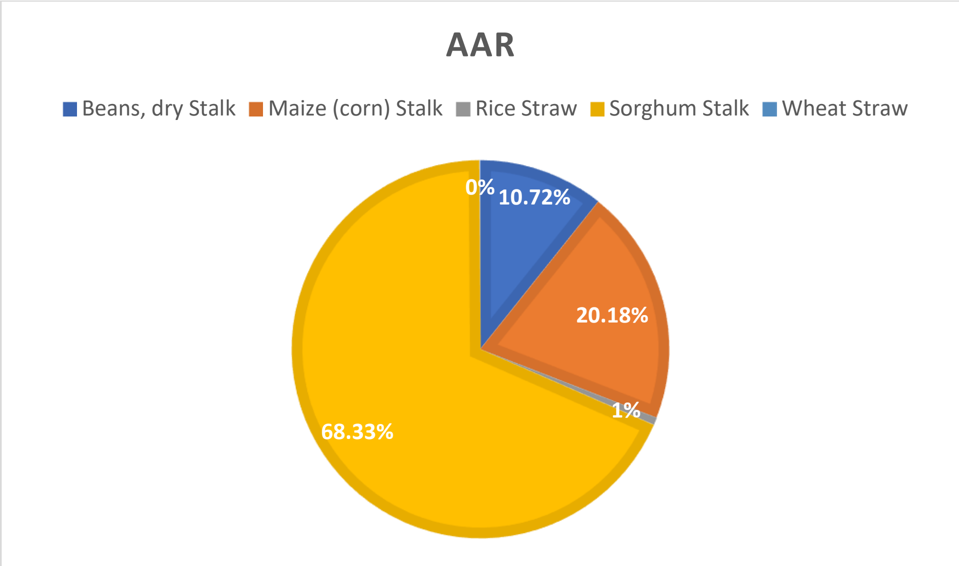

Figure 2. Amount of agricultural residues in Somalia (ton)

4. CONCLUSION

The study aims to offer a comprehensive understanding of how agricultural residues can be leveraged to support sustainable energy development in Somalia. The potential for biomass energy derived from agricultural residues in Somalia is substantial but currently underutilized. Agricultural residues such as maize stalks, sorghum stalks, bean dry stalks, and other crop by-products present a viable resource for energy production through technologies like biomass gasification and anaerobic digestion. However, several challenges, including inadequate infrastructure, limited technological expertise, and economic barriers, hinder widespread adoption. Addressing these challenges requires targeted investment in infrastructure development, capacity building, and policy support to promote sustainable biomass energy initiatives.

Harnessing Somalia's agricultural residues for energy not only offers a renewable alternative to fossil fuels but also contributes to rural development, energy security, and environmental sustainability. Future efforts should focus on fostering partnerships between the government, the private sector, and international organizations to unlock the full potential of biomass energy in Somalia. Somalia possesses a substantial supply of raw materials for energy production from agricultural residues. The total energy potential of these residues was calculateed to be approximately 41.4 TJ for the 2021 production period.

4.1. Recommendations

- Develop and improve infrastructure for biomass collection, storage, and transportation to facilitate efficient utilization of agricultural residues for energy production.

- Promote technology transfer and provide training programs to local communities and stakeholders on biomass energy technologies like biomass gasification and anaerobic digestion.

- Implement supportive policies and regulations that incentivize the use of agricultural residues for energy production, including subsidies, tax incentives, and feed-in tariffs.

- Foster collaborations between government entities, private sector stakeholders, and international organisations to mobilise financing, expertise, and resources for scaling up biomass energy projects.

- Encourage research and development initiatives to optimise biomass conversion technologies, improve efficiency, and explore new uses for agricultural residues beyond energy production.

- Involve local communities in decision-making processes and project planning to ensure their needs and concerns are addressed, promoting social acceptance and sustainability of biomass energy projects.

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