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Assessment of Adoption, Market Potential and Environmental Impact of Carbonized Briquettes Among Farmers in Western Uganda's Beef-Producing Regions

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Abstract: A lot of agricultural residues are generated each year in developing and developed countries. About 60-70% of the total Agricultural biomass is left in the fields annually in Uganda. Making Briquettes helps to turn waste into wealth, saves money and provides an alternative for firewood and charcoal. This study was developed to assess the adoption and market potential of carbonized briquette production among farmers in beef producing communities in Uganda. NARO introduced briquettes making in the beef producing communities of Isingiro, Mbarara and Masindi districts. After four months, an adoption study was conducted to determine how many farmers continued to produce, use and sell the briquettes. Approximately 58.2%, 50.6% and 66.7% farmers were found producing and using briquettes in Isingiro, Masindi and Mbarara districts respectively. Farmers mostly used cow dung (82%) as binders and charcoal dust (83%) as class B material. Over 93% farmers used briquettes to cook their food while 57.4% saved money on buying traditional fuels, and 49.5% mentioned that briquettes lasted longer while cooking respectively. Farmers in all the three districts produced 447.5 basins of briquettes which generated 6,712,500shs in revenue at a price of 15,000shs/basin of briquettes. Briquettes making can help the farmers in beef producing communities to earn income, while reducing agricultural waste, tree cutting and protecting the environment.

Keywords: Renewable Energy, Waste Management, Fuel Energy, Environmental Protection, Agricultural Residues, Briquettes, Biofuels

1. Introduction

A lot of agricultural waste is generated every year in developing and developed countries. A significant increase in agricultural waste has been observed globally as developing countries intensify agricultural systems due to global increase in population [1]. When products are harvested from crops, only grains, fruits, pods and tubers are removed, which represents about 30-40% of the total biomass. Approximately 60 to 70% of the agricultural biomass produced annually in Uganda is not harvested and remains as residue in the fields. Only a small portion is utilized as feed for livestock, and the remaining biomass is left unused. Biomass is the primary source of energy in Uganda, accounting for 90% of the total energy consumption, which can be classified into three categories: firewood (78.6%), charcoal (5.6%), and crop

residues (4.7%) [2].

Incorporating agricultural residues into the production of briquettes not only reduces the amount of waste generated in the agricultural sector but also helps to minimize the consumption of fossil fuels, making it a sustainable and eco-friendly alternative to traditional fuel sources [3]. It also solves the problem of waste disposal and deforestation by providing a substitute for firewood [4]. Making briquettes also has economic benefits. In Uganda, briquette making has also helped some citizens save money, cut energy costs in half and turn waste into wealth [5].

During briquette production, there are characteristics to consider before qualifying the raw material for briquetting. The moisture content should be between 8 and 12% [6]. A low ash content of less than 4% is desirable. Other biomass characteristics to consider include high caloric value, no major alternative uses, and low nutritional value to avoid food resource problems. Briquetting improves the energy characteristics of biomass through densification, thus reducing the total volume needed for the same energy value [7].

Over the past two decades, several studies have been developed to develop briquettes from agricultural waste. Ifa, L. etc. [8] produced bio briquettes from cashew nutshell waste obtained from South West Sulawesi, Indonesia, Nuriana. W. etc. [9] developed and tested bio briquettes from durian's peels and Ahmad K. etc. [10] developed briquettes as a source of biomass fuel using banana tree waste. In addition, several studies have been conducted to assess the social and economic factors which influence wide production and adoption of briquettes in developing countries. The use of biomass briquettes has been severely limited due to factors like poorly developed supply chain structures [11], lack of appropriate government backed policies [12] and lack of suitable technologies for biobased economies [13].

In Uganda, studies have also been conducted to assess the production, distribution and factors that affect biomass acceptability in communities. Briquettes have been produced locally from coffee husks [14], groundnut shells and bagasse [15] and municipal organic solid waste [16]. Mahoro. B. etc. [17] conducted a study on the different types of biomass briquettes and briquette making technologies that are available in Uganda while Mugabi. P. etc. [18] assessed the production and distribution of briquettes in urban areas by interviewing briquette consumers and producers in Kampala district. However, most of these studies do not address the context of farmers in rural beef producing communities who may have different motivations, challenges, and opportunities compared to briquette consumers and producers in other regions, which can affect their willingness to adopt new technologies and their ability to access markets for their products.

This paper aims to contribute to the understanding of the potential of carbonized briquette production as a sustainable and cost-effective alternative to traditional charcoal production, particularly in rural contexts such as beef producing communities in Western Uganda. In particular, the paper will further highlight the potential for carbonized briquettes to reduce deforestation, conserve biodiversity, and mitigate climate change, while also contributing to the global Sustainable Development Goals.

2. Methods

The study was an activity within a larger project, 'Market Oriented and Environmentally Sustainable Beef Industry in Uganda (MOBIP), with NARO's intervention specifically focused on improving the competitiveness and productivity of the beef sub-sector by promoting sustainable, inclusive and gender-sensitive management of rangelands, agroforestry and water resources (RAWM-Beef). Interventions were implemented in 9 districts; Kiboga, Kyankwanzi, Nakasongola, Nakaseke Mbarara, Kiruhura, Isingiro, Masindi and Ssembabule. This study was carried out in Isingiro, Mbarara and Masindi. Focus group discussions were conducted with nine women and youth groups in Isingiro, Mbarara and Masindi. This was done to establish what women and youth saw as business opportunities in the area of crop-livestock interactions. After four months, an adoption study was conducted to determine how many people took over the business and produced, used and sold the briquettes. The study was also to establish the advantages and problems associated with the production, use and sale of briquettes. Suggestions for improvement were requested from young people and women. Semi-structured questionnaires were developed and pre-tested on 6 people. Corrections were made and improved questionnaires were produced. These were administered to the youths and women by the research group. Sampling was done randomly from farmers who participated in the training and demonstrations of the interventions that were introduced in the different sub-counties of Masindi, Isingiro and Mbarara districts. A total of 179 farmers were selected from the three districts. The descriptive statistics were conducted using the Excel program through pivot tables.

3. Results and Discussion

3.1. Education Levels of Interviewed Farmers

Table 1. *Literacy levels of interviewed farmers.*

Percentage of interviewed farmers at different levels of education			
Level of education	**Isingiro (%)**	**Masindi (%)**	**Mbarara (%)**
Adult education	1.5	0	0
No Education	11.9	11.4	15.2
Primary	56.7	55.7	48.5
Secondary	23.9	30.4	24.2
Tertiary	6	2.5	12.1

56.7%, 55.7% and 48.5% of the farmers in Isingiro, Masindi and Mbarara districts were educated only up to the primary level. About 11% - 15% farmers were not educated at all. This suggested that future educational programs aimed at promoting briquette production would need to be tailored to the educational background of farmers in the area. Given that a significant proportion of farmers have limited access to formal education, it would also be necessary to provide targeted training and educational resources to promote the

adoption of briquette production techniques.

3.2. Gender Distribution of the Farmers

Table 2. Gender of the farmers.

Percentage farmers			
Sex	**Isingiro (%)**	**Masindi (%)**	**Mbarara (%)**
Female	73.1	62.0	33.3
Male	26.9	38	66.7

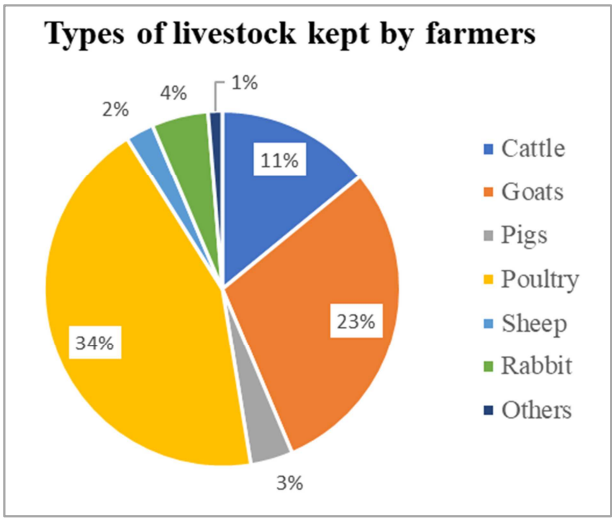

Figure 1. Types of livestock kept by the farmers.

Results from Table 2 showed that the higher percentage of farmers in Isingiro and Masindi districts were predominantly female, at 73.1% and 62.0% respectively. Given that a higher percentage of farmers in Isingiro and Masindi districts are predominantly female, efforts to promote the adoption of briquette production techniques would need to consider the specific needs and constraints faced by women in the area.

The farmers mainly kept poultry (34%) followed by pigs (25%), goats (23%) and cattle (11%) in the three districts as shown in Figure 1. The livestock distribution data indicates that poultry and pigs are the most commonly kept animals among farmers in the three districts. This suggests that there may be opportunities to promote the use of briquettes as an alternative energy source for poultry and pig farming, which could ultimately help to reduce the environmental impact of livestock production in the region.

3.3. Reasons for Livestock Rearing in the Study Area

Figure 2 demonstrates that approximately 32% of farmers keep livestock for meat while 25% and 20% keep livestock for generating cash and manure respectively. The fact that approximately 32% of farmers keep livestock for meat suggests that there may be opportunities to promote the use of briquettes as an alternative energy source for meat production, which could help to reduce the environmental impact of livestock farming in the region, since traditional fuels such as wood or charcoal are often used for cooking or heating in livestock production facilities.

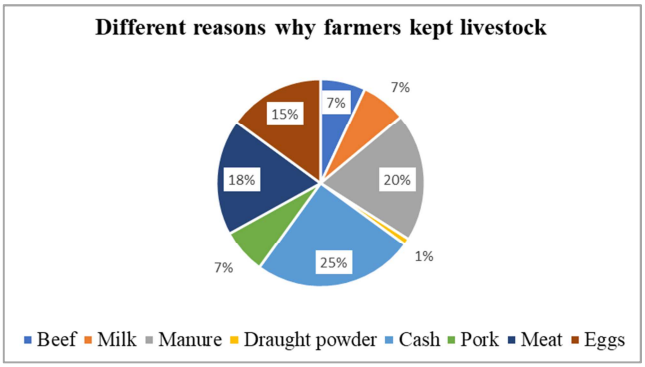

Figure 2. Reasons why farmers keep a particular livestock.

3.4. Training Programs for Farmers

Figure 3. Different training programs for farmers.

NARO was the major training agent of briquettes to farmers, as 88% farmers were trained by NARO. This suggests that government agencies and research organizations can play a critical role in disseminating knowledge and skills related to briquette production to farmers. Additionally, the finding that approximately 6% of farmers learned from other farmers in the region indicates the potential for peer-to-peer learning and the spread of best practices from more experienced farmers to others in the community, as written by Bategeka L. etc. [19].

3.5. Adoption of Briquettes by Farmers

This study found that briquettes were adopted and used by 66.7% of farmers in Mbarara district, 58.2% of farmers in Isingiro district and 50.6% of farmers in Masindi district respectively with 58.2% and 50.6% farmers respectively. The relatively high adoption rates observed in Mbarara and Isingiro districts indicate that farmers in these regions have recognized the benefits of briquette production, such as reduced environmental impact and cost savings. However, the lower adoption rates in Masindi district suggest that there may be additional barriers to adoption in this region that warrant further investigation. Despite these differences, the overall findings suggest that there is significant potential for briquette production to be scaled up and adopted more widely in the region, particularly with targeted educational

and promotional efforts.

Table 3. *Adoption rates of briquettes.*

District	Percentage of farmers who produce and use briquettes (%)	Number of farmers who produce and use briquettes
Isingiro	58.2	67
Masindi	50.6	79
Mbarara	66.7	33
Total	100	179

3.6. Different Types of Materials Used to Make Briquettes

Table 4. *Classification of briquette materials.*

Farmers who use different types of materials from class A binders and class B to make briquettes			
Class A Material (Binders)	**Number of farmers using class A material**	**Class B material**	**Number of farmers using class B material**
Cow dung	82	Charcoal dust	83
Cassava flour	66	Banana leaves	34
Clay	24	Dry bean husks	29
Ant hill	9	Dry grass	28
Molasses	7	Dry tree leaves	11

The study shows that 82 farmers used cow dung as binder, and 66 farmers used cassava flour as binder. Compared to traditional charcoal production, which relies on wood as the primary source of fuel, briquette production using cow dung and cassava flour may have a lower carbon footprint, since cow dung is a significant source of methane and carbon dioxide emissions, which are potent greenhouse gases that contribute to climate change. Class B materials are mainly agricultural waste, which farmers use to make briquettes for use in cooking food and sale for cash instead of using traditional fuels like charcoal and firewood. Charcoal dust was predominantly used in class B materials due to its pre-existing carbonized state, which made it easier for farmers to use. On the other hand, other agricultural wastes required a carbonizing machine to carbonize the materials, which was not accessible to the majority of the farmers, making it less practical for them to use.

3.7. Benefits from Production and Use of Briquettes

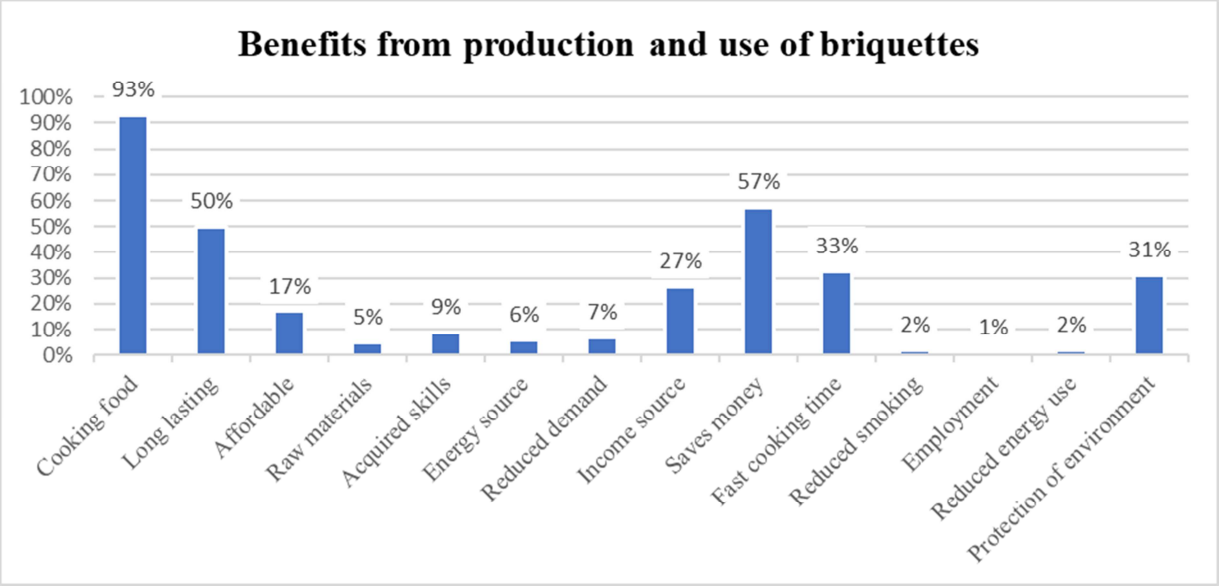

Figure 4. *Farmers' benefits from production and use of briquettes.*

Over 93.1% farmers use briquettes to cook their food. This indicates a high level of adoption, since the majority of farmers who participated in the study used briquettes as their primary fuel source for cooking. 57.4% and 49.5% of farmers mentioned that briquettes saved them money to buy fuel energy and last longer while cooking respectively. About 32.7% of farmers mentioned that briquettes cook faster than charcoal and 30.7% farmers said use of briquettes protects the environment. 26.7% farmers were able to earn money from selling the briquettes. These findings suggest that briquette production has the potential to be a sustainable and cost-effective alternative to traditional charcoal production in rural communities such as those in Western Uganda.

3.8. Quantities of Briquettes Produced, Used and Sold

Table 5. *Briquette quantities and sales in the three districts.*

Quantities of briquettes produced, used and sold in the 3 districts			
District	**Quantity of briquettes made (basins)**	**Quantity of briquettes sold (basins)**	**Quantity of briquettes used for cooking at home (basins)**
Isingiro	211	46	165
Masindi	129	33.5	95.5
Mbarara	107	54	53
Total	447.5	133.5	314

Most farmers used the briquettes they produced in residential cooking. Farmers in Isingiro produced the largest quantities of briquettes (211 basins) followed by Masindi district (129.5 basins). However, Mbarara sold the most briquettes (54 basins). On average briquettes were sold at 15,000 UGX per basin, generating revenue of 810,000 UGX from briquettes. The total value of briquettes made in the three districts was 6,712,500 UGX. This represents significant cost savings for farmers compared to purchasing charcoal, or firewood. These results suggest that the adoption of briquette production can be a cost-effective and sustainable alternative to traditional charcoal and firewood use, benefiting both the environment and the farmers' livelihoods.

Majority farmers sold their briquettes from home (32%) while 28% farmers sold the briquettes in the market. Approximately 40% farmers did not sell their briquettes. This could be due to various reasons such as lack of access to markets, lack of knowledge on how to sell the briquettes, or simply using the briquettes for personal use only. It is important to address these barriers in order to encourage more farmers to sell their briquettes, and potentially provide additional sources of income.

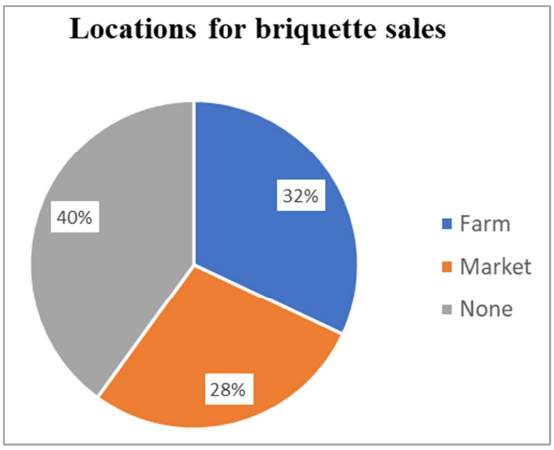

Figure 5. *Locations for briquette sales.*

3.9. Challenges Faced by Farmers and Suggestions for Improvement

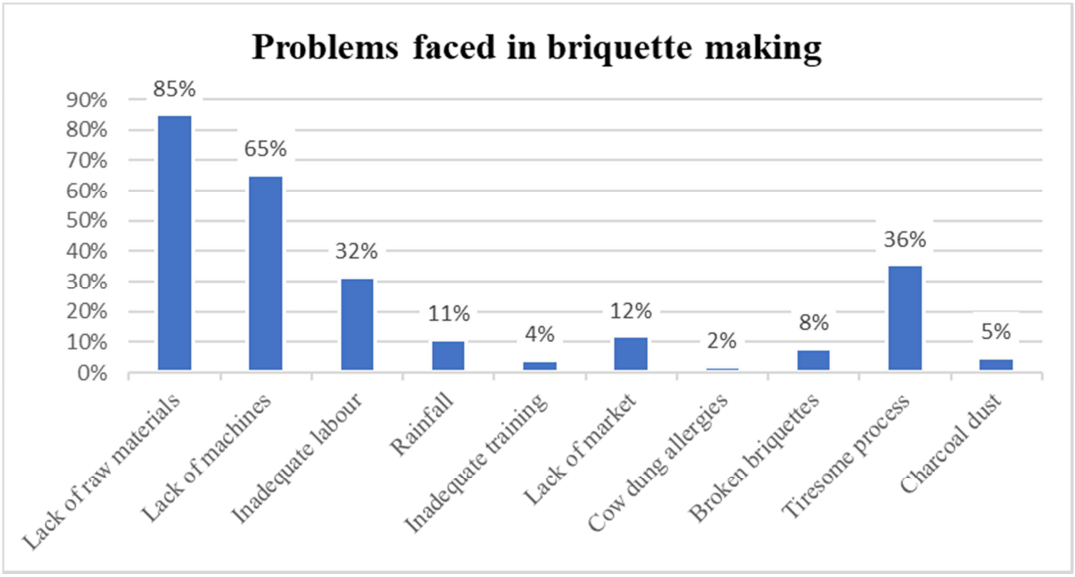

Figure 6. *Challenges faced by farmers.*

The biggest problem facing farmers making briquettes were lack of materials (85.1% farmers) and lack of machines (65%). The farmers faced challenges sourcing the raw materials, mainly cow dung, cassava flour, clay and anti-hill soils. Farmers also always preferred to use already carbonized charcoal dust because they had lacked a carbonizing machine. Inadequate labor, inability to fry briquettes during rainy seasons and lack of an established market to sale briquettes were also challenges faced in briquette production and adoption. These findings suggest that efforts to promote briquette production and adoption should address these challenges, such as through improved access to materials and machines, as well as better

market linkages for selling briquettes.

Farmers had suggestions for improving the briquettes production and utilization. They indicated more training about briquettes (86%) as one way of improving this business, while 78.2% recommended support for purchasing more machines to produce briquettes. 60.4% requested for more funding to purchase materials and equipment, while 23.8% recommended provision of solar dryers for rainy seasons.

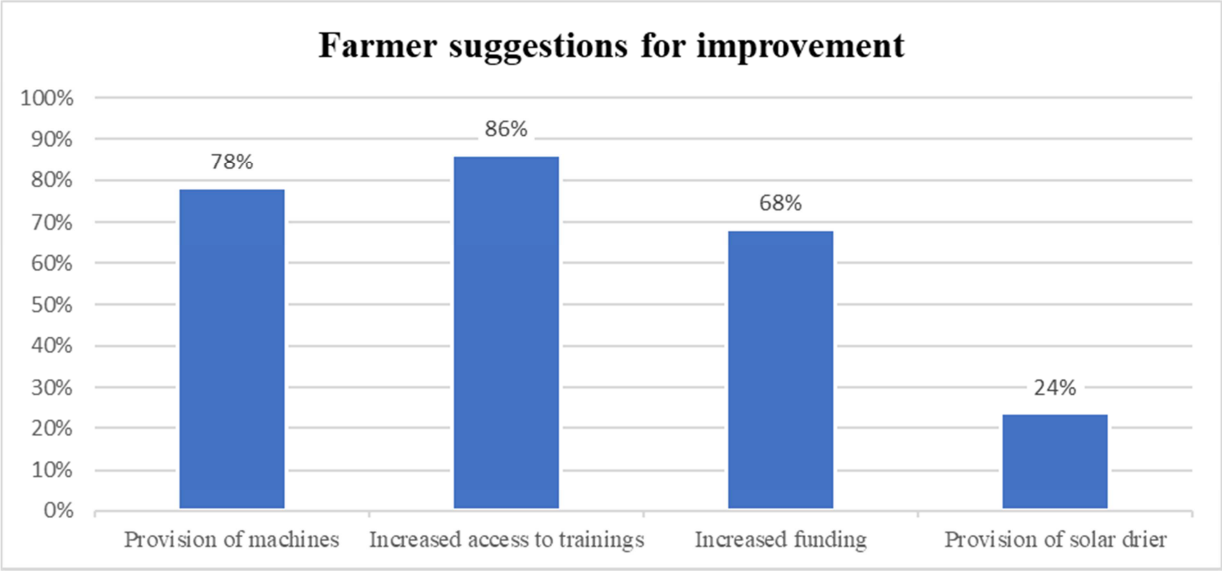

Figure 7. *Farmers' suggestions for improvement.*

4. Conclusion

The study shows that making briquettes from agricultural waste is a viable way to turn waste into wealth and provide an alternative for firewood and charcoal. The adoption and market potential of carbonized briquette production were assessed among farmers in beef-producing communities in Uganda. The results indicate that approximately 58.2%, 50.6%, and 66.7% of farmers continued to produce, use, and sell briquettes in Isingiro, Masindi, and Mbarara districts, respectively. Briquette production and adoption were found to be a good enterprise that can help farmers earn income while reducing agricultural waste, tree cutting, and protecting the environment. The study highlights that lack of machinery and materials, especially binders like cassava flour, clay, and anti-hill soil, were the main challenges faced by farmers. They also suggested more training, provision of equipment and more funding as recommendations for improving briquette production, utilization and adoption in the community. Overall, briquette making has the potential to empower women and youth economically and promote sustainable agriculture in Uganda.

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