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Toward Adaptation of Briquettes Making Technology for Green Energy and Youth Employment in Tanzania: A Review

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Abstract

Briquette technology is an alternative green energy source to offset the increasing demand for charcoal and firewood to save the forests and the environment while creating employment for youth and women. Using the scoping and realistic review techniques, a review study was conducted to establish the briquette technology's existence, and its value chain, identify stakeholders and challenges along the value chain and explore the policies supporting the technology and potential employment opportunities for youth in the green energy sector. The review results indicated that the briquette technology value chain consists of sourcing raw materials, production process, distribution, and consumption as its components while transportation, storage or packaging, marketing, and training are its supporting services. In addition, it was found that stakeholders in the value chain are manufacturers, producers, and supporting service providers who differ based on their formalities, such as groups, companies, government organizations, Non-Governmental Organizations (NGOs), institutions, and enterprises. Furthermore, five challenges were identified that impair the briquette adoption. They include the technology, raw materials, and the quality of briquettes, promotion, and marketing. Also, the study found that there are limited policies that provide a conducive environment for briquette technology to flourish. The study concludes that briquette technology exists in Tanzania. However, it is not yet matured as compared to the developed countries, and the technology is not backstopped by existing policies. The study recommends the briquette technology as a viable employment opportunity, especially for youth and women; therefore, the formulated briquette value chain should be utilized for easy coordination of stakeholders and deployment of the technology. Also, there is a need to create

awareness and innovative strategies for promoting and engaging more stakeholders in the technology through the policies that explicitly insist on adopting the briquette technology.

Keywords

Renewable Energy, Briquettes, Biomass, Awareness, Perception, Adoption

1. Introduction

Charcoal and firewood are the primary sources of cooking energy in most African countries. The projected demand for charcoal and firewood in Sub-Saharan African (SSA) countries is projected to be 2.8 times and 1.4 times, respectively, by 2050, with 2015 being the reference year of projection [1]. In Tanzania, charcoal and firewood contribute about 85% of national energy consumption [2]. Projections show that, by the year 2030, the consumption of charcoal may cause a loss of 2.8 million hectors of the forest, accumulating a total of 49.7 million tons of Carbon dioxide (CO_2), and release 20 million tons of CO_2 into the atmosphere in Dar es Salaam alone [3]. Unfortunately, in Sub-Saharan African (SSA) countries, there is no sign of diminishing demand for charcoal and firewood [1]. The main reason for the consistent increase in demand is that apart from being cheap energy for limited-income communities, the business of charcoal and firewood employs a good number of youths in the regions.

Population growth in SSA, including Tanzania, has triggered increased demand for charcoal and firewood for cooking. Alternative sources of energy that are sustainably obtained and utilized are required to offset the increasing demand for charcoal and firewood to save the forests and the environment. One of the sustainable and utilized energy sources is the briquettes [4]. The briquette is produced by densifying the raw materials under various compressive loads [5]. The raw materials used to produce the briquettes originate from agricultural biomass and non-hazardous domestic waste. This kind of raw materials offers a quality alternative and sustainable energy resource.

Various technologies at different capacities are applied in briquette making or production, ranging from manually operated to advanced and automated technologies [5] [6]. Applying these technologies in economic and financial merits creates a sustainable generation of employment. A choice of technologies and its feasibility for use in a certain area depends on various issues, including the type of raw materials and technology available; the financial capability of the community; the quality of the products or briquettes produced, the government policies, strategies and frameworks available to support the adoption of the technology, and a clear established value chain of the briquette making. In Tanzania, there is limited information regarding the issues mentioned above. In addition, technology has existed for decades in the country. However, studies to assess its

viability for youth employment are limited. The clear information related to the briquette-making technology viability provides the grounds for promoting the adoption of the technology and hence provides the opportunities for enhancing youth skills and employment through its entire value chain.

Therefore, this review study aimed to sightsee the limitations and opportunities for youth employment in the briquette industry. The study's main objective was to conduct a comprehensive review of the briquette technology towards exploring green employment for youth in Tanzania. The main objective was achieved by determining the briquette technology value chain and the main stakeholders, identifying the challenges associated with the briquette technology, identifying the opportunities for youth employment, and assessing the relevance of the policies in supporting the briquette technology.

2. Materials and Methods

2.1. Scope and Implementation Tools of the Study

The study focused on identifying the value chain components of the briquette technology and its primary stakeholders. In addition, it targeted exploring the challenges, opportunities, and policies associated with the briquette technology for the potential employment opportunities for youth in Tanzania. The study implementation techniques involved the scoping review, which provides a snapshot of the field and a complete overview of what has been done [7]. The technique facilitates the conceptual boundaries identification of the matter and its size based on the available evidence and the research gaps related to the matter in question. Another applied technique is the realistic review, which is useful for evaluating policies that may have differential or inequitable impacts on the subject matter [7]. Also, the snowball technique that requires the currently enrolled research participants to help recruit future subjects [8] was applied in this study.

The tools used to conduct this review study are computers for internet access, relevant research papers, reports, dissertations, and theses, and a prepared checklist for validation of the collected information. Key briquette stakeholders were identified and interviewed using a prepared checklist. The stakeholders were identified through internet searching, contacting, and the snowball technique. In addition, the key informant opinions were collected through semi-structured interviews [9].

2.2. Formulation of the Value Chain of Briquette Technology for Tanzania Context

All techniques and tools explained above were applied to identify the components which make up the value chain of briquette technology in the context of Tanzania. Also, the supporting mechanism of the components was established through a search in literature, reports, and field visits of different NGOs or companies dealing with briquettes in Tanzania. The components were linked logically from the input, process to output phase of the briquette-making tech-

nology. The framework showing the linkage of the components was produced and adapted as the formulated briquette technology value chain for this study. The pictorial presentation was used for the description of some of the components.

2.3. Identification of Stakeholders in Briquette Technology Value Chain

The pioneer stakeholders of briquette technology in Tanzania were identified using the scoping review technique. Also, stakeholders and the time of the start of large-scale briquette production were revealed through the same technique. After completing this task, the compilation of all stakeholders based on the position in the value chain, location of operation, level of the enterprise, duration in the business, and current status was tabulated.

2.4. Exploration of Challenges along with the Briquette Technology Value Chain

The challenges facing the stakeholders along the value chain of briquette technology were identified. The identification was made by searching the information from the reports and literature presented by the stakeholders and researchers dealing with briquettes and directly contacting the stakeholders through emails and phones and visiting them at their working stations. The information on the challenges is presented based on the components forming the value chain of the briquette technology. In addition, the exploration of creating employment opportunities for youth by addressing the challenge was done. The authors dissected the challenges and the interventions to address them along the briquettes technology value chain. The authors synthesized the interventions through intuition backed by situation analysis logic and literature support. The pictorial and tabulated presentation was applied for clarity of information.

2.5. Relevance of Policies towards Briquette Technology Adaptation

The realistic review technique was effectively applied to find the information on the relevance of policies to support the up-scaling and out-scaling of the briquettes technology. The literature reviewed for this case was based on information from developing countries (75%) and developed countries (25%). In addition, the Tanzania policies and strategies related to energy issues were reviewed to find out whether they favour the condition of promoting the briquette technology in the country.

3. Results and Discussion

3.1. The Value Chain of Briquette Technology

The value chain was identified and adapted for this study during the review of different articles, as indicated in **Figure 1**. The value chain diagram illustrates

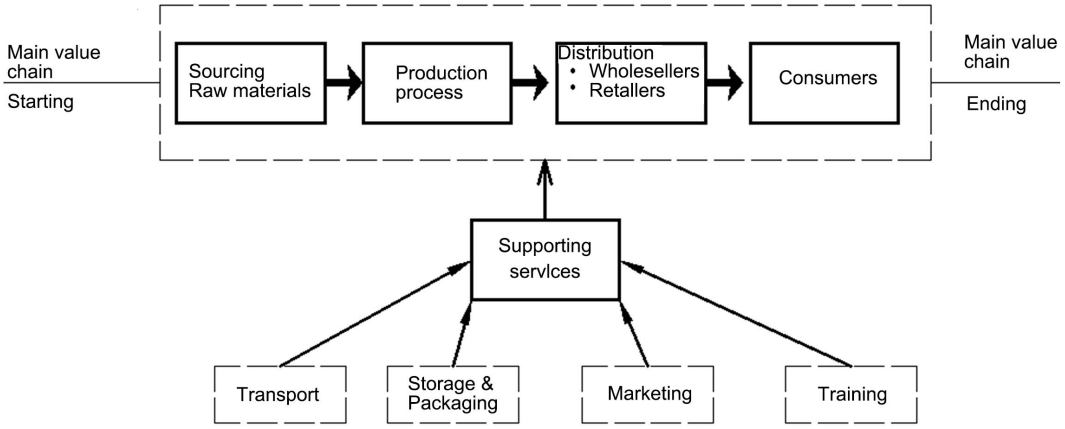

Figure 1. Briquette technology value chain.

the linkage of four primary components and the supporting services. The primary components include sourcing raw materials, production process, product distribution, and consumption. The supporting services involve but are not limited to transportation, storage or packaging, marketing, and training. The details of each component are narrated in subsequent sub-sections.

3.1.1. Main Components of the Briquette Technology Value Chain

Sourcing Raw Materials

Briquettes are made from raw materials such as rice husks, sawdust, palm tree biomass, coconut shells, eucalyptus wood, and municipal solid waste [10]. However, it is necessary to assess each material since they require different specific pre-treatment before producing briquettes. Preheating is an example of such pre-treatment, allowing higher quality briquettes [5].

The type and availability of the raw materials may be site-specific depending on the area's main activity producing biomass. For example, rice husks may adequately be found in areas producing significant quantities of rice, while sawdust is found in areas engaged highly in timber production or wood processing. Unfortunately, most of the biomass highly produced in a site-specific is lost, as shown in **Figure 2**.

Furthermore, the effect of varying the die temperature and the raw material (sawdust) preheats temperature on the energy consumption for sawdust using a heated die screw press saves a significant amount of energy [11]. Binding materials such as waste paper and starch are used in manual press briquette machines [3]. However, the powered briquette-making machine does not require any binder material since it generates sufficiently high pressure and temperatures for binding the feedstock.

Production Process

Briquette making is turning materials with low bulk density into a high bulk density fuel with concentrated energy [12]. This process is known as the densification of briquette. It requires specific moisture content, temperature, binder, and pressure. Densification increases the net calorific value per unit volume; enables

Figure 2. Example of the abandoned biomass material observed during a field visit. (a) rice husks, (b) sawdust, (c) charcoal specks of dust, and (d) banana tree leaves.

easy transportation and storage. In addition, it reduces residue disposal and produces briquettes uniform in size and quality. Briquetting technology was introduced in India in the early 1980s [13]. In 1998 there were about seven commercial manufacturers of briquette-making machines in India, manufacturing piston-press type briquette-making machines. Fifteen enterprises were found distributing piston press type briquette-making machines in seven Brazilian States whereby almost all machines were mechanical, and only two were hydraulic type [14]. Briquette equipment technology in East Africa uses an agglomerator, screw extruder, pillow-briquette, and ram/piston press. These technologies are appropriate for the carbonised approach to making briquettes.

Screw press briquette-making is a popular densification method suitable for small-scale applications in developing countries. This process can produce denser and stronger briquettes compared with piston presses. There are two types of screw presses: conical screw press and screw press with heated die [15]. However, the hydraulic piston briquette press is affected by the temperature of pressing [4]. In Tanzania, the screw press machine (Grill Mill-Tanzania model) with a capacity of 120 kg/h of rice husks briquettes was developed by TROMSO Company Limited in collaboration with Kilimanjaro Industrial Development Trust (KIDT) and Small Industries Development Organization (SIDO) Mbeya through the funding from Japan International Cooperation Agency (JICA). The machines were installed in areas producing rice, however, their limited information to indicate positive progressions

Distribution of Briquettes

The study finds that the briquettes vary greatly, and the market lacks standards or guidelines that can inform purchase to the extent of posing challenges to distribution. Therefore, charcoal has remained undisputed household energy

of choice for a majority of urban households, and this has remained the same for several decades. There is a need to improve the distribution processes for briquettes to enhance their availability to communities. In fact, both briquettes and charcoal use similar energy conversion technologies (various forms of cooking stoves), but briquettes are more difficult to ignite, have much higher ash content, and are less readily available.

Consumption

The rationale for energy consumption at the household level is more complex. It goes beyond price and energy density considerations, even though the two factors contribute the most towards choosing the type of energy. At the household level, energy consumption options and patterns for cooking and heating applications are influenced by price, energy content, ash content, smoke and fumes, the available cooking appliance, the availability of the fuel, the type of food (meal) to be prepared and the time of preparation. Additional criteria include the rate of energy extraction, availability, safety, fluidity, and storage requirements [16]. For example, regarding briquette consumption, it was reported that the markets for briquettes are food stores, pizza restaurants, bakeries, and also factories with fuelwood-burning furnaces, like red brick factories [14]. Generally, the briquette finds its uses in households, schools, hotels, prisons, industry boilers, brick kilns, incinerators, and crop drying processes.

3.1.2. Supporting Services

Transporters, trainers, funders, policies, and marketing strategies support one or more segments in the value chain, as shown in **Figure 1**. For example in Kenya, they conducted training of different stakeholders on briquette technology [17] using TERRA NUOVA, an Italian Non-Governmental Organization (NGO) with extensive knowledge of briquette making and construction of briquette presses. They contributed training materials on briquette technology and introduced the youth group and the project team to the artisans who fabricate briquette-making machines.

Margret Kisakye runs a briquette-making business from Kimaanya in Masake, Uganda. She decided to start her briquette business in Oct 2009 after receiving training from Global Village Energy Partnership (GVEP), which runs the Developing Energy Enterprises Project (DEEP) in East Africa [18]. She began by making briquettes by hand out of charcoal dust, grass, and cassava flour but has since expanded her operations by purchasing a manual machine and a single drum carbonisation kiln. She employs one permanent and two casual workers. Margret estimates that her average sales are around 1000 kg per month, and she sells to local households, institutions, schools, and poultry farmers and attracts customers from as far as 20 km away.

Appropriate Rural Technology Institute (ARTI) has been running its Waste to Wealth briquette training programme in Dar es Salaam, Tanzania, since 2006. In 2011 they received funding through the World Bank's Biomass Energy Initiative for Africa (BEIA) to conduct a pilot project that trains 1800 people in 60 villages

in the four rural districts surrounding Dar es Salaam. After completing this training in the selected districts, they started working to help these villages commercialise their enterprises. ARTIs have trained farmers to fabricate charcoal kilns with which they can produce char and equipping some with briquette-making technology developed by the ARTI technology institute. In addition, ARTI has created a production network, community sensitisation, and sales by linking producers together to form "community-based enterprises" [18].

3.2. Stakeholders in Briquette Technology Value Chain

Briquette production in Tanzania started back in the 1970s. It was picked up by the Center for Agricultural Mechanization and Rural Technology (CAMARTEC) and Tanzania Traditional Energy Development Organization (TaTEDO) during the World Bank's Energy I Project [19]. Both organisations have continued to promote briquette-making to substitute for unsustainable charcoal production and promote end-user efficiencies for biomass energy, whether in households, enterprises, institutions, and industries. Twelve commercial productions began in Moshi in 1982 through KIDT. The largest operation was done by East African Briquettes Company Limited, based in Tanga. Under the World Bank's Biomass Energy Initiative for Africa (BEIA), ARTI-Tanzania has helped 720 people in 24 villages in two Districts to receive comprehensive training and the essential equipment to begin producing briquettes.

Also, Sao Hill Industries was supported by Norway to produce briquette from sawdust in 2009 and 2010. United States Agency for International Development (USAID) provided funding to Camco Clean Energy (Tanzania) Limited to commercialise briquettes from the East African Briquette Company in Dar es Salaam city. Several other groups, NGOs, and small-scale entrepreneurs are producing briquettes in Tanzania today, as shown in **Appendix 1.0**. The unconfirmed information was excluded from appearing in the appendix.

However, the rate of briquettes utilization varies significantly across the country. There is limited information on a comparative analysis that could give concrete insights into what has worked well in some places and what has not worked well in others [20]. The experience reported on briquette technology in East Africa shows that producers have opportunities to adapt and develop their briquette industry [12]. Its value chain has been summarized to comprise the inception of the raw materials, production, distribution, and consumption.

Amongst the stakeholders, the main ones in briquette charcoal production reported include East Africa Briquettes Company (EABCL) in Tanga, KIDT in Moshi, Space Engineering Company Tanzania Limited based in Dar es Salaam, ARTI in Dar es Salaam and Bagamoyo Brikwiti Company (BBC) in Bagamoyo [19]. Information on their value chain position and activeness in briquette production in Tanzania was obtained during this review. It is reported that most companies use briquettes extruders with an actual production capacity of 25 kg/hr. However, the projected capacity for small, medium, and large scales is 60 kg/hr, 360 kg/hr, and 1320 kg/hr, respectively (*ibid.*). The study found that the

capacity was not attained due to inadequate knowledge and skills on the technology, unreliable feedstock supply, and rainfall seasons. Other challenges reported included lack of public awareness on briquette, lack of capital, business license, availability of non-sustainable charcoal producers, inadequate programme, and policies/incentives in charcoal production [2].

The producers were found to sell most of their briquette charcoal to Dar es Salaam, but the distance between the production and consumption centres directly affected the cost of the briquettes. For instance, 1 kg of briquette from EABCL was sold at $0.16 in Tanga City, and briquette from Kilimanjaro Industrial Development Trust was sold at $0.11 in Moshi Municipality. Nevertheless, the same products were sold at $0.26 to $0.35 per kg in Dar es Salaam. Therefore, the consumers were covering transportation costs in most cases. In 2017, about 90% of all Tanzania households were using charcoal (21%) or firewood (69%) as their primary source of energy for cooking [21]. Therefore, there are many opportunities to adopt briquettes on a large scale and promote this business for the developing countries to enhance the Tanzanian producers to develop their briquette industries.

According to Kuja and Kushoka Tools Manufacturing Group (KKTMG), the demand for briquettes in Dar es Salaam is about 2000 tons per day. To meet this demand, it requires 100 machines, each with a capacity of 20 tons per day. Nevertheless, due to a lack of adequate capital, the production of machines for making briquette was difficult. Among the products made by this group are bio briquette machines, tobacco leaf driers, efficient cooking stoves, and carbonised biomass briquette. The group started to expand to capture the Dar es Salaam market, the largest consumer of charcoal. The company's chief executive officer explained that they needed about 300 million to invest in the project.

On the other hand, briquette production was done but the carbonised type (Tanzania Daily News, April 2020). In consultation with the stakeholders such as KuniSMART, KKTMG, and Green Conservers, it was noted that the production cost of briquette ranged from $0.09 to $0.65/kg, which depends on the quality of briquette the customer needed. In addition, some stakeholders reported that the selling of briquette at a wholesale price ranged from $0.22 - $0.26 per kg, whereas in the export market, the selling price ranged from $2.17 - $4.35/kg.

3.3. Challenges along with the Briquette Technology Value Chain

Briquette technology has existed in developing countries for at least 50 years. Nevertheless, the technology/product adoption is not promising in SSA at any large scale, despite the many desirable attributes of the product and the industry. Therefore, it is essential to identify challenges faced by the briquette sector to shed light on where different actors can intervene to overcome those challenges, hence enhancing the adoption of briquettes. Inadequate technologies and non-supporting policies are among the challenges limiting production. Also, the absence of a domestic market to absorb supply from fully operational briquette-making facilities, contribute to productivity stunting [12].

Availability and type of feedstock play a significant role in the production process of briquettes [22]. Low bulk density, variable moisture content, mixing ratios, and various ingredient and particle sizes may create feeding, handling, quality, storage, and transportation challenges during briquette making [23] [24]. Also, briquettes' quality has been associated with briquette-making technology. Calorific value, ash content, and frequency of crushing during storage and transport are some parameters determining the quality. In a study conducted in Kilimanjaro, rice husks briquettes performed severely poorly compared to charcoal and firewood (See **Table 1**) a sign that improvements are required.

Mugabi and Kisakye [22] found that Kampala briquette users face similar challenges (ash and high crushing frequency). There are two types of briquettes: carbonised and non-carbonised (**Figure 3**). One of the main challenges affecting the uptake of carbonised briquettes is their inefficiency in transferring heat [25].

Producers of briquettes face technological challenges such as regular machine breakdown and poor carbonising units. Briquette producers are not considering the users' preferences to produce according to the user's needs. Suitable cooking stoves are not availed to users, and there is a need for standards to ensure the quality of briquettes [22]. There have been several challenges facing the promotion and adoption of briquettes in urban areas, as they compete directly with wood charcoal, which is unregulated and has a price advantage [17]. Also, neither industry nor governments are taking full advantage of the opportunities to expand briquette production and consumption [12]. Therefore, there is a need for the government to collaborate with industry and other stakeholders to create policies and initiatives that enable the briquettes to compete with wood charcoal.

Figure 3. Briquettes obtained from stakeholders during field visit: (a) Non-carbonised stick; (b) carbonised hexagonal; (c) Non-carbonised spherical; (d) Spherical waste papers.

Table 1. Comparison of three kinds of fuel (Source: SIDO-KDIT, 2017).

	Rice husk briquettes	Firewoood	Charcoal
Price	200 (Mbeya) - 300 (Moshi) Tsh/kg	100 - 200 Tsh/kg	500 - 800 Tsh/kg
calorific value	3 3500 kcal/kg	2 4000 kcal/kg	1 6800 kcal/kg
Ignition	3 (takes time)	1	2
Power	3 (not so strong)	2	1
Smoke	3 (at the beginning)	2	1
Burning time	1 (long)	3	2
Handling	1 (same size/ not dirty)	3 (should be split)	2 (dirty)
Remaining ash	3 (much)* can be used as fertilizer	2	1 (few)
Forest conservation	1	2	3 (loss of calorific value by carbonization)

*1 means No. 1, 2 means No. 2 and 3 means No. 3 out of three.

3.4. Identification of Opportunities for Youth Employment in Briquette Technology Value Chain

One of the key merits of briquette making is the creation of employment for youths. It provides many opportunities for youths to be engaged along the briquette technology value chain and supporting services of the briquette technology value chain. A study conducted in Kenya [24] showed immense opportunities for youths in the briquette industry that have remained untapped. It observed tremendous opportunities available in briquette making and possibilities for all businesses to grow, such as biomass feedstock suppliers, briquette machine fabricators, producers, and end-use consumers. The intervention of the challenges offers a chance of exploring the opportunities to address youth unemployment using green technologies. The detailed exploration of the opportunities to create youth employment along the briquette technology value chain is presented in the subsequent subsections.

3.4.1. Raw Materials

Biomass is one of the dominant energy sources in developed and developing countries [26]. Biomass material may be obtained from wood, agricultural waste, animal manure, and municipal solid waste. Among many other functions, biomass may be used to produce briquettes, one of many sources of energy needed to power many appliances for purposes such as cooking or heating [27]. In developing countries, vast amounts of biomass residues are produced annually as

by-products of agricultural, industrial, and commercial forestry [17] [28]. For example, in 2008, global statistics reported about 134 million tons of rice husks from 671 million tons of rice production. Again, approximately 135 million tons of corn cobs from 797 million tons of corn production were reported [29]. Likewise, in 2010, agricultural and forest biomass feedstock was reported to be 242 million tons, and it was projected to increase to 281 million tons in 2030 due to growing crops production [30]. Also mentioned is that the annual supply of biomass from various sources worldwide is approximately 220 billion tons per year [31]. It is evident from this perspective that the availability of these biomass materials offers an excellent opportunity for youths to collect and sell biomass to briquette producers as raw materials, therefore creating employment and reducing poverty. Similarly, youth groups may be employed by waste collection associations to collect and sort wastes, and these workers may receive salaries. For instance, in Nairobi, Chardust Limited works with youth groups to collect charcoal dust from informal settlements and sell it to briquette producing companies.

3.4.2. Production/Processing (Machine Manufacturers, Briquette Producers, Storage, and Packaging)

Briquette making can be a source of employment for many youths living in urban cities highly affected by a lack of jobs in the formal sector. An action research initiative on briquette making was conducted among the residents of Kahawa Soweto village in Kenya through the Soweto Youth in Action (SOYIA) a youth group in collaboration with Urban Harvest and Kenya Green Towns Partnership Association (Green Towns). Through this initiative, the SOYIA youth group produced 600 briquettes and sold half of them within the first two months.

Moreover, the demand was expected to rise through market surveys and promotion exercises among institutions, supermarkets, and charcoal dealers. Through this, the SOYIA youth benefited through income generation and a source of employment while providing affordable, good-quality fuel to the community.

In Nairobi County, young women from Soweto, Mathare, Kibera, Kayole, and Kahawa slums started a briquette-making business to solve their energy problems in 2010. According to [32], they have managed to earn up to 2000 USD/year. Women groups affirm that briquette making is a significant venture Kenyans can explore to realise their environmental goals and economic development [33].

Another study conducted among briquette producers in Nairobi revealed that the handmade briquettes offered great opportunities for the unemployed youth in urban areas. However, the number of briquette producers varied widely, and the production rate is still unknown [6]. It was also reported that the ram-type and motorised screw press were mainly used since they could be locally fabricated from locally available materials, which offered a great opportunity to in-

terested youths to engage themselves in machine making. In addition, the selling price of locally made briquette equipment was around 400 USD, while the imported one was around 15,000 USD [12]. Therefore, it shows that the locally made briquette equipment is affordable in terms of selling price compared to the imported one indicating an excellent opportunity for interested machine makers to participate in manufacturing/fabricating.

In Uganda, hundreds of micro-scale producers make briquettes with manual equipment, and many of these entrepreneurs seek to scale up their production. However, there is a shortage of locally fabricated briquette machines [6]. Reliable compaction machines with 800 - 1000 kg/day are required. It presents an excellent opportunity for youth engagement as machine fabricators who can develop machines and lease or sell them to smaller entrepreneurs. Equipment suppliers can play a pivotal role in the briquettes value chain, and it is important to increase their visibility in addition to marketing themselves.

3.4.3. Distribution

Briquettes must be distributed from production centres to agents (retailers or wholesalers) or final consumers. One among the challenges, especially in Tanzania, is the presence of few dealers in the briquette business. Youths, especially in urban areas, may also engage in the distribution of briquettes since many of the briquette producers in Tanzania have limited distribution channels, especially in urban areas because there are very few dealers who are motivated to invest in the briquette business. For instance, in the Kilimanjaro region, most of Kilimanjaro Industrial Development Trust (KIDT)'s briquette consumers are institutions, industries, and restaurants within Moshi Municipality except Green Acres School Dar es Salaam. For East Africa Briquettes Company Limited, located in Tanga, its consumers are found in Tanga, Dar es Salaam, Moshi, and Arusha only.

3.4.4. Supporting Services of the Value Chain

Transportation

Transportation plays a pivotal role in almost every step of the briquette technology value chain. For instance, raw material sources are always scattered, and they need to be collected and transported to the production facility. Similarly, briquette needs to be transported from manufacturers/ production centres to consumers after production. Therefore, transport is an essential service. In most cases, the briquette is transported from production centres to institutional consumers and identified distributors/ agents by trucks. Almost all medium and large-scale briquette producers have at least three agents in urban areas. In addition, youths may participate in this area by becoming agents.

Trainers

Despite being around for many years, knowledge of briquettes and how they differ from other sources like wood and charcoal remains unknown to the large population. Most rural town consumers have not been sensitised to evidence of

the health benefits and potential fuel savings derived from briquettes [6]. Youth may participate in training programs to raise consumer awareness about using briquettes as an alternative energy source.

An informal meeting among the various briquette producers and other interested stakeholders in Nairobi was conducted in 2011. It was discovered that most consumers lacked knowledge of the existence of briquettes, and even some failed to distinguish between charcoal and briquettes. Therefore, an awareness campaign is needed to sensitise the population on the advantages of using briquettes in fuel savings, health benefits, and environmental protection. Youths have an opportunity to participate in the campaign, which shall involve demonstration exercises such as cooking using briquettes. They may also participate in training in briquette making, machine use and maintenance, and any new efficient and effective way (s) of making and utilising the briquettes.

Furthermore, to improve the briquette production efficiency and product quality, the training of farmers is indispensable. Therefore, youths may participate in farmers' training to enhance the provision of suitable crop residues with lower moisture content and storage of crop residue appropriately to reduce the moisture content. An ideal situation is observed in Kampala, Uganda, where Jellitone Suppliers Limited helps organise farmers into groups and trains them on the best way to dry their agricultural residues to attain the suitable moisture content (*i.e.*, 15%) for briquette making.

3.5. Relevance of Policies towards Briquette Technology Adaptation

Efficient and effective production and utilization of the briquettes support Sustainable Development Goal number seven and its targets, which stresses affordable, greener, and accessible energy for all [34]. Briquette making is a mature technology in developed countries compared to developing countries. European countries, the developed ones, are the largest consumers of briquettes [35]. The briquette suppliers to these countries include the United States of America (USA), Russia, China, and South Africa. On the other hand, the developing countries have placed several initiatives on the priority for up-scaling and out-scaling the application of the technology. The initiatives include formulating policies and policy frameworks, strategies, and master plans.

The Asian, South American, and African countries, which fall in the group of developing countries, formulated and implemented the policies and strategies for enhancing the uptake of the briquette making and utilization technologies. Excellent examples of the countries in Asia, South America, and Africa, which have taken the initiative to strengthen the utilization of the briquette technology are Nepal, Chile, Malawi, and Tanzania [2] [21] [35] [36].

In Asia, Nepal has formulated and implemented policies and strategies, enacted laws through the legislature that stimulate the utilization of briquettes technology [37]. The policies include the 2006 National Agricultural Policy for the promotion and proper use of natural resources, environment, and biodiver-

sity to control deforestation; Rural Energy Policy, 2006, which proposed the preparation of separate action plans for the promotion and use of briquette, and other renewable energy sources; Industrial Policy, 2011, for promoting green industries and making the established industries pollution accessible and zero to carbon emission; Forest Policy, 2015 for promoting forest enterprises and offer financial and technical support to the users of alternative energy including bio-briquette; and Renewable Energy Subsidy Policy, 2016, which promote the subsidy of biomass energy technologies that include the briquettes utilization [21].

Similarly, in Africa, Tanzania has formulated policies and strategies that bolster the briquettes' production and utilization. For example, the 2015 National Energy Policy stresses the use of renewable energy to increase the national energy consumption mix. As a result, the briquette falls in the renewable energy category. Additionally, the vision of the National Energy Policy set a tune for the nation with a vibrant Energy Sector that contributes significantly to economic growth and improves the quality of life of Tanzanians. On this note, poverty reduction, employment, and economic development matters are central to the policy's vision [2]. Hence, considering the policy vision, the briquette technology value chain and its drivers are supported and play a significant role in fostering the nation's economic growth by creating greener employment.

Furthermore, the technology offers a chance of increasing the participation of Tanzanians in reliable, affordable, safe, efficient, and environment-friendly modern energy services. Also, the 2013 Biomass Energy Strategy-Tanzania (BEST) focuses on 1) identifying means of ensuring a more sustainable supply of biomass energy, 2) raising the efficiency with which biomass energy is produced and utilised, 3) promoting access to alternative energy sources where appropriate and affordable, and 4) ensuring an enabling institutional environment for implementation [36]. Therefore, regarding the energy policy and the strategy, the briquette technology becomes relevant for uptake and adoption in Tanzania, although it is not explicitly mentioned.

4. Conclusion and Recommendations

4.1. Conclusion

The limitations and opportunities of creating green employment for youths in Tanzania were explored based on the briquette technology. Exploring these issues, has revealed the key findings, which led the authors to conclude as shown in this section. The authors conclude that tremendous opportunities are available in all components of the briquette technology value chain formulated. The opportunities are possibilities for all businesses to grow, such as the biomass feedstock supplying, fabricating of the briquette machine, producing the briquettes, and even the end-use consumption of briquettes. In addition, there are challenges encountered in the briquette technology related to technology, policy, raw materials, quality of briquettes, promotion, and marketing. Furthermore,

briquette technology exists in Tanzania, but it is not yet mature as that found in developed countries. The technology is currently missing the coordination and clear supporting policies and strategies that facilitate the transition from non-green energy to green energy use. Finally, the supportive national energy policy and the renewable energy-related strategies make the briquette technology business relevant and viable for creating the green energy employment opportunity for youth and women in Tanzania.

4.2. Recommendations

The conclusion drawn by the authors, while referring to the main objective of this study, gives them the base to recommend that the briquette technology should be considered a viable employment opportunity, especially for youth and women, by policymakers. The formulated briquette value chain should be utilised for easy coordination of stakeholders and technology deployment. Additionally, Tanzanians should be aware to elevate their understanding of the briquette technology; innovative strategies should be formulated to promote and engage more stakeholders in the intended technology. Moreover, training of technical personnel for briquette-machine making, maintenance, and repair should be conducted. Further studies are recommended to explore the exact issues which make briquette the best competitor as an energy resource for cooking from the consumer perspective. Finally, there is a need for the government, through policymakers, to formulate policies that explicitly support briquette technology for easy market penetration.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendices

Appendix 1.0. List of briquette technology stakeholders in tanzania.

S/N	Stakeholder	Position in the Value Chain	Location	Level of Enterprise	Duration in the Business	Current operating Status
1	Tanzania Engineering and Manufacturing Design Organisation (TEMDO)	Manufacturer	Arusha	Institution	12	Active
2	SIDO Mbeya	Producer	Mbeya	Organisation		Active
3	DEMACO Engineering. Limited	Producer	Morogoro	Nil		
4	Green Conservers	Producer	Dar es Salaam	CBO	5	Active
5	Sustainable Agriculture (SAT)	Producer	Morogoro	NGO		Active
6	SAO HILL	Producer	Iringa	Company		Active
7	Tanzania Forest Service (TFS) Kahama	Producer	Shinyanga	Agency		
8	KuniSMART	Producer	Kisesa, Mwanza	Company	4	Active
9	Tanzania Industrial Research and Development Organization (TIRDO)	Supporting services	Dar es Salaam	Organisation		
10	Mkaa Imara	Producer	Dodoma	enterprise		
11	Joint Environmental Techniques (JET)	Producer	Dar es Salaam	enterprise		
12	Mkaa Endelevu	Producer	Mafinga, Iringa	enterprise		
13	Kuja na Kushoka Tools Manufactures Group (KKTMG)	Manufacturer and Producer	Tabora	Group	10	Active
14	Eng. Kalutu Koshuma	Producer	Arusha & Dodoma	Entrepreneur		
15	Women Development for Science and Technology (WODSTA)	Producer	Njiro, Arusha	NGO	15	Active
16	Space Engineering Company Limited	Manufacturer and Producer	Dar es Salaam	Enterprise	31	Active
17	Mena Wood Briquetting Company Limited	Producer	Iringa	Enterprise	14.6	Dormant
18	Bagamoyo Brikwiti Company (BBC)	Producer	Dar es Salaam	Company	10	Active
19	Kilimanjaro Industrial Development Trust (KIDT)	Producer	Kilimanjaro	Centre for training	40	
20	Sustainable Energy & Development Centre (SEDC)	Producer/Supporting services	Dar es Salaam	Centre under TaTEDO	10	
21	East Africa Briquette Company	Producer	Tanga	Company	23	
22	Mkombozi Women group Dochi Village	Producer	Lushoto, Tanga	Group	15	
23	Environmental Engineering Company Limited (EECO)	Producer	Tanga	Company	13	
24	Engineer Mwinama	Producer	Tabora	Entrepreneur		
26	Charcoal Briquette Tanzania Limited	Producer	Dar es Salaam	Company		
27	Iringa-based Tractors Company Limited	Producer	Iringa	Firm/Company		