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Likelihood of Adopting Briquette Technology in Abundance of Competitive Energy Sources: A Case Study of Morogoro Urban and Rural Districts, Tanzania

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Firewood and charcoal are the primary energy resources in many developing countries, especially in sub-Saharan Africa. However, the unstainable collection and use of these resources negatively impact the environment. Equally, using briquettes as green energy resources can address the energy shortage and conserves the environment. However, the information on people's preference to use briquettes instead of other alternative energy sources is scarce. Furthermore, studies demonstrating the briquette technology preferences and adoption to prospective users, including youth and women in urban and rural areas, are limited. Therefore, this study was conducted in the Morogoro district to (1) characterise the respondents' demographic issues useful for evaluation of people's preferences, (2) assess the preference for briquette fuels, particularly for youth and women, and (3) evaluate the extent of using the briquettes as sources of energy as compared to other alternative sources of energy. The household survey involved 330 respondents in urban, peri-urban, and rural areas of Morogoro. The areas were chosen to represent the Tanzania sceneries. Besides, supplementary key informants' interviews involved village leaders, charcoal retailers and other people with knowledge of briquette technology. The results show that over 95% of

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respondents preferred to use briquette as an alternative energy source and expressed their willingness to engage in the briquette business. Additionally, the study shows low use of briquettes compared to other energy sources like charcoal and firewood in urban, peri-urban, and rural areas. Furthermore, there was no significant difference between men and women in their willingness to join the briquette business (p-value =0.517). Therefore, a few people are aware of briquette technology. This study recommends increasing the awareness of briquette technology through training youths and women on briquette technology and insisting on the availability of briquette products and stoves. In addition, assessing the factors hindering the briquettes from being a hundred per cent preferred by people is a point of research interest.

Keywords: Briquette; preference; willingness; adoption; energy sources.

1. INTRODUCTION

Reducing over-reliance on charcoal and firewood through green energy technology reduces negative impacts like deforestation on ecosystems, thus ensuring the welfare of living organisms and the environment [1]. However, the benefits offered by charcoal and firewood cause the over-reliance mentioned above. The benefits include low-cost energy, simple tools used for fuel production, and employing youth, especially in low-income areas of Sub-Saharan African (SSA) countries. In SSA countries, if green energy sources are not utilised, the demand for charcoal and firewood is expected to increase by 2.8 and 1.4 per cent, respectively, by 2050 [2]. This increase is estimated to produce 49.7 million tons (Mt) of CO_2 buildup and 20 Mt of CO_2 emissions [3].

Briquette technology is one of the alternative green energy strategies for reducing the overreliance on charcoal and firewood [4]. Reducing the negative impacts of charcoal and firewood also saves cooking fuel costs due to its adequate energy efficiency when properly densified [5,6]. In developing countries, vast quantities of forest and agricultural waste may support briquette production [7] while at the same time conserving the environment by reducing the decomposition and release of greenhouse gases into the atmosphere [8]. For example, in SSA, forestry and agriculture produce around 1000 Mt and 140 Mt of biomass wastes annually, respectively [9]. The forest and agricultural wastes mentioned include wood shavings, coffee and rice husks, corn stalks, cotton stalks, sawdust, groundnut shells, coconut residues, and bamboo [10,7].

Various initiatives have been portrayed to advance the briquette technology to diverge people from using charcoal and firewood. For example, the design of reciprocating ram/piston/screw press mechanism for briquette making machines, particularly in industrialised countries such as Europe, Asia, and the United States [6,8,11]. In addition, some machines have been adapted and or used in developing countries. For example, in collaboration with Japan International Cooperation Agency, Tanzania developed a screw press machine (Grill Mill-Tanzania type) with a capacity of making 120 kg/h briquettes from rice husks. Furthermore, the design and development of briquette-relevant cooking stoves while making them available and accessible at an affordable price to speed up the adoption of those stoves is vivid [9,12]. These stoves alleviate some of the problems associated with traditional charcoal and firewood cooking stoves.

Recognition of the presence of other options of cooking energy sources is vital apart from the advancing and advocating the use of briquette fuels in SSA countries, including Tanzania. Such optional energy sources include electricity [13,14], liquefied natural gas [15], kerosene [16], biogas [17,18], and crop residues [19]. However, the dilemma is how people may prefer to use briquettes instead of other alternative energy sources. Studies to assess the extent of using briquettes in urban and rural areas, the preference of people for briquettes, and the possibility of youth and women adopting the briquette over other energy sources are limited. For these reasons are required studies to assess the extent of using briquettes in urban and rural areas also the preference of people for briquettes and the possibility of youth and women to adopt the briquette over other energy sources. Consequently, this study aimed to characterise the respondents' demographic issues useful for evaluation of peoples preferences; to assess the extent of using briquettes fuel in urban and rural areas based on the obtained profile of demographically characterised people; demographically to investigate the preference of

people for briquettes fuel, and establish the feasibility of youth and women to adopt the briquette over other energy sources, in Morogoro urban and rural, Tanzania.

2. METHODOLOGY

2.1 Study Area

The research took place in the urban and rural districts of the Morogoro region, Tanzania. The selected areas included urban, peri-urban, and rural characteristics, as shown in Fig. 1. The representative units from these different characteristic areas were wards. The wards included Chamwino, Kichangani, and Magadu for urban, Mkundi, Kingolwira, and Mindu for peri-urban; and Kisaki, Kiroka, Kinole, and Kolero for rural. The Morogoro region was chosen because it is considered among the regions with high potential in agriculture, consequently producing large volumes of biomass. In addition, Morogoro is prone to environmental degradation through deforestation since it is among the top regions supplying charcoal and firewood to Dar es Salaam city.

2.2 Data Collection

The baseline study involved a household survey targeting youths and women. Key informants such as village leaders, charcoal retailers and people with knowledge of briquette technology were also interviewed. Information on the respondents' demographic issues related to gender, age, occupation and household membership of participants involved in this study were collected. In addition, information on respondents' preference and rate of using briquettes compared to other heating energy sources and willingness to engage in briquette business were collected. A 5-points Likert scale (not preferred, least preferred, moderately preferred, more preferred, and most preferred) was used in collecting these data.

The opinions of respondents who were not aware of the briquette were gathered after describing and showing them the briquettes. The information during the interview was collected using an electronic questionnaire coded in the Geographical Open Data Kit (ODK) application. The ODK was installed on the trained enumerators' tablets and Android cellphones. Before using the electronic questionnaire on the respondents, it was pre-tested to see if the questions were well structured, understood, and provided the information required. Four wards from rural, three peri-urban, and three urban wards were selected randomly. In addition, 34 streets or villages were selected randomly from the proposed wards, as shown in Fig. 2. The target was at least 30 respondents who were chosen purposively using a snowball technique in each ward. The total number of respondents interviewed in all wards was 330.

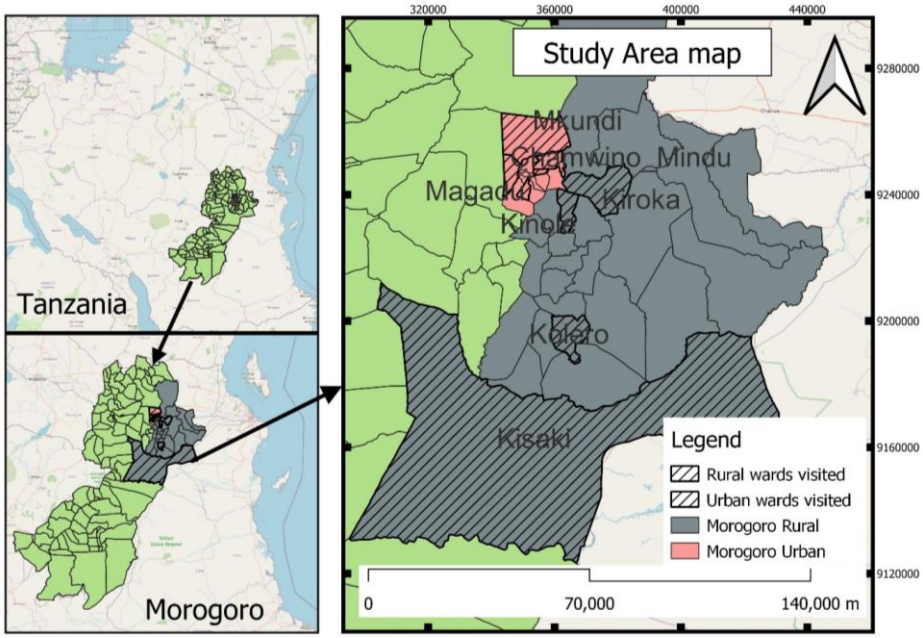

Fig. 1. The map of the study area

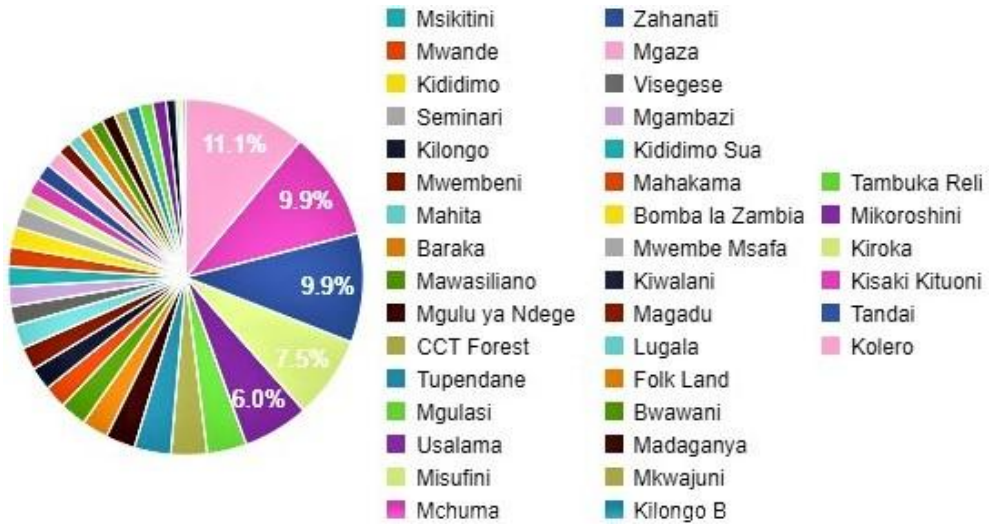

Fig. 2. Percentage of respondents as per streets and villages that largely contributed during the survey

2.3 Analysis

The Statistical Package for Social Sciences, version IBM SPSS Statistics 20 Program, was used to perform descriptive and inferential statistics. The Chi-square test was used to test if there is a significant difference in preference for briquette energy versus other energy sources between men and women or between urban and peri-urban locations. Frequency was used to characterise the respondents' demographic variables, to analyse the level of respondents' preference and rate of using briquettes compared to other heating energy sources, and assess demographically the willingness to engage in briquettes business.

3. RESULTS AND DISCUSSION

3.1 Demographic Profile of the Respondents

Table 1 illustrates the gender and age distribution of respondents in the baseline survey. The results show that 37.6% of respondents were men, and 62.4% were women. The majority of respondents were aged between 16 and 25 years (47.9%). It was followed by those between the ages of 26 and 35 years (27%) and those between the ages of 35 and 45 years (15.8%).

In addition, it was found that the primary occupation of the respondents was small-scale business (44.5%), followed by small-scale farming (33.6%). Other occupations, such as livestock keepers, civil servants, and students, contributed the remaining percentage. Furthermore, 15.5% of respondents were jobless. Most households had family members between 2 and 4 years (44.5%) and 2-and 4 years (40.6%).

3.2 Preference of Respondents for Various Sources of Cooking Energy Based on Gender

Table 2 shows the degree of gender preference on various options of cooking energy sources and the ranks of the sources. It was found that most of both men (40.3 %) and women (33 %) fall under the "more preferred" category under briquette energy source. The large percentage of men who preferred briquettes over women might be due to men perceiving briquettes as a business possibility rather than the use itself. On the other hand, the women's concern may rely on briquette performance rather than a business opportunity. Similarly, past studies highlight that men are often active in energy opportunities as a business, while women consider energy sources for cooking [20]. In addition, the percentage of men and women who did not prefer the briquette was marginal (12.4 %). It indicates that a significant per cent (87.6%) of the respondents are ready to adopt briquette technology, especially when briquettes match the criteria of the majority of customers.

Moreover, when considering the total number of respondents and all energy sources, charcoal relatively scored the least in the "not preferred"

category (1.2%), followed by briquette (12.4%), firewood (20.9%), while the highest score as "not preferred" was biogas (66.1%). The fact that briquette energy was next after charcoal indicates that it may overtake charcoal soon if advocated adequately. The high percentage of "not preferred" under biogas, the green energy, was due to a lack of awareness.

Table 1. Profile status of surveyed respondents

Response item	Description	Frequency (N = 330)	(%) of respondents
Gender	Men	124	37.6
	Women	206	62.4
Age of respondent	16-25	158	47.9
	26-35	89	27.0
	36-45	52	15.8
	46-55	16	4.8
	56-65	12	3.6
	66 and above	3	0.9
Primary occupation	Small business	147	44.5
	Small farming	111	33.6
	Livestock keeping	5	1.5
	Civil servant	7	2.1
	Student	9	2.7
	Idle	51	15.5
Household members	1– 2	27	8.2
	2 – 4	147	44.5
	5 –8	134	40.6
	9 and above	22	6.7

Table 2. Comparing the preference level of male and female respondents on cooking energy sources options

		level of preference					
		Not	**least**	**Moderate**	**More**	**Most**	**Total**
Men	Charcoal	1(0.8)	8(6.6)	21(16.9)	32(25.8)	62(50.0)	124(100)
	Briquettes	**10(8.1)**	**11(8.9)**	**30(24.2)**	**50.0(40.3)**	**23(18.5)**	**124(100)**
	Firewood	25(20.2)	21(16.9)	23(18.5)	25(20.2)	30(24.2)	124(100)
	Gas (LPG)	29(23.4)	21(16.9)	21(16.9)	31(25)	22(17.7)	124(100)
	Biogas	76(61.3)	25(20.2)	13(10.5)	9(7.3)	1(0.8)	124(100)
	Kerosene	78(62.9)	32(25.8)	10(8.1)	2(1.6)	2(1.6)	124(100)
	Electricity	68(54.8)	15(12.1)	16(12.9)	14(11.3)	11(8.9)	124(100)
	CR	63(50.8)	29(23.4)	19(15.3)	7(5.6)	6(4.8)	124(100)
Women	Charcoal	3(1.5)	3.0(1.5)	30(14.6)	42(20.4)	128(62.1)	206(100)
	Briquettes	**31(15)**	**22(10.7)**	**41(19.9)**	**68.0(33.0)**	**44(21.4)**	**206(100)**
	Firewood	44(21.4)	40(19.4)	32(15.5)	45(21.8)	45(21.8)	206(100)
	Gas(LPG)	51(24.8)	27(13.10)	39(18.9)	28(13.6)	61(29.6)	206(100)
	Biogas	142(68.9)	35(17.0)	23(11.2)	4(1.9)	2(1.0)	206(100)
	Kerosene	121(58.7)	50(24.3)	24(11.7)	7(3.4)	4(1.9)	206(100)
	Electricity	124(60.2)	33(16.0)	15(7.3)	15(7.3)	19(9.2)	206(100)
	CR	123(59.7)	50(24.3)	18(8.7)	11(5.3)	4(2.0)	206(100)
Total	Charcoal++	4(1.2)	11.0(3.3)	51(15.5)	74(22.4)	190(57.6)	330(100)
	Briquettes++	**41(12.4)**	**33(10)**	**71(21.5)**	**118(35.8)**	**67(20.3)**	**330(100)**
	Firewood++	69(20.9)	61(18.5)	55(16.7)	70(21.20)	75(22.7)	330(100)
	Gas (LPG)**	80(24.2)	48 (14.5)	60(18.2)	59(17.0)	83(25.2)	330(100)
	Biogas++	218(66.1)	60(18.2)	36(10.9)	13(3.9)	3(0.9)	330(100)
	Kerosene++	199(60.3)	82(2.8)	34(10.3)	9(2.7)	6(1.8)	330(100)
	Electricity++	192(58.2)	48(14.5)	31(9.4)	29(8.8)	30(9.1)	330(100)
	CR++	186(56.4)	79(23.9)	37(11.2)	18(5.5)	10(3.0)	330(100)

*CR: represent crop Residue, ** indicates a significant difference in preferences between men and women at 2-Tailed Pearson Chi-Square Tests (p-value <0.001, α=0.05), and ++ indicates No significant difference in preferences between men and women (p-value >0.001, α=0.05)*

Briquettes scored the fourth position under the "Most" category, while charcoal, gas (LPG), and firewood scored the first, second, and third positions, respectively, based on the total respondents. The briquettes mainly were preferred to kerosene, biogas, and energy from the crop residues. Briquettes' ability to compete with other key cooking energy sources like charcoal and firewood may be attributed to their ability to burn well, stability, and durability during storage, handling, transportation, and environmental safety when combusted [4,5].

Under the "Most preferred" category, the interest of women (62.1%) in charcoal was higher than that of men (50%). However, a small percentage of men were interested in charcoal compared to women because men faced difficulties in making the charcoal. In addition, considering the category of the "Moderate" level of preference as the minimum level of interest in adopting briquette, then from the row of briquette in the section of Total of Table 2, it is shown that 77.6% of respondents are interested in utilising the briquette.

Also, it was revealed that at the "Not preferred" level of preference, both men and women (more than 50%) did not prefer biogas, kerosene, electricity, and agricultural residue. The rejection of biogas could be attributed to the need for frequent maintenance [21]. Kerosene's rejection might be associated with increased pricing, indoor air pollution, extended cooking times, and a negative impact on health [22,23]. Furthermore, lower acceptance of electricity for cooking might be linked to the cost, reliability, and insufficiency of electric cooking stoves and a lack of optimism about acquiring it, particularly in rural areas.

3.3 The Extent of use of Cooking Energy Sources with Respect to Administrative Location

The research evaluated various cooking energy alternatives with respect to urban, peri-urban, and rural areas (Fig. 3). It was found that, in urban areas (Fig. 3a) and peri-urban areas (Fig. 3b), the trend in the use of different types of energy sources was nearly similar. Over 80% of respondents reported that they always used charcoal as their primary source of cooking energy. This finding aligns with findings reported in the prior research [24]. Such overusing charcoal may be attributed to its relatively low cost and availability. In addition, charcoal may be extensively overused because of being accessed and accepted by households of different levels in terms of income, family size, and educational attainment [22]. Kerosene, LPG, and firewood were rarely utilised, while over 80% of respondents had never utilised biogas, briquettes, electricity, or crop residues. Kerosene and firewood might be rarely used in urban and peri-urban because of being considered inferior cooking energy sources [22].

Fig. 3c shows that the trend of using different energy sources in the rural areas was nearly similar to that of urban and peri-urban areas except for firewood. The findings revealed that the percentage of people who use firewood in rural is nearly the same as those using charcoal. The similarities in percentages of people utilising firewood and charcoal in rural might be due to easy accessibility and low cost [25]. Furthermore, the rising percentage of firewood utilisation in rural communities might be connected to the low standard of living [26].

Most respondents (Fig. 3d) reported that their primary cooking energy sources are charcoal and firewood, followed by gas (LPG). Other energy sources were reported as never used, rarely or moderately used.

3.4 Willingness towards Briquette Business

Fig. 4 shows that more than 95% of men and women respondents expressed their willingness to engage in the briquette business. There was no significant difference between men and women in their willingness to join the briquette business (p-vale =0.517, Pearson Chi-Square value = 0.273, N =330). The respondent pointed out various reasons, including the fact that charcoal is inadequate during the rainy season, the unemployed youth, the desire to learn new skills, and the desire to generate income. Moreover, other factors include the fact that the money required to start a briquette business appears to be minimal compared to other energy sources such as gas (LPG). Moreover, 98.9 % of respondents believed that the briquette technique is potential for environmental conservation.

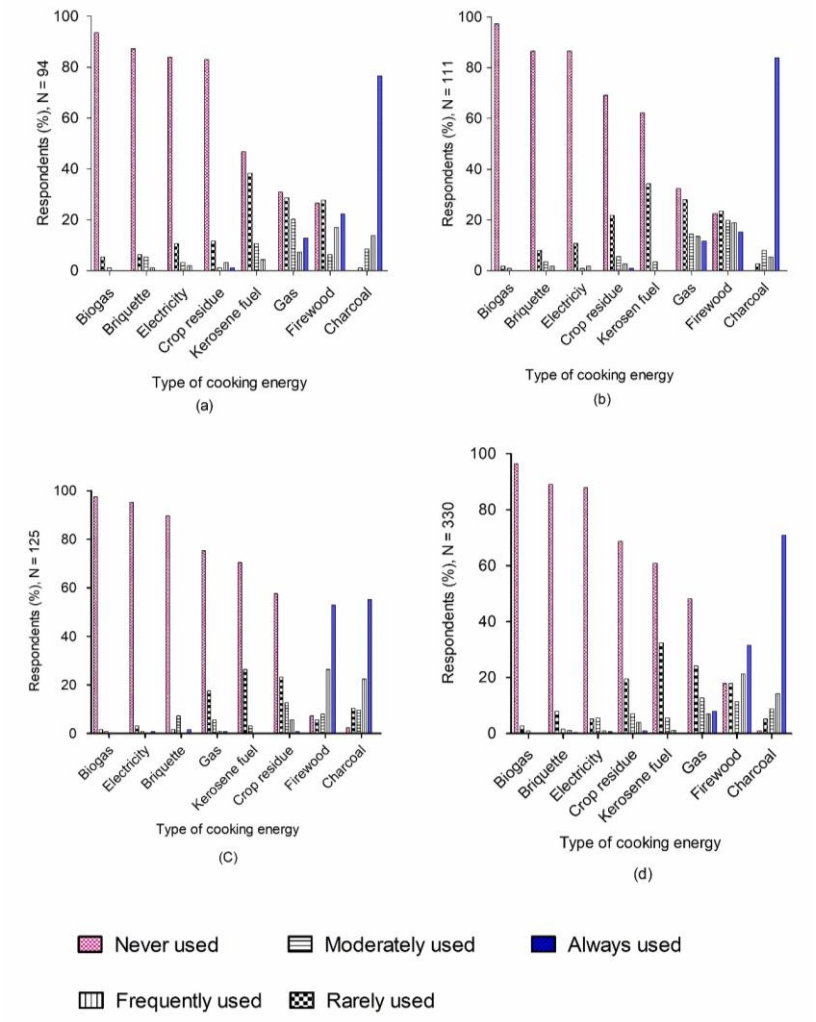

Fig. 3. The usage rate of different energy sources. (a) Urban, (b) peri-urban, (c) rural and (d) Combined (urban, peri-urban, and rural)

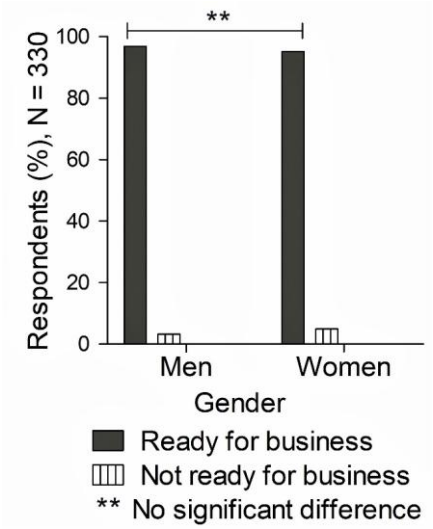

Fig. 4. Respondents' willingness toward briquette business

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusions

The use of green energy sources is crucial for minimising the adverse environmental consequences to a tolerable level. BiomassBased on this study's findings, briquettes as a green energy source are rarely utilised in urban, peri-urban, and rural areas. However, it indicates that briquettes have not been introduced to those areas. In addition, charcoal and firewood are the most consumed cooking energy sources in the areas mentioned above. However, a large number (>70%) of people in these areas are interested in adopting the briquettes. Additionally, a small number (12%) of people are not interested in briquette adoption. Most men and women (>95%) consider the briquette technology a business opportunity and are ready to engage in it, posing this green technology as the potential initiative of the major source of cooking energy and employment. Therefore, briquette technology acceptance by youths and women, particularly for cooking, business opportunities, and serving the environment, is feasible.

4.2 Recommendations

The authors recommend raising awareness of briquette technology's advantages over charcoal and firewood among people who are potential users of briquette products. Facilitation of the raising the awareness should be done through training, conferences, radio and television programs and brochures. In addition, assessing the factors hindering the briquettes from being a hundred per cent preferred by people is a point of research interest, facilitating the innovative improvement of the technology. Furthermore, training on business skills should be provided to people, especially youths and women, to exploit the business opportunities along the briquette technology value chain. Availability and accessibility of briquette products and stoves that are technologically improved to accommodate briquettes should also be prioritised by stakeholders for upscaling and out-scaling the adoption of the briquette technology.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company; instead, it was funded by the SWISSCONTACT (Region: CESAF), under the Skills for Employment Tanzania (SET) programme aiming to sensitise the creation of green employment for youth through Project Number 81060031.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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