Original Research Article

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

ABSTRACT

Firewood and charcoal are the main resources of energy in many developing countries especially in sub-Saharan Africa. The unstainable collection and use of these resources creates negative impact on the environment. Equally, using briquettes as green energy resources can address the shortage of energy and conserves the environment. However, the information of people 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. This study was conducted in Morogoro district to (1) assess the preference for briquette technology particularly for youth and women, and (2) evaluate the extent of using the briquette technology as compared to other alternative sources of energy. The household survey involved 330 respondents in Morogoro urban, peri-urban, and rural areas. The areas were chosen to represent the Tanzania sceneries. Additionally, supplementary key informants' interviews involved village leaders, charcoal retailers and other people with knowledge on briquette technology. The results show that over 95% of respondents preferred to use briquette as alternative energy source and expressed their willingness to engage in the briquette business. Additionally, the study shows low use of briquettes as compared to other source of energy 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 to youths and women on briquette technology, and insisting the availability of briquette products and stoves. In addition, assessing the factors hindering the briquettes from being a hundred percent 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 utilizing green energy technology reduces negative impacts like deforestation on ecosystems, thus ensuring welfare of living organisms, and the environment [1]. The over-reliance on charcoal and firewood is due to the benefits offered by both, including low-cost energy, produced by simple tools, and providing employment for youth, especially in low-income areas of Sub-Saharan African (SSA) countries.

In SSA countries, if green energy sources are not utilized, the demand for charcoal and firewood is expected to increase by 2.8 and 1.4 percent, 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]. Apart from reducing the negative impacts associated with charcoal and firewood, it 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 same time conserving the environment by reducing the decomposition and release of greenhouse gases into the atmosphere [10]. For example, in SSA, forestry and agriculture produce around 1000 Mt and 140 Mt of biomass wastes annually, respectively [8]. The mentioned forest and agricultural wastes are such as wood shavings, coffee and rice husks, corn stalks, cotton stalks, sawdust, groundnut shells, coconut residues, and bamboo [9][7]. .

Various initiatives for advancing the briquette technology to diverge people from using charcoal and firewood have been portrayed. For example, the design of reciprocating ram/piston/screw press briquette making machines, particularly in industrialized 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, Tanzania in collaboration with Japan International Cooperation Agency 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 the available and accessible at affordable price to speed up 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 of the briquette technology, 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 in lieu of other alternative energy sources. Studies to assess the extent of using briquettes in urban and rural areas; the preference of people on briquettes and possibility of youth and women to adopt the briquette over other energy sources are limited. Therefore, this study aimed to assess the extent of using briquettes in urban and rural areas; the preference of people on briquettes 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 Morogoro Urban and rural districts of Morogoro region, Tanzania. The selected areas included urban, peri-urban, and rural characteristics as shown in Figure 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 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.

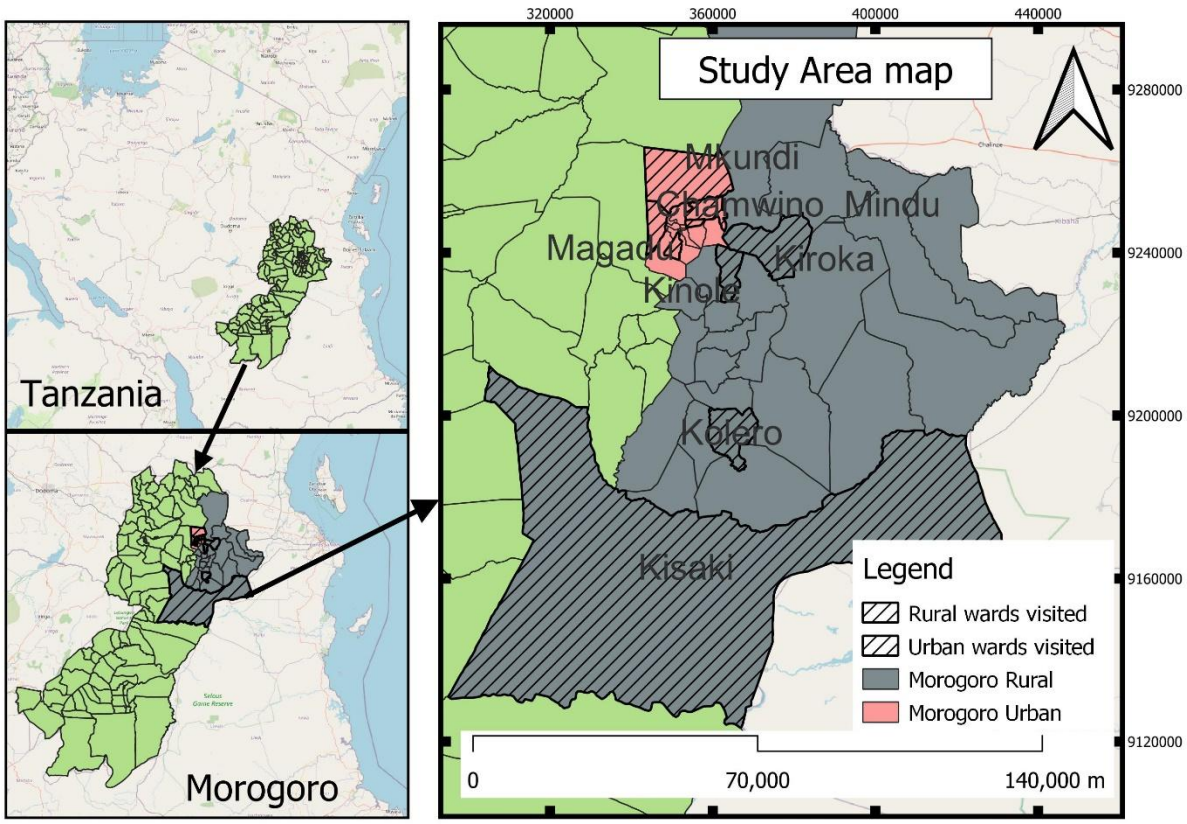

Figure 1: The map of the study area

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 on briquette technology were also interviewed. 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, moderate preferred, more preferred, and most preferred) 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 interview was collected using 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 Figure 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.

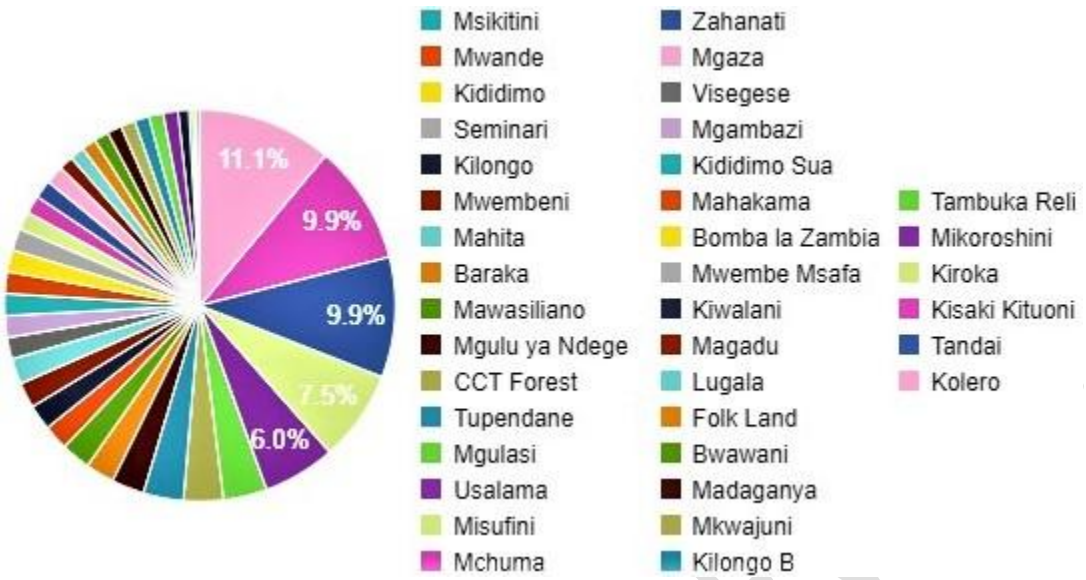

Figure 2: Percentage of respondents as per streets and villages surveyed

2.3 **Analysis**

The Statistical Package for Social Sciences, version IBM SPSS Statistics 20 Program, was used to perform both 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 in the analysis of level of respondents' preference and rate of using briquettes compared to other heating energy sources, and willingness to engage in briquette.

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 the respondents were between the age of 16 and 25 years (47.9%), followed by those between the age of 26 and 35 years (27%), and by those of the age between 35 and 45 years (15.8%).

In addition, it was found that the primary occupation of the respondents was small business (44.5%) followed by small-scale farming (33.6%). Other occupations, such as livestock keepers, civil servants, and students, contributed the remaining percent. Furthermore, 15.5 percent of respondents were jobless. Most of the households had family members between 2-4 (44.5%) and 5-8 (40.6%).

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

3.2 Preference of respondents on 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 prefer" 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. 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 %). This indicates that a significant percent (87.6%) of the respondents are ready to adopt briquette technology, especially when briquettes match the criteria for the majority of customers.

Table 2: Comparing the preference level of men and women respondents on options of cooking energy sources.

		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)

Moreover, when considering the total number of respondents and all energy sources, charcoal was 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 in the near future if advocated adequately. The high percent of "not preferred" under biogas, which is also a green energy, was due to lack of awareness.

Considering the total respondents, briquettes scored the fourth position under "Most," category while charcoal, gas (LPG), and firewood scored the first, second, and third positions, respectively. The briquettes were mostly 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%). The reason why a small percentage of men were interested in charcoal compared to women may be due to the fact that, men are the ones facing the difficulties in making the charcoal. In addition, considering the category of the “Moderate” level of preference as the minimum level of interest to adopt 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 utilizing 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 negative impact on health [22][23]. Furthermore, lower acceptance of utilizing electricity for cooking might be linked to the cost, reliability, and insufficiency of electric cooking stoves and a lack of optimism for acquiring it, particularly in rural areas.

3.3 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 (Figure 3). It was found that, in urban areas (Figure 3a) and peri-urban areas (Figure 3b), the trend on the use of different types of energy sources were nearly similar. Over 80% of respondents reported that they always used charcoal as their primary source of cooking energy. This finding is in line with findings reported in the prior research [24]. Such overusing of 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 utilized, while over 80% of respondents had never utilized 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].

Figure 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 to those using charcoal. The similarities in percentages of people utilizing firewood and charcoal in rural might be due to both easy accessibility and low cost [25]. Furthermore, the rising percentage of firewood utilization in rural communities might be connected to the low standard of living [26].

In summary, most respondents (Figure 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.

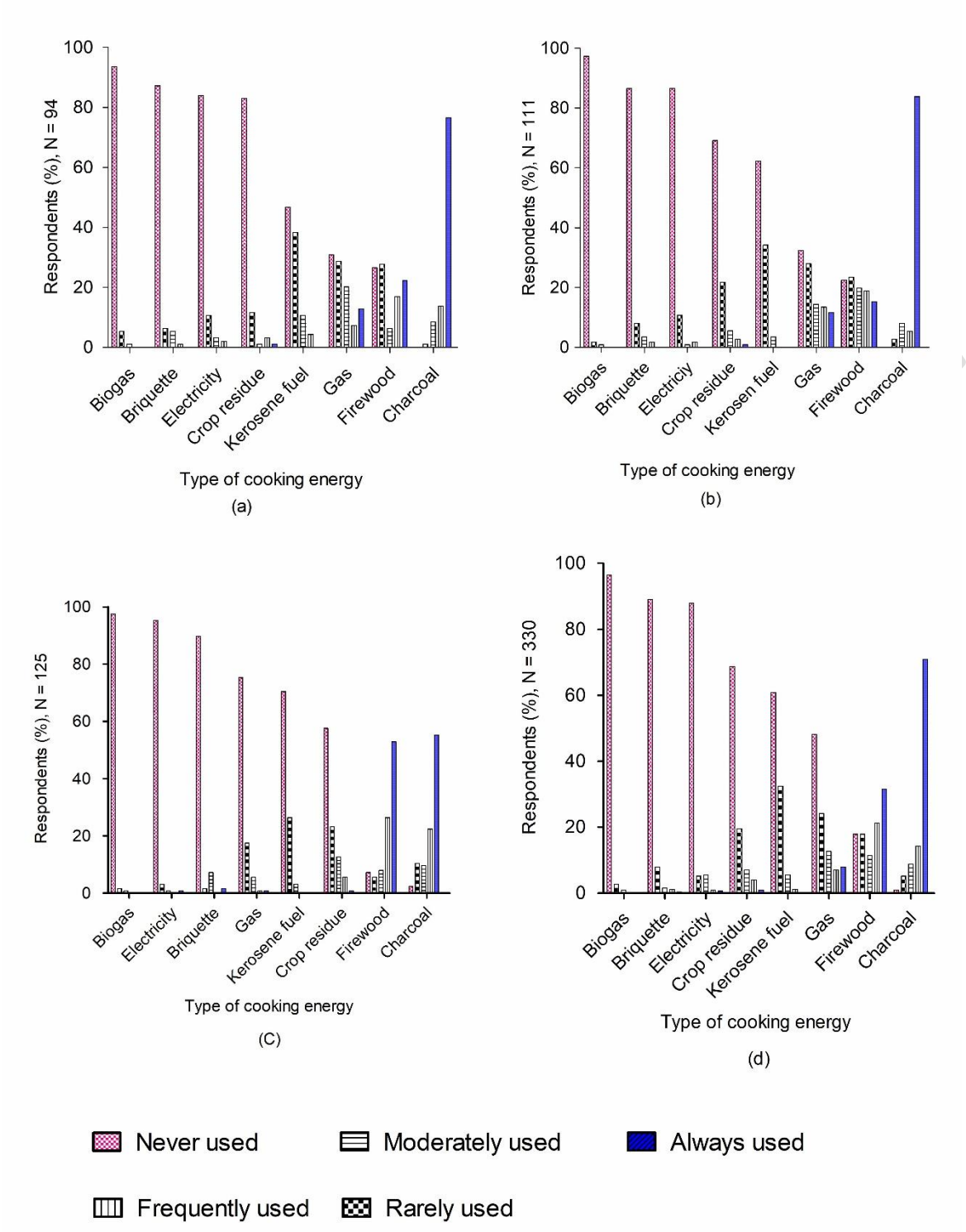

Figure 3: The usage rate of different energy sources. (a) Urban, (b) peri-urban (c) rural and (d) Combined (urban, peri-urban, and rural).

3.4 Willingness towards briquette business

Figure 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.

Figure 4: Respondents' willingness towards briquette business

4. CONCLUSION AND RECOMMENDATIONS

Conclusions

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

briquette technology acceptance by youths and women, particularly for cooking, business opportunities, and serving the environment is feasible.

Recommendations

The authors recommend raising of awareness on 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 percent preferred by people is a point of research interest, which will facilitate the innovative improvement of the technology. Furthermore, training on business skills should be provided to people, especially youths and women, on exploiting 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 given a priority by stakeholders for upscaling and out-scaling the adoption of the briquette technology.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use 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 rather it was funded by personal efforts of the authors.

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