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Sustainable Utilization of Woodfuel in Selected Sites of Mwala Sub-county, Machakos County, Kenya

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Abstract
Biomass energy provides 68% of Kenya's national energy requirements and it is expected to remain the main source of energy for the foreseeable future (Mugo, F. and Gathui, T. (2010). The traditional stoves which happen to be very popular with most households wastes a lot of fuel due to its low energy efficiency and this leads to negative environmental impacts such as deforestation and pollution. This study focused on understanding the sustainable utilization of woodfuel in two (2) Sub-locations of Mwala Sub-county namely: Mwala and Kibauni. The primary objective of this study was to determine if woodfuel utilization by the households in the study areas is sustainable. The specific objective of the study was to establish the level of adoption of the energy saving techniques in the selected sub-locations. This study used survey methodology and observation to collect data. The total household sample size was 160. Data collection instrument was questionnaires. Data was analyzed using descriptive statistics and inferential statistics and the software was Statistical Package for Social Sciences (SPSS) version 23.0. The study revealed low adoption of rationing of wood with majority of the respondents 84% in Kibauni and 65% in Mwala not practicing it. There was significant relationship between rationing of woodfuel and the number of days taken to consume a bundle of wood (df=1 and 158, F=462.898, p=0.00). The study also revealed low adoption of splitting of wood with 70% of respondents in Mwala and 88% in Kibauni not doing the splitting. There was significant relationship between splitting of wood and pollution challenges (df=1 and 158, F=28.456, p=0.00). Low adoption of the practice of putting off fire after use was also revealed with 66% of respondents in Mwala and 80% in Kibauni not practicing it. The study revealed a significant relationship between putting off fire after use and the number of days taken to consume one bundle of wood (df=3 and 156, F=57.292, p=0.00.). It was also found out that there was no significant relationship between the type of stove and pollution challenges (df=1 and 158, F=0.072, p=0.789). The study recommended that aggressive campaign in dissemination of improved stoves and related technology in order to reduce pressure on forests, the Government to have a structured management in production of charcoal and fuel wood by small scale farmers so as to have a source of income, promote capacity of field extension staff in the energy sector and establish an Energy Centres in the Sub-county to help disseminate knowledge and materials related to energy conservation.
Keywords: Woodfuel, Fuelwood(Firewood), Sustainability, Utilization, rationing, splitting, putting off fire, adoption

1. Introduction

Six million hectares of primary forests are lost every year due to deforestation and modification through selective logging and other human interventions, among which are wood fuel needs especially in developing countries (UNEP, 2007). Globally wood fuel accounts for 6 % of the Total Primary Energy Supply (FAO, 2014). In the developing countries wood fuel accounts for the largest share of household energy primarily for cooking and space heating (Sepp *et al*., 2014). In Kenya biomass energy provides 68% of the national energy requirement (Muchiri, 2008;Gathui and Mugo, 2010) and is expected to remain the main source of energy for the foreseeable future. According to (Republic of Kenya, 2007; Muchiri, 2008; Gathui and Mugo, 2010), it is estimated that about 80 % of Kenya's population live in the rural areas characterized by limited access to affordable and convenient energy sources which is argued to be amongst the greatest impediments to social and economic development of the rural populations. There has been a shortage of woodfuel in many parts of Kenya Ngugi, (1988). This high demand causes people to turn to nearby forests for firewood and charcoal thus leading to deforestation and soil erosion (Wanambwa, 2005). Fuel wood is the most common type of energy in rural setups, while charcoal is considered an urban fuel. Other energy sources are electricity, which is too expensive; liquefied petroleum gas whose appliances are too expensive; kerosene, mainly used for lighting but proves relatively expensive when used for cooking (Republic of Kenya, 2003). Harvesting of wood as fuel is associated with increasing levels of deforestation (Muchiri, 2008; Bett *et al*., 2009;). The declining supplies lead to further loss of vegetation cover, deterioration of environmental stability, diversion of agricultural residues from agricultural use and increased expenditure of time and effort on wood fuel gathering, (Labelle *et al*,. 1988; Sepp e*t al*., 2014). Inefficient and unsustainable cooking practices can have serious implications to the environment, such as land degradation and local and regional air pollution (Arnold et al., 2003) A study done by Chris Howorth (1992) in Tanzania on Management of fuel wood reported that fuelwood energy is wasted by many residents by not managing the amounts used and so women manage to use less wood more efficiently by spending more time over the fire, ensuring that flames are direct and not wasted outside the cooking pot and that every scrap of wood and charcoal remaining from the fire is saved for later use. Using better stoves without employing improved practices at the same time is to lose the full benefits of energy-saving that might be achievable. Thick logs burn slowly and often incompletely. Smaller pieces of wood, with a greater surface area, ignite faster and burn more completely and efficiently with no sacrifice in heat output. Sticks with a diameter of 3-5cm are best for most cooking jobs and are easy to handle (UNCHR 2002). People sometimes are insensitive on utilization of excess energy after cooking. Most residents leave fire to die out after cooking regardless of how hot it was on completion of cooking task which is purely wastage of fuel (Wanjala F. and Dr. G. Obwoyere 2015). Therefore the main objective of this study was to find out if utilization styles of the residents in the study areas are actually sustainable.

2. Methodology

The study was carried out in two Sub locations of Mwala Subcounty. Random household visits of a total of 160 households representing about 10% of households in each sublocation were interviewed (Mugenda and Mugenda, 2003). Data collection instrument was questionnaires and the type of data collected included information on education level, common stove used, common fuel, pollution challenges in the kitchen, energy saving measures such as rationing usage of wood, splitting wood before use and putting off fire after use. Data was cleaned and analyzed using descriptive statistics and inferential statistics and the software was Statistical Package for Social Sciences (SPSS) version 23.0

3. Results

In Mwala sub location, 65% and 69 % of the residents did not ration fuelwood and charcoal respectively during their cooking process. Those who adopted rationing of fuel wood and charcoal were 35% and 31% respectively (Table 4-14 and Table 4-22). In Kibauni area 84% and 96% did not ration fuelwood and charcoal respectively while those who adopted rationing of fuelwood and charcoal were 16% and 4% respectively (Table 4-14 and Table 4-22). After doing ANOVA Test it was revealed that was significant relationship between rationing of woodfuel and the number of days taken to consume a bundle of wood (df=1 and 158, F=462.898, p=0.00). On splitting of wood it was observed that 69% representing 58 households in Mwala sub location were not splitting their firewood as they put in their stoves and 30% representing 25 households did splitting (Table 4-15).In Kibauni sublocation 88% representing 68 households were not splitting their firewood while only 11% representing 9 households were doing splitting (Table 4-15). Anova test showed significant relationship between splitting of wood and pollution challenges (df=1 and 158, F=28.456, p=0.00 Regarding putting off fire after use 66% representing 55 households in Mwala Sublocation were not putting off their fire after cooking as compared to 33% representing 28 households who were putting off their fire after use (Table 4-16). In Kibauni Sublocation 80% representing 62 households were not putting off their fire after cooking and 19% representing 15 households were doing it (Table 4-16). The test revealed a significant relationship between putting off fire after use and the number of days taken to consume one bundle of wood (df=3 and 156, F=57.292, p=0.00.). However, there was no significant relationship between the type of stove and pollution challenges (df=1 and 158, F=0.072, p=0.789)

4. Discussion

Wood rationing as a means of controlling the amount of wood fuel consumed was not practiced by majority of the respondents (Table 4-14 and Table 4-15). In Kibauni 84%and 65% in Mwala did not practice wood rationing. Again In Mwala 68% of residents and in Kibauni 96% were not rationing their charcoal. Non rationing of woodfuel leads to fuel wastage and this endangers our little forest cover hence unsustainable utilization. Earlier results show that charcoal is used once a week and most households get it through buying (Table 4-20). So by not rationing charcoal the general usage leads to unsustainable use. The results relate with a study done by Chris Howorth(1992) in Tanzania on Management of fuel wood reported that fuelwood energy is wasted by many residents by not managing the amounts used and so women manage to use less wood more efficiently by spending more time over the fire, ensuring that flames are direct and not wasted outside the cooking pot and that every scrap of wood and charcoal remaining from the fire is saved for later use.

Majority of respondents in Mwala (69%) and in Kibauni (88%) did not practice splitting of wood before burning (Table 4-15). As a result there is great wastage of the woodfuel since much of the heat energy is not channeled to the cooking vessel and so sustainable utilization is not realized here. Using better stoves without employing improved practices at the same time is to lose the full benefits of energy-saving that might be achievable. Thick logs burn slowly and often incompletely. The results agree with what was reported by UNCHR ,2002 that smaller pieces of wood, with a greater surface area, ignite faster and burn more completely and efficiently with no sacrifice in heat output. Sticks with a diameter of 3-5cm are best for most cooking jobs and are easy to handle. Most residents in the study areas did not practice splitting of wood presumably because of non-awareness of the relationship between energy saving measures and pollution effects.

The practice of putting off fire after use was not commonly practiced in the study areas (Table 4-16). This is confirmed by 66% of respondents in Mwala and 80% in Kibauni not practicing it. The respondents who used charcoal in Mwala (69%) and in Kibauni (97%) were again not putting off excess charcoal after cooking. If fire is not put off after use, the excess wood or charcoal burn unnecessarily and much energy is wasted leading to high fuel usage per week.

These results are consistent with the findings of Wanjala F. and Dr. G. Obwoyere (2015) that most residents leave the fire to die out after cooking regardless of how hot it was on completion of cooking task which is purely wastage of fuel. Low level of adoption of putting off fire after use may mean the residents assumed that fire automatically goes off after cooking which might not be the case or lack of knowledge on implication in energy loss or availability of alternative fuel sources.

In the study areas low adoption of the three energy saving measures ie.rationing of wood, splitting and putting off fire after use is an indication of wastage of fuel and energy and will lead to increasing wood fuel scarcity. The usage styles imply unsustainable utilization of fuel wood which the respondents reported as scarce (Table 4-17). As reported by Mugo, 1989; 1999 inefficient end use utilization techniques are key contributors of wood fuel scarcity and unsustainable utilization.

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Table 4-14: Wood rationing

	FACTOR	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	Rationing	29	34.9		83	.480
	No rationing	54	65.1	1.65		
KIBAUNI	Rationing	12	15.6		77	.365
	No rationing	65	84.4	1.84		
TOTAL		**160**		1.74	**160**	.438

Table 4-15: Splitting of wood

	SPLITTING WOOD	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	Splitting	25	30.1		83	.462
	No splitting	58	69.9	1.70		
KIBAUNI	Splitting	9	11.7		77	.323
	No splitting	68	88.3	1.88		
TOTAL		**160**		**1.79**	**160**	**.410**

Table 4-16: Putting off fire after use

	PUTTING OFF FIRE AFTER USE	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	Putting off	28	33.7		83	.476
	No putting off	55	66.3	1.66		
KIBAUNI	Putting off	15	19.5		77	.399
	No putting off	62	80.5	1.81		
TOTAL		**160**		**1.73**	**160**	**.445**

Table 4-17: Wood supply

	WOOD SUPPLY	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	Scarce	83	100.0	1.00	83	.000
	High supply	-	-			
KIBAUNI	Scarce	74	96.1	1.04	77	.195
	High supply	3	3.9			
TOTAL		**160**		**1.03**	**160**	**.136**

Table 4-20: Charcoal usage

	CHARCOAL USAGE	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	1	48	57.8			
	2	32	38.6			
	3	2	2.4	1.47	83	. 612
	4	1	1.2			
	5	0	0			
KIBAUNI	1	49	63.6			
	2	25	32.5			
	3	1	1.3	1.44	77	. 716
	4	1	1.3			
	5	1	1.3			
TOTAL		**160**		**1.42**	**160**	**.496**

Table 4-21: Source of Charcoal

	CHARCOAL SOURCE	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	Buying	82	98.8	1.01	83	. 110
	Making at home	1	1.2			
KIBAUNI	Buying	71	92.2	1.08	77	. 270
	Making at home	6	7.8			
TOTAL		**160**		**1.04**	**160**	**.205**

Table 4-22: Rationing of Charcoal

	CHARCOAL RATIONING	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	Rationing	26	31.3	1.69	83	. 467
	No rationing	57	68.7			
KIBAUNI	Rationing	3	3.9	1.96	77	. 195
	No rationing	74	96.1			
TOTAL		**160**		**1.82**	**160**	**.386**

Table 4-23: Putting off excess charcoal after use

	PUTTING OFF EXCESS CHARCOAL AFTER USE	FREQUENCY	%	MEAN	N	STANDARD DEVIATION
MWALA	Putting off	25	30.1	1.70	83	. 462
	No putting off	58	69.9			
KIBAUNI	Putting off	2	2.6	1.97	77	.160
	No putting off	75	97.4			
TOTAL		**160**		**1.83**	**160**	**.376**