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Factors Influencing Adoption of Biomass Energy Conservation Technologies in Selected Areas of Kitui County, Kenya

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Abstract: In Kenya, demand for biomass energy has increased due to increasing population and urbanization and high cost of alternative energy sources. This coupled with use of inefficient production and utilization technologies, has led to increased deforestation, environmental degradation and increased health impacts. In Kenya, a number of improved technologies have been developed and promoted; however, adoption still remains low. This study sought to assess factors influencing adoption of biomass energy conservation technologies in four selected areas of Kitui County, Kenya. Data were collected using a structured questionnaire and guidelines for institutional and focus group discussions. Sampling was done through purposive and stratified random sampling. Results revealed three categories of biomass energy conservation technologies: energy saving stoves (46%), woodlots (9%) and improved charcoal conversion kilns (2%). The mean percentage adoption rate in the four study areas stood at 48% with Chuluni having the highest (51%) while Kitui West had the least (46%). Agriculture (28%), forestry (26%) and NGOs (Non-Governmental Organizations)/CBOs (Community-Based Organizations) (23%) were indicated as the main sources of information, while field days (35%), community trainings (30%) and demonstrations sites (22%) were the most preferred dissemination channels. High cost of technologies, lack of awareness, financial constraints, cultural preferences, gender aspects, lack of follow up programmes and inadequate capacity to enforce implementation of existing energy policies and regulation were indicated as key constraints to adoption of technologies. The study recommends development of a joint implementation strategy and follow up programmes that will look at the cost of technologies, dissemination channels and involvement of stakeholders' in development and dissemination of biomass energy conservation technologies.

Key words: Biomass energy, conservation, technologies, dissemination, adoption.

1. Introduction

Over one third of the world's population, about 2.7 billion people, rely on traditional biomass energy in form of wood fuel, agricultural residues and animal wastes for their basic energy needs [1, 2]. Wood fuel (fuel wood and charcoal) is the most important single source of renewable energy, providing more than 9 percent of the global total primary energy supply [1]. In Sub-Sahara Africa (SSA), 90% of the inhabitants use biomass energy for domestic purposes, the remaining 10% use either petroleum based fuels such as kerosene and gas and the least use biogas, electricity or solar energy [3]. The high number of biomass energy consumers and increased demand is associated with rapidly increasing populations, increasing urbanization, high poverty levels and relatively high prices of alternative energy sources [4]. The increasing population has also seen increased use of agricultural residues for energy purposes thus contributing to low soil fertility a major factor in food security [5].

In Kenya, most of the wood fuels resources are obtained unsustainably from dry forest, wood lands

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and farmlands. The traditional way of producing and utilizing biomass energy is also unsustainable as the technologies used are inefficient and has significantly contributed to increased overexploitation of the preferred tree resources. With increased awareness on climate change and energy security, wood energy has become far more important and visible as a global issue. Unsustainable harvesting of tree resources and use of inefficient technologies has contributed increased emission of greenhouse gases thus contributing to climate change [6].

In Kenya, wood based energy provides 70% of the national energy needs with about 90% of Kenyan's rural households depending on fuel wood as basic source for cooking and heating while it is estimated that 83% of Kenyan urban households depend on charcoal for cooking. Apart from being an important domestic energy source, wood fuel is also an important source of energy for rural based Small and Medium Enterprises (SMEs) such as agro-processing industries, confectioneries and mineral-based industries such as brick making and ceramics [7] and institutions such as schools, hospitals and prisons. It is estimated that in Kenya, the national demand of charcoal is over 16 million m^3 while supply is estimated at about 13.5 million m^3 [8]. The current deficit is estimated at over 60% [9]. This state of affairs has major implications on the environment and the people as most of the energy is produced and utilized in traditional and inefficient kilns which have low efficiency rates of between 12-15% [10] and utilized in inefficient stoves.

1.1 Problem Statement and Justification

Overexploitation of wood resources to meet domestic and commercial energy in Kitui County has led increased environmental degradation, threatened tree species, wood scarcity and food insecurity. The proximity of Kitui County to major towns has made charcoal production a big business even for outsiders and this has led to increased impacts on the environment and the people. To curb the negative impacts, a number of organizations have developed and promoted biomass energy conservation technologies to local communities and institutions within the county. The technologies include energy saving cook stoves, improved charcoal conversion technologies and establishment of wood fuel plantations. Information on available technologies has been disseminated to local communities through trainings, demonstrations sites, field days, exchange programmes and development and provision of extension materials. Despite the high number of organizations involved in development and promotion of sustainable energy technologies, adoption and continued use of the technologies still remains low. This was observed in the socio-economic study undertaken in the County [11]. The study indicated low level of adoption of energy conservation technologies thus contributing to wood fuel scarcity and environmental degradation. However, no studies have been undertaken to establish factors influencing the adoption of the technologies. This study therefore sought to assess factors influencing the adoption of energy conservation technologies in four selected areas of Kitui County.

1.2 Overall Objective

To assess factors influencing adoption of biomass energy conservation technologies in four selected areas of Kitui County.

1.3 Specific Objectives

To document energy conservation technologies used by the local community, institutions and small scale commercial enterprises in the study area.

To determine how various information dissemination pathways by organizations have influenced adoption of the technologies by the community.

To establish how environmental and socio-economic related factors have influenced adoption of the technologies.

2. Materials

2.1 Study Area

The study was undertaken in four selected areas of Kitui County namely: Kitui Central, Chuluni, Matinyani and Mutonguni Sub-Counties (Fig. 1). The total area of the County is 30,496.4 km^2 [11]. The estimated population in 2013 stands at 1,065,829 with 86% of the population estimated to be living in rural areas and only about 14% living in urban areas [12]. The county is divided into three regions, the South, the North and the Central region which comprises of Kitui Central, Matinyani, Chuluni and Mutonguni Sub-counties. Over 50% of the population are settled in the Central region which cover the study areas. The central region is characterized by small land sizes and high population densities which puts a lot of pressure to the available forest and tree resources.

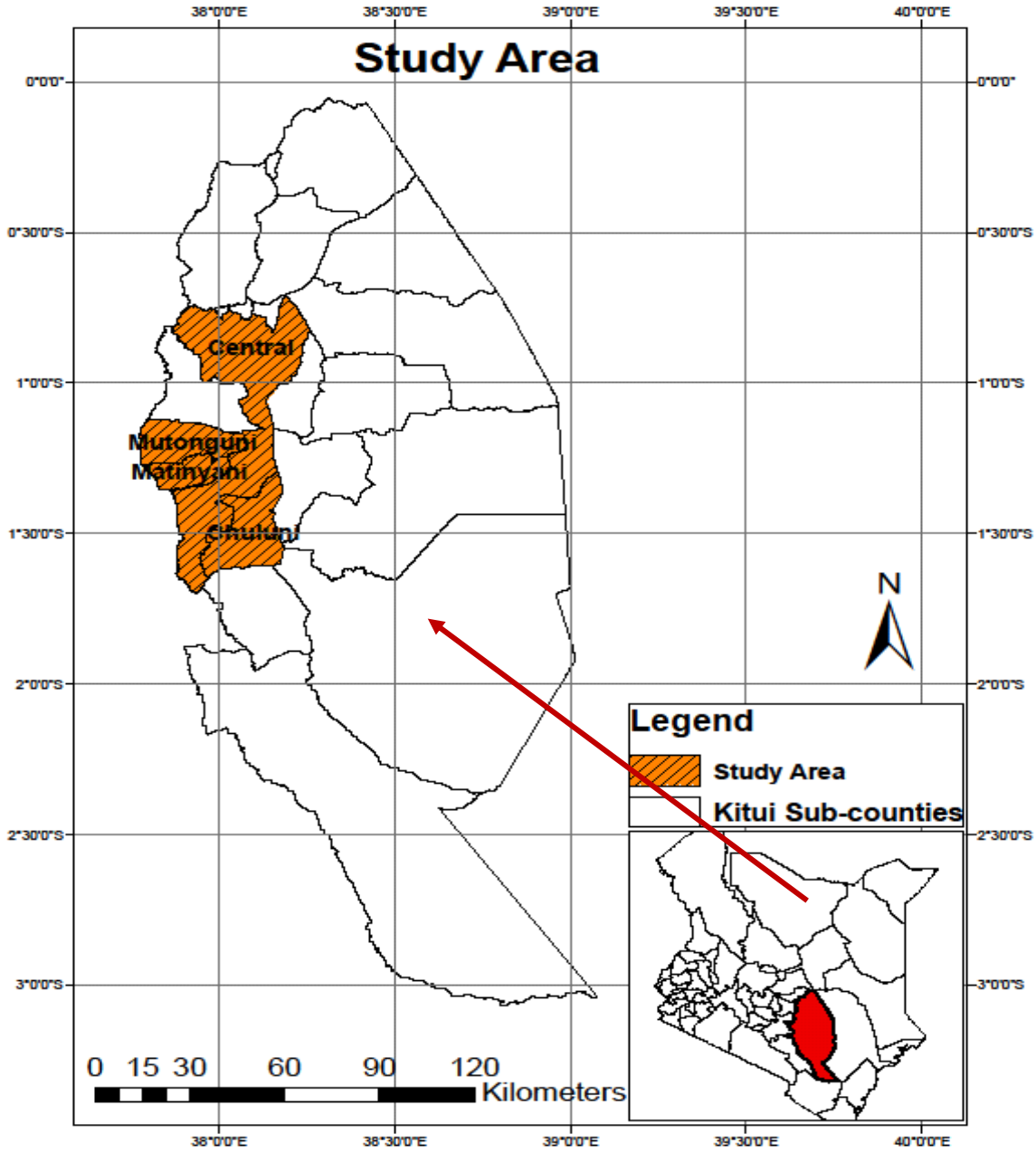

Fig. 1 Map of the study County/area.

2.2 Sampling

Sampling was done through purposive and stratified random sampling. The four study areas were identified and stratified into locations and then sub-locations. A total number of 1,920 households in the selected sub-locations formed the population sample frame. Through random sampling, 10% of the total households in each sub-location were selected for individual household interviews and according to [13] a sample of at least 10% of the household population per sampling unit was adequate. A total of 192 households and eight organizations identified through focus group discussions were interviewed.

2.3 Data Collection and Analysis

Data were collected using structured questionnaires for individual households and institutional interviews and questionnaire guidelines for Focus Group Discussions (FGDs). The study employed Microsoft Excel and SPSS (Statistical Package for Social Scientists) computer packages for descriptive and inferential statistics.

3. Results and Discussions

3.1 Socio-Economic and Demographic Factors of the Population

The result shows that 77% of the respondents were women and 23% men. Men literacy level is generally high at over 70%, however women make 75% of people with little or no education at all. Most farms were privately registered (72.9%) mostly under the name of the head of household, the majority of whom were men except where land was jointly bought.

3.2 Sources of Energy of the Respondents

The results showed that firewood (97%) followed by charcoal (86%) was the main sources of energy for cooking and heating in all the four study areas. Other sources of energy for cooking, heating and lighting included crop residues, kerosene, gas, solar and electricity at 62%, 53%, 28%, 12% and 7%, respectively indicated in Fig. 2

Majority of head of the households were men at 61.9% while women were 39.1%, mainly widows and single parents. Most families are large with a mean of seven members.

The high percentage of usage of biomass based fuels i.e. firewood, charcoal and crop residues confirms the information that biomass energy is a major source of energy for a big percentage of the population in the study area. This is due to its availability, affordability and ease of use as indicated by over 90% of the respondents. The high prices of the alternative energy sources such as LPG (Liquefied Petroleum Gas) and electricity were indicated by 75%

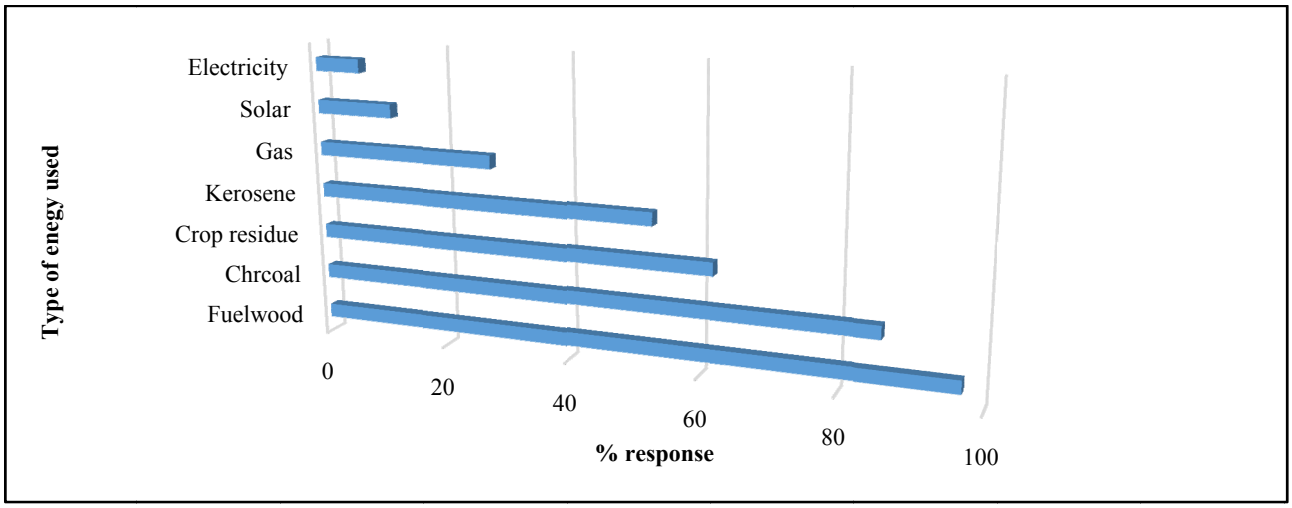

Fig. 2 Sources of energy of the respondents.

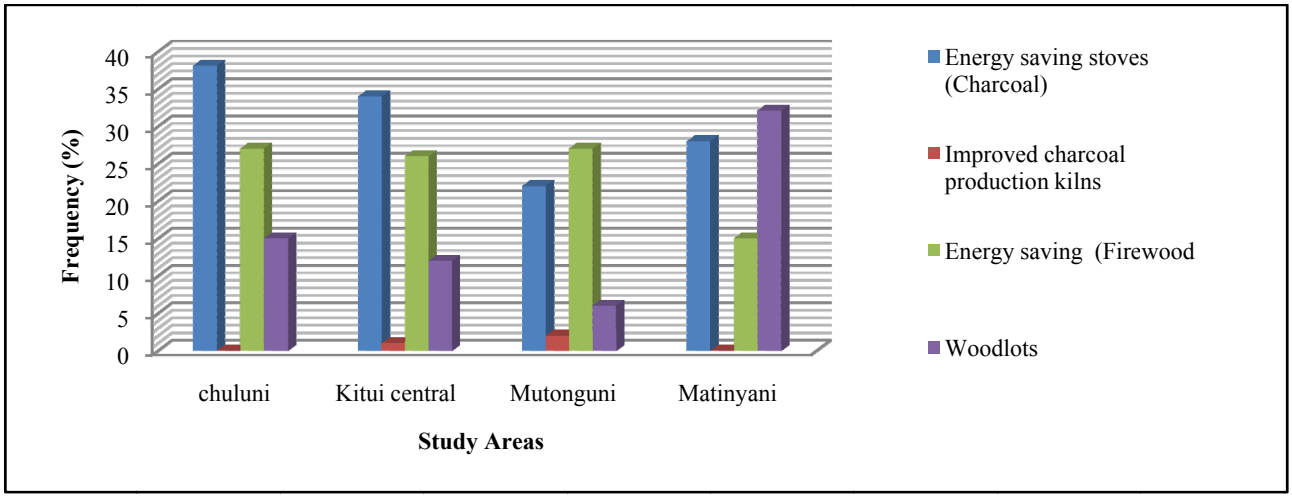

Fig. 3 Proportion of respondents who have adopted energy conservation technologies in the four study areas.

of the respondents as one of the major constraints to use of alternative energy sources. Apart from the cost, they also lack the necessary accessories and devices such cylinders and cookers to use the alternative energy. Brick making, liner and pottery firing and tobacco curing enterprises were also observed as major consumers of fuel wood mainly from farmlands.

3.3 Energy Conservation Technologies by the Local Community and SMEs

Three categories of biomass energy conservation technologies used by the communities and the SMEs (Small and Medium Enterprises) were identified in the four study areas. The technologies included: improved energy saving cook stoves (46%), establishment of wood fuel plantations or woodlots (9%) and improved charcoal conversion kilns (2%). The technologies varied within the study areas as illustrated in Fig. 3.

3.4 Adoption of Energy Saving Cook Stoves and Reasons for Adoption

Adoption of biomass energy conservation technologies in the areas was noted to be improving given the variety of stoves and devices available within the community and the high number of organizations involved in their development and promotion. Adopted cook stoves and devices included "Kuni mbili", Kenya Ceramic Jiko (KCJ), "Maendeleo" liner stove, the "Enzaro", modified simple brick, Rocket and "Jiko poa" stoves. While most of the cook stoves were being promoted freely or through cost-sharing by the various organizations and are also available in retail shops, the "Jiko Poa" cook stove was being provided through a credit facility by K-REP micro-finance instituion.

3.5 Reasons for Adoption of Energy Saving Stoves

Respondents had varied reasons for the adoption of the stoves as indicated in Table 1.

From the results, the overall percentage of the community members adopting and using sustainable energy conservation technologies was noted to be low (47%), However, this was an improvement from 33% recorded in an earlier study [12] despite the various efforts by both state and non-governmental organizations to create awareness on the availability of the technologies and benefits accrued from using them The technologies were noted to save energy and time spend collecting firewood due to low fuel consumption, thus less cutting of trees, provides a cleaner cooking environment through reduced smoky and polluting environment hence reduced beneficial health impacts and lastly, saves money which would otherwise be used to buy fuel. Despite the multiple beneficial aspects associated with use of energy saving cookstoves a large number of community

members who still rely on biomass energy as the basic source of fuel, still use the traditional cookstoves. According to WHO/UNDP, report, traditional cook stoves and solid fuel used in poorly ventilated houses are a major contributor to respiratory diseases in the developing world [3] and the impacts are high among women, children and the elderly who are continuously exposed. Most of the stoves used are substandard and don't meet the international World Health Organization (WHO) standards as they lack chimneys for directing the smoke and particulate matter outside. The traditional technologies continue to enjoy cultural preference because as they have been in use for ages thus the indigenous knowledge is being passed through generations. Installation and operation of the traditional technologies requires no special skills. The materials used (stones and vegetative materials) are freely available and according to the local community, installation has no financial implications and the sizes of the traditional technologies can be expanded depending on the needs of the people.

Apart from the various beneficial aspects associated with the use of improved cookstoves and kilns, the availability of local materials used for construction of some of the stoves such as bricks and sand was indicated as a contributing factors to increased use of the devices. The traditional cook stoves continue to enjoy cultural preference despite its associated health and environmental related issues. In a related study undertaken in Peru, Kenya and Nepal, on behavioral altitudes and preferences in cooking [14], the traditional cook stoves were still preferred culturally, as they are perceived to yield tasty staple food, faster in cooking, food more pleasing to the people when associated with traditional stoves, using locally available materials, can be used for other cultural activities and is part of the culture of the people as they share information and stories around the open fire. In all households where the improved stoves were observed, the traditional stoves were still in use, despite the low efficiency levels since most of the fuel wood is obtained from own at low cost, has no financial implication. There ease of mobility and installation anywhere within the homestead and community makes the traditional three stone and the metal stoves highly preferred for large families and social activities such as wedding and funerals. The cultural preference for the three stone stoves especially by the elderly in the community is due to its multiple uses such as heating, cooking, lighting and performing cultural activities. The smoke from the traditional stoves also as an aspect of food security as observed in the study area, where cereals are stored in structures below the roof of the kitchen just above the traditional stoves and the smoke from the fire below repel pests, this saves them the cost and use of chemical pesticides for food preservation.

3.6 Charcoal Conversion Technologies

According to the results, over 97% of the respondents involved in charcoal production in the four study areas used the traditional earth kilns while only about 2% used improved charcoal conversion kilns. Improved charcoal production technologies available in Kenya are in three categories; namely earth, metal and brick kilns. The earth kilns include the improved traditional

Table 1 Reasons for increased adoption of energy saving cook stoves.

Study sites	Low consumption of fuel	Cleaner cooking environment	Less cutting of trees	Less smoky and polluting environment	Saves time and labor	Improved health	Saves on money
Mutonguni	10	15	10	18	20	14	13
Central	23	17	8	14	13	14	20
Matinyani	15	10	16	12	18	16	13
Chuluni	22	18	6	14	14	10	16
Means	17.5	15	10	14.5	16.25	13.5	15.5

earth and the *Casamance* kilns. These kilns have recovery rates of up to 30% [10]. Other kilns include the metal kiln (portable metal, the *Mekko* and the drum kilns) and lastly and the masonry kilns which include the half orange and the retorts. The recovery rates of the improved kilns range between 25% and 38% [10]. In addition to the high recovery rates, the metal and masonry kilns are friendly to the environment as they do not require any vegetation material to cover the wood in the process of carbonization. The production capacities of these kilns range between 5-120 bags depending on the size. Use of traditional kilns for charcoal production is an old art and has been used for charcoal production until the beginning of the twentieth century [15]. The use of the technology still persists because it is cheap, easy to handle, skills learnt on job and information passed on through generation. It can be operated at the source of wood thus saves the producers' that extra costs of transporting the wood to the kiln site. The traditional kilns are known to be inefficient, with efficiency levels ranging between 12% and 15% according to studies undertaken by Kenya Forestry Research Institute (KEFRI) on efficiency of different types of kilns [10], however, charcoal producers still prefer them. The kilns are known to produce low and inconsistent quality of charcoal products and also contribute to environmental degradation through release of tar, greenhouse gases such as methane and other polluting gases to the environment. According to the study, only about 2% of the respondents indicated to have used the improved kilns. Two types of improved kilns observed during the field study were the brick kiln ("half Orange") and the metal "*Mekko*" Kiln, which were observed in Musengo and Miambani Locations respectively. The adoption and usage of the improved kilns by the community was noted to be very low due to a number of factors key among them; lack of skills and information on how to install and operate the kilns, high cost of the technology, ignorance of the benefits accrued from using improved efficient kilns and high extra costs of transporting the wood materials to the kilns sites as some of the kilns are permanently constructed. According to the respondents, charcoal producers are cautious of any extra cost that would increase their production costs and make their products less competitive in the market. Despite being dependent on charcoal production as source energy and livelihood, the community is ignorant of the benefits accrued from using the improved kilns which would improve their production capacity and sve the environment.

3.7 Establishment of Woodlots

Tree planting or wood fuel plantations have the potential to make biomass energy sustainable and also mitigate climate change through increased tree cover. Though generally tree planting activities in the study area was well established, small land sizes and competing interests such as food and livestock production were noted by majority of the respondents, to be a major constraint to tree planting especially for wood fuel production. Other reasons included lack of seeds and seedlings of preferred tree species, lack of skills and knowledge on how to propagate indigenous trees, and prolonged droughts as result of changing weather patterns leading to depressed rains and water scarcity. Planting trees as source of fuel wood would save the community enormous amount of time and money which would have otherwise be used to procure wood fuel from distance forests or market. According to the results, respondents with small farms were more likely to engage in tree planting unlike respondents with big farms who could access tree resources from their land at no cost. Matinyani area led in the number of respondents with planted woodlots. The small size of the farms is as result of high population leading to increased fragmentations of the farms. Respondents indicated preference of integrating agroforestry trees on farm as boundary planting, shade, or scattered trees in the compound. In a related study in Central Kenya [7] trees planted

Table 2 Correlation analysis between income sources, education level and adoption of technologies.

		Source of income	Education level	Energy conservation methods
Source of income	Pearson Correlation	1	.070	.433**
	Sig. (2-tailed)		.338	.000
	N	441	188	231
Education level	Pearson Correlation	.070	1	-.009
	Sig. (2-tailed)	.338		.915
	N	188	189	159
Energy conservation methods	Pearson Correlation	.433**	-.009	1
	Sig. (2-tailed)	.000	.915	
	N	231	159	249

** Correlation is significant at the 0.01 level (2-tailed).

scattered on farm or as border planting plays a major role in supplementing wood fuel production for household use and income generation.

3.8 Correlation Analysis between Income Sources, Education Level and Adoption of the Technologies

In reference to costs of technologies and technologies adopted, the cost of technology and level of awareness was noted to be key in adoption of the energy conservation technologies. I that regard, analysis was done in relation to income levels, education levels and adoption of the technologies. From the results, households with higher levels of income, had higher levels of adoption of the energy conservation technologies. According to the analysis, there is a significant correlation between income sources/levels and energy conservation methods, p = 0.000 as indicated in Table 2. This relationship also applies to other clean energy conservation technologies such as use of electricity, gas and solar energy which require good financial capacity to install and use.

From the results, households with higher levels of income had higher levels of adoption of the energy conservation technologies. This means with more alternative income sources leading to improved income levels within households and especially among the women, adoption levels and continued use of the energy conservation technologies will increase.

3.9 Information Dissemination on Energy Conservation Technologies

The results showed that a number of organizations were involved in development and promotion of biomass energy conservation technologies. MoALD (Ministry of Agriculture and Livestock Development) at (28.5%), KFS (Kenya Forest Service) at (23.3%), (Non-Governmental Organizations) and (Community-Based Organizations) NGOs/CBOs such as Kenya Energy Non-governmental Organization (KENGO) and trees for energy project (16.8%), were indicated as the main sources of information on biomass energy conservation technologies. Others included Ministry of Energy (12%), KEFRI (11%), others (radio/church and schools) (8.5%) and Micro-finance institutions (K-Rep) (4%). Information was disseminated through training, demonstrations, study exchange tours and provision of extension materials. In all study areas, MoALD, KFS and NGOs/CBOs were ranked as the best sources of information in that order, while others (radio, churches and schools) and micro-finance (K-Rep) were ranked the least sources of information. The Ministry of Energy was least mentioned despite the docket of renewable energy falling under the ministry and the presence of a Renewable Energy Centre in the County. Inadequate human and financial resources were indicated as the major constraints to information dissemination by the Energy Centre. Presence of well

trained personnel and a well-developed extension service programme by the Ministry of Agriculture and livestock development up to locational level was indicated as one of the reasons for the institution being a major source of information on energy conservation technologies especially the energy cooking stoves, despite its mandate being in agriculture related fields.

3.10 Information Dissemination Channels Used

Information acquisition and dissemination channels refer to the transfer or exchange of information from person to person or from one place to another [16]. The purpose of any information dissemination pathway is to increase the level of uptake of a technology or product.

The results showed, a number of information dissemination channels were used by the various organizations to transfer information to the communities. They included: field days, community trainings, demonstrations site, home visits, study tours, group meetings and use of extension materials. The dissemination channels indicated were common across the board given the commonality of organizations working in the area. The three most preferred dissemination pathways included field days (59.5%), demonstrations (50.5%) and group trainings (44.5%). The three pathways depict practical demonstration of the technology and an interactive discussion of how the technology works. Other included group meetings (31.5%), use of extension materials (29.75%) (Leaflets pamphlets, posters, and documentaries) and home visits (28%) in that order.

3.11 Barrier to Effective Information Dissemination in the Study Areas

Despite the various channels used for information dissemination, there were barriers to effective communication for increased awareness and uptake of the technologies while there was no significant differnce in the types of dissemination channels used within the four study areas ($p = 0.05$). In Chuluni, the respondents felt the field days were too few, while in Kitui Central, respondents felt the extension materials were too technical for most of the participants majority of whom ae women with low literancy levels. The repondents felt the materials meant for the local community could be simplified further to and be relevant to their interests, and if possible be translated to local languanges. In Kitui Central and Matinyani the respondents felt the demonstration sites were few thus inadequate to effectively pass the information to the community. The use of various dissemination pathways by various organizations in the community has however not translated to actual increased adoption and continued use of the energy conservation technologies disseminated. The community noted that there was a knowledge gap between the information available with organizations and the information needs of the community. There was also lack of cooperation among the information dissemination agents thus creating a feeling of repetition, barrier to information flow and community fatigue.

The community proposed various improvements for increased positive impact to the community. This included increasing the number and frequency of field days held, conducting more community/group trainings, setting up more demonstration sites, and using public forums *(Barazas*) to disemminate the information.

3.12 Socio-Economic and Technical Constraints to Adoption of Biomass Energy Conservation Technologies

The results showed a number of socio-economic, technical and environmental constraints to adoption of energy conservation technologies. The social aspects included resistance to change (68%) due to cultural preference of traditional technologies especially the traditional cook stoves which are mainly preferred by the elderly women as they have been part of the culture of the people and apart from cooking, they are

used for other cultural activities.. Others included ignorance of the beneficial aspects associated with use of improved energy technologies due to low education levels especially among the women who are the main beneficiaries of these technologies. Decision making in the community was also noted to be major hindrance to adoption of technology as observed in the study. According to the respondents, men are the main decision makers on matters touching on household investments including decision on tree planting and choice of species and sites to be planted as trees are regarded as mark of land ownership. According to majority the respondents (72%) men prefer multipurpose trees for products like poles posts and timber for construction. This overshadows the needs of the women to plant trees for wood fuel production. As a result wood fuel is only obtained as a by-product after the trees have been harvested for other purposes. This affects adoption woodlots as a technology for energy production and conservation. Though men had a higher literacy levels according to the findings, their participation in the study was very low at (15%) and women at (85%) as men are absent from home most of the time in search of alternative livelihoods. This denies them the opportunities to participate in information dissemination activities like training and field days, hence lack the necessary information to make decision on improved biomass energy technologies which mainly affects women. This has led to less investment on the bio-energy conservation technologies hence the low adoption of the technologies. On the other hand, though women are available, their low literacy levels compared to men affects their active participation in information dissemination activities such as trainings and use of extension materials. It also affects their knowledge level and understanding of the technologies, the benefits accrued from using them in their production activities and on their health. In a related study [17], it was reported that only 15% of extension agents disseminating information on agricultural technologies were women while only 5% of the women received extension services in Africa. Men with higher literacy level, are in a better position to participate in the information dissemination activities, however their continued absence from home and villages most of the times, leaves a gap for information in most households. With lack of information and skills, men and women are unlikely to adopt technologies they know and understand little about and this affects adoption and continued use of biomass energy conservation technologies.

On the economic aspects, financial constraints or lack of credit facilities to procure the devices were indicated as e major factors affecting adoption. Improved energy saving stoves have financial implications and thus the cost of devices is major hindrance to the technology adoption according to 76% of the respondents. Installation of improved energy saving cook stoves requires procurement of construction materials and masonry expertise which all have financial implications. Procurement of a readymade improved stoves such as the Kenya Ceramic Stove (KCJ) or “Jiko Poa”, from local retailers requires more finances than traditional metal stoves as they cost more in the range of Kenya Shillings (KES) 600-4,000 per piece depending on the type and size of the devices and this affects adoption of the technology.

The costs of improved charcoal conversion kilns such as the Metal kilns and the “half orange” kilns also have financial implications and require a higher capital investment in the range of KES 50,000-250,000 depending on the size (100 KES =1$) . The high cost of the devices is a discouraging factor especially for communities with low income sources with competing needs like food, education and health services. Most of the improved kilns observed during the study, were either procured through donor or government funding. Being free issues, the community was not obliged to take care of them, thus there was lack of sense of ownership and in most

cases the devices were never used, repaired or maintained for lack of finances and skills. Financial investment in biomass energy technologies such as improved cook stoves and efficient kilns to most financially constrained families with more pressing family needs is not a priority. Lack of organized supply chain system and credit facility from financial institutions with support from the government and the donor's community was noted to be lacking by 67% of the respondents. Existence of such credit facility could open up an avenue to provide the stoves/devices cheaply to the local communities on credit basis. K-REP, a micro-finance institution was the only one indicated by the community in Kitui Central providing improved stoves on credit basis. The respondents felt there is need to link trained organized community groups with organizations or micro-finance instituions working in the area for follow -up and financial assistance through credit facilities.

3.13 Technical and Environmental Aspects

On the technical aspects, information disseminated to the community through use of extension materials was considered to be beneficial but too technical (58%) for the local community especially for the majority of the targeted audience who are mainly women with low literacy levels. The community also lack technical capacity to install and operate the technologies especially the improved charcoal conversion kilns (65%) as most of them had technical designs from outside of the community that never addresses the cultural needs of the community. The community felt that there is need for local artisan to be trained including women who are majorly available to provide the technical services and where possible, fabricate the technologies locally.

Indigenous trees growing naturally in the woodlands were indicated as the most preferred tree species (67%) for wood fuel production. Despite the decreasing trends in existence of indigenous woodlands according to the respondents, the community in the study area are not planting exploited indigenous tree species for wood fuel production. About 35% indicated they lacked technical knowledge on how to propagate indigenous species, while seeds and seedling were indicated as not available in the local nurseries. Overexploitation of preferred indigenous trees to meet increasing fuel wood demands without any conservation measure was noted to be contributing factor to increased deforestation and loss of biodiversity. Other than unavailability of planting materials, small land sizes ranging between two and three acres for the majority of respondents (54.2%) were noted to hinder establishment of woodlots for fuel wood production. Due to increased competition from crop and livestock production, most respondents preferred to plant multipurpose trees scattered on farm or along the boundaries. Others factor influencing adoption of the technologies included lack of follow-up programmes (67%) to ensure implementation of community action plans after trainings, which would ensure installation, use and continued maintenance of the devices/technologies disseminated and lastly, lack of information sharing within the local community among the recipient of the technologies.

4. Conclusion

The study concludes that despite the availability of technologies and information by various state and development organizations on available biomass energy conservation technologies and the benefits accrued from using them, existence of the various socio-economic, technical and environmental factors such as cost of the technologies, genders aspects in decision making on adoption of the technologies, unavailability of credit facilities and preference of indigenous technologies and species still hinders adoption and continued use of the technologies. The study therefore recommends collaborative efforts to promote adoption of modern and efficient biomass energy production and utilization of technologies,

provision of credit facilities by the government in collaboration with financial and development partners with longer repayment periods to community's members to procure and install preferred technologies rather than free issues of technologies whose designs the communities have no inputs in their development. There is also need to promote use of available local materials such bricks, mud, sand and local skills to make modified versions of the biomass energy technologies which will address the needs of the people for increased adoption. Funding agencies also need to commit more resources to research and outreach programmes for development and transfer of appropriate technologies that will incorporate the positive cultural aspects of the traditional technologies in the development of improved efficient technologies to be more acceptable to the target community.

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