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Challenges of Adopting Energy Efficient Stoves in the Sudano Sahelian Region of Cameroon

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Authors' contribution

This work was carried out in collaboration between both authors. Author VCT designed the study and wrote the manuscript. Author IRT supervised, read and approved the final manuscript.

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ABSTRACT

The study aimed at investigating the cultural and socio-demographic factors that affect household's probability to adopt energy efficient stoves (EES) in the Sudano-Sahelian region of Cameroon. It examined among other aspects, cooking patterns, stoves and fuel types. Major stove types used are the traditional three stone fire-place, improved mud stove, gas cookers and the metallic stoves. Through questionnaires, interviews with experts and a participant observation, the derived data was analysed using SPSS and in-depth analysis. This study Analyses the data related to the Sudano-Sahelian "agro-ecological" zone, which is one of the most affected by land degradation and desertification. While results show that there is potential for households in this region to adopt energy efficient stoves, the adoption rate is still low. Household size, cooking patterns, age and "physico-technical" characteristics of EES do not positively influence the adoption of EES. The results also indicate that there is a high degree of awareness on environmental changes, and the need to protect the environment. Thus, the study recommends the introduction to culturally acceptable stoves. These culturally friendly stoves will have a greater likelihood of being accepted and used by households, in the long run, thus improving the level of deforestation, soil fertility and mitigate climate change tendency.

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Keywords: Social; cultural factors; "physico-technical" characteristics energy efficient stoves; environmental degradation.

1. INTRODUCTION

Energy is vital for daily livelihood as it is used for very important and indispensable daily activities such as transportation, shaving, drying, lighting and cooking. Even though it is very important, access to clean and sustainable energy is not easy and thus a majority of the population turns to unsustainable sources which deplete, pollute, consume time and expose women and children to health risks. Additionally, it is known for its major negative social and environmental impacts though excess time and money spent, contribution to outdoor pollution, deforestation and climate change [1,2]. Recent literature holds that more than 3 billion people in developing countries depend on traditional fuels: such as firewood, charcoal and dung for cooking, heating and drying [3,4,1]. This has a significant negative impact on health, causing more than 4 million premature deaths annually [5,6,7]. The World Health Organization [8] shows that approximately 2.5 million women and young children die prematurely each year because of health problems associated with burning of biomass for cooking [9]. Contact to smoke through the use of traditional three stone open fire-place is associated with adverse health impacts like respiratory infections [10, 11].

Ischemic heart disease [12], stroke [13], lung cancer [14], and cataract formation [15]. Household air pollution is ranked the eighth leading health risk factor and associated with nearly three million deaths in 2015 [16]. For example, in Sub-Saharan Africa, more than 50% child deaths and 60% adult female deaths were caused by environmental pollution [17]. According to [18] the collection, production and burning of these types of fuels can also be linked to severe environmental impacts, such as deforestation and the emission of short-lived climate pollutants [19,20]. In order to reduce these environmental and health risk associated with traditional cooking technologies, energy efficient stoves have been developed [21]. Also, the Global Alliance for Clean Cook-stoves was created to promote household adoption of clean cook-stoves and fuels. Efforts to promote EES will go a long way to enhance the sustainable development goal for affordable, cleaner and sustainable energy in line with the Paris agreement on climate mitigation targets. Thus, this and other studies [22,23], advocate that household's adoption of energy efficient stoves and clean energy sources lessens the negative ecological, health and social impacts of black carbon. Poor households that are highly dependent on firewood make up approximately 70% of Cameroonian households. They use firewood as their main energy source for cooking. As the rapid population growth in Cameroon was not followed by changes in human behaviour, high dependence on firewood has damaged the natural environment of the country [24]. While forests cover three quarters of Cameroon's territory and the availability of biomass resources is abundant, unsustainable exploitation of these resources is increasing the number of deforested areas throughout the country [25]. Due to the fact that most regions in the country cannot afford a reliable power source, electricity is not a realistic fuel option, especially in rural areas [26]. Energy access in poor urban and "peri-urban" areas of Cameroon remains very low despite progress made in the last 10 years by the government. The lack of access to modern energy resources also extends to the use of traditional biomass. The impact of indoor air pollution is particularly severe in the case of women and children living in poverty while the reliance on biomass for cooking also contributes to deforestation and forest degradation.

2. LITERATURE REVIEW

The use of biomass in inefficient stoves increases household demand for wood fuel, yet energy needs of developing countries must be attained without jeopardizing future resources [27]. The development and diffusion of EES in developing countries are one of the strategies perceived as instrumental in combating the negative effects related to the use of traditional three stone fireplace [28]. For more than four decades, governments, scientific institutions, funding agencies and NGOs have introduced, facilitated and implemented uncountable EES programs in different parts of the world [29].

The adoption and continuous use of improved cook-stoves in the developing countries are of social, economic and environmental concern [30]. In particular, such innovations have potential for delivering triple dividends:

household health, local environmental quality and regional climate benefits [31]. Despite the social, economic, and environmental benefits of EES, the rate of adoption of these technologies promoted is not as fast as initially anticipated [32]. According to Jan 2017, to lessen health problems caused by incomplete combustion of biomass fuels in traditional cooking devices, EES programs were launched. These programs were initiated and supported in many countries such as China, Guatemala, India, Kenya, Malawi, Mexico, Nepal, Pakistan, Peru, Sudan, Thailand and Cameroon [30].

Conversely, there is a range of factors (social, socio-demographic, economic and institutional) that affect the smooth functioning of these EES programs. Social and cultural factors such as household size, age, food taste preferences, cooking utensils and gender role as well as the characteristics of the innovation itself seem to slow the pace of adoption.

Household size is expected to have a positive influence on the model of the stove used and the adoption of the EES technology [33]. It is assumed that larger households will cook more food for the household members requiring use of large pans and more firewood hence will be more inclined to adopt the EES technology. It is expected, therefore, that a larger household size will affect positively the decision of adopting EES technology. Education is vital in the transformation of information to the knowledge which in turn influences adoption. People who have adequate information about the knowledge of technology use are likely to adopt it [34]. Traditionally, educated people are expected to understand the benefits of the innovation in question at a faster speed than the uneducated [35,36]. Educational status is assumed to influence the adoption decision of many technologies because with the higher level of education the adopter would be in a position to technically and economically assess the new technology to clear doubts and uncertainties associated with it, and enhance its adoption [37]. The more learned (educated) respondents are, the more likely they are to use efficient cooking technologies [30]. According to [38], people with higher education level have better access to information and knowledge that is beneficial in their domestic activities. They also tend to have a higher analytic capability of the information and knowledge to implement new technology and realize the expected result. Hence, higher education level allows household heads to make efficient adoption decisions. Consequently, being the early adopters that can take advantage of new technology and profit from it. Some studies in establishing the effects of education on adoption, in most cases relate it to years of formal schooling. [39]. Education generally creates a favourable mental attitude to the acceptance of new practices [40]. According to [41], technology complexity has a negative effect on adoption, and this could only be dealt with through education. Though it is not necessary that more education equates to greater awareness, it is assumed that more educated people have more knowledge about benefits of new technologies like the ‘foyer Centrafricain’ stove technology than do uneducated people. Awareness of the ‘foyer Centrafricain’ stove technology in which the respondents had been introduced in the study area was high, the main sources of information being family members, community group and extension staff. In this context, awareness has been identified as a major factor impacting the adoption of the “foyer Centrafricain" stove technology. In the study area, educated respondents may be assumed to be more aware of the environmental effects of using biomass fuels, and therefore, formal education may increase the speed of adoption. There was a significant difference in the stages of schooling of the respondents among the young and the older respondents, with the former being more educated. There was no significant difference observed between respondents with formal education and non-formal education in terms of the gap between adopters and non-adopters. Adopters had significantly higher contact with extension visits than did non-adopters.

According to [41] and [42], women's choices of fuel-efficient stoves also depend upon existing environmental factors and culture. The cultural factor has particular significance because it can form the basis through which individual decisions are made. It comprises not only the local traditions specific to ethnic groups but also of a woman's beliefs and understanding like age and education. A study in determining barriers to fuel switching in Sri Lanka by [43,44] confirmed that cultural factors play an important role in cooking fuel decision- making and should not be overlooked. The study identified that attachment to past practices, the belief that food prepared on firewood stoves tastes better than that cooked on other stoves. This justifies the reasons for not switching from biomass to cleaner fuels. The cultural factors considered in the study include: food tastes and preferences, cooking practices, indigenous cuisine, cultural attachments and the type of food regularly cooked. Tastes and preferences are expected to influence the choice of cooking fuel through perceived tastes as a result of cooking with certain fuel and preferences for certain fuel over the others by the households. For example, some communities believe that if certain foods are cooked with a particular fuel (i.e. fufu with firewood) it will have better taste. Cooking practices are expected to influence fuel /stove choices through the many years of orientation and reliance on particular fuels. For example, if the household practices is to prepare breakfast with charcoal then that orientation will go down the family members as the common practice for cooking breakfast. Cultural attachments are expected to influence the choices of cooking fuel and stoves since different communities have different cultural attachments in the preparation of their local cuisines and thus they will choose different fuel for their cooking. For example, “nyebe”, “bilbil” are cooked using heavy firewood, while “chai” and other soups can be prepared with charcoal. The type of food regularly cooked in the household will be expected to influence the choice of cooking fuel regarding the length of time this food takes to cook, the amount of time members of the households have to wait for the food. For example, “Nyebe” which takes long hours to cook will not be prepared by household members who are in hurry for work in the morning but will be preferred in the evening and firewood will be the fuel of choice. Although the social, economic, and environmental benefits of the improved stove programmes seem to be rather clear, the rate of adoption is not as fast as hoped and anticipated. Literature review on the diffusion of innovations reveals possible explanation about the slow diffusion process of technologies. Factors that may have influence on the adoption of “foyer Centrafricain” stove include: socio-economic and cultural factors (i.e. age, education, household size, gender and food taste preferences); and finally institutional factors (access to extension services, membership to groups). These factors were used to examine issues in the context of the Maendeleo stoves in the study area. The purpose of this study is to determine the influence of social and cultural characteristics on the adoption of energy efficient stoves in the Diamare division.

2.1 Research Problem

Cameroon is one of the African countries endowed with various energy sources, yet most of its population is not privileged to have electricity and energy for cooking [45,46].

Consequently, the total access rate to electricity in Cameroon is quite low and has been estimated at 11% [46]. As a result of this, there is unstable and hiking prices of domestic gas which favors the use and heavy dependence on biomass as the major cooking energy source.

The acquisition and use of energy efficient stoves are very important for the Sudano Sahelian area of Cameroon as it could decrease demand on firewood and tackle the problem of deforestation. The heavy reliance by households on biomass fuels contributes to deforestation, land degradation and low agricultural productivity. Indoor air pollution from solid fuel use is a major cause of death and disease - the World Health Organization ranks indoor air pollution from solid fuels the world's eighth largest health risk, causing 2.7% of global losses of healthy life [47].

2.2 Objectives

The objectives of this study are as follows:

- Identify the “physico-technical” characteristics of energy efficient stoves developed in the Northern region of Cameroon.
- Assess the social and cultural factors that affect the appropriation of energy efficient stoves in the study area.
- Propose strategies to ameliorate the appropriation of the energy efficient stoves by Cameroonians and partners of the CEMAC and Lake Chad Basin (for example, Chad, Central African Republic, Gabon, and Congo.

3. METHODOLOGY

3.1 Study Area

Cameroon, often described as ‘Africa in miniature’, is located between latitudes 2^{o} N and 13^{o} N. The study was carried out in the Diamare division in the Far North region. This area is situated in the sudano-sahelian zone. This zone is the northernmost climatic type, extending from Maroua to the Lake Chad Basin. It is characterized by a short rainy season and a marked dry season. The rainfall amounts range from 900 mm around Maroua to 500 mm around Kousseri and 400 mm around shores of Lake Chad. It consists of degraded shrubby steppes on sandy clay soils, periodically grassy flood plains (the Yaéres) which serve as second season grazing land for cattle farmers and the Sudano-Sahelian woodland savanna. National parks and savanna woodlands cover 9% of the area, with great wildlife resources concentrated in the national parks, and 23% is arable land, half of which is under cultivation. This zone is threatened by desertification, a process evident in the shortage of water and poor savanna scrub. Soil degradation stems from the depletion of vegetation cover, ill-adapted pastoral activities and the irrational use of water resources. The exploitation of dams in the area does not take into consideration the needs of other users, and the choice of the site and type of dam does not provide for the full development of water resources so vital to this region. Fig. 1 paints a geographical presentation of the study area.

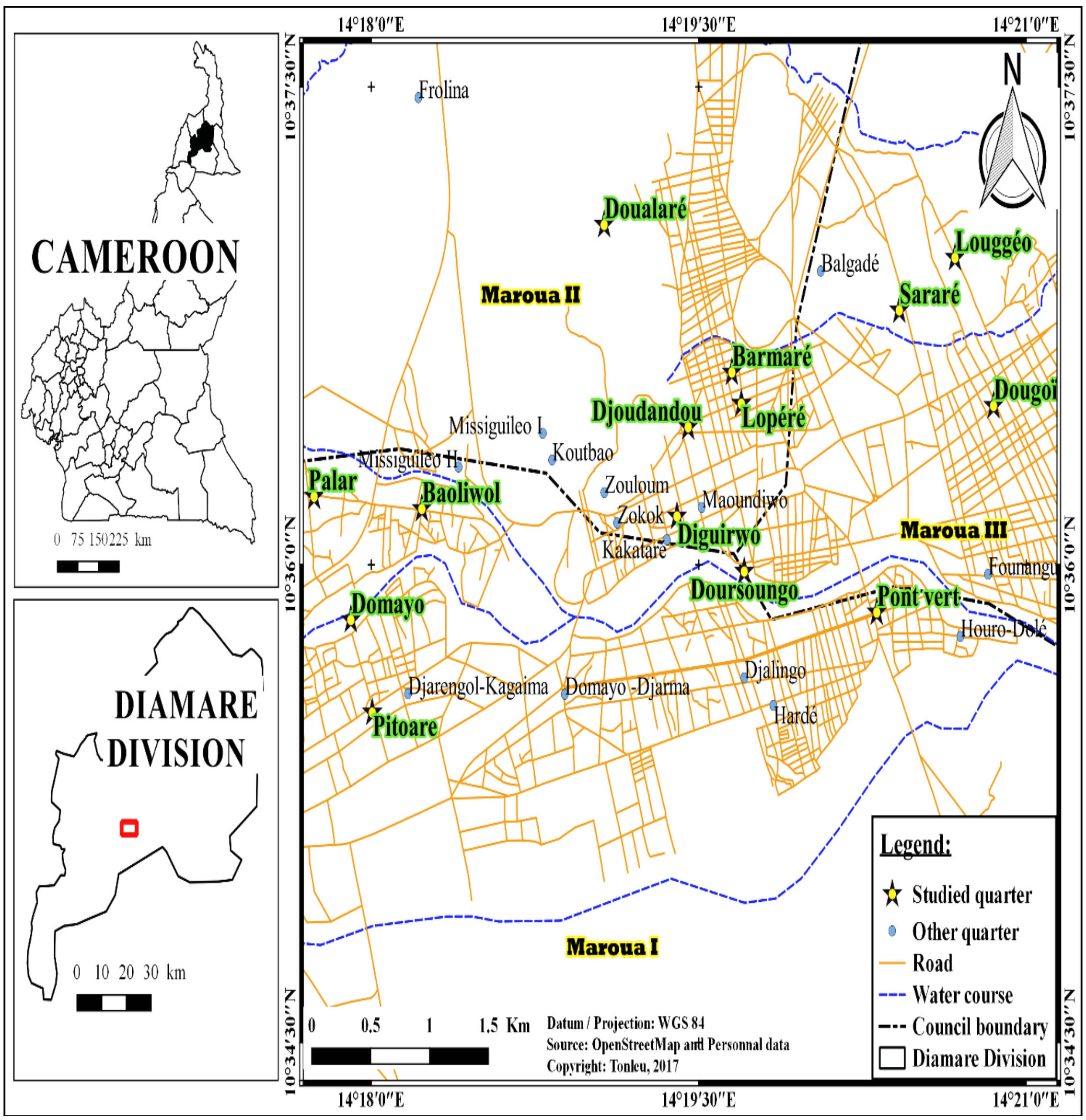

Fig. 1. Map of study area

3.2 Data Sources

Households for the structured interview guide were selected by using systematic random sampling technique. The reason behind using this sampling technique is its simplicity, fast and low cost [48]. In addition to that, systematic random sampling was used to select the households involved in the study in each council area. According to [49], a systematic sample is frequently spread more uniformly over the entire population and provides more information about the population than an equivalent amount of data contained in a simple random sample. To overcome some flaws of this technique, the researcher checked whether the households were systematically arranged or not, in each quarter/street. In the case of selecting the respondents of the interview guide, the mothers/women were selected as it is in line with [50] who indicated that women are the main expected beneficiaries of the EES. In many cases they are the ones in charge of firewood collection, food preparation and usually spend a higher amount of time inside the dwelling place, benefiting significantly from reductions in indoor pollution. However, on some occasions, males (family heads) insisted on attending to the research team for cultural and religious reasons Data for this study was collected from October 2016 through July 2017. The study used triangulation method in data collection. This method enabled the researcher to collect both quantitative and qualitative data relating to the research objective. The primary data was collected from the field through the administration of questionnaires and interview guide. Secondary sources of data provided the bases of existing literature gap as well as relevant literature on what has been done with respect to determinants of household fuels adoption. Relevant literature reviewed included books, academic journals, credible and government publications. Primary data was collected through a structured questionnaire. The quantitative data were employed in order to address research objectives that could be better addressed quantitatively. The data about respondent's age and household size were gathered numerically.

3.3 Structured Interview

Primary data was collected by use of structured questionnaire. The questionnaire had both open and closed ended questions. Interviews were administered to the selected respondents on a face-face basis. The main primary data source was the individual households living in the targeted municipality of the Diamare.

3.4 Data Analysis

This section describes the procedures used to analyse the collected data. The study used both quantitative and qualitative methods of data analysis. Data analysis was done at two levels: the first level involved quantitative analysis which provided general description that cut across individual respondents while the second level analysis involved qualitative analysis of from observation and photographs. Questionnaires were coded and data cleaned to check for completeness, consistency and accuracy. The data were analysed using SPSS, Microsoft excel spreadsheet for the descriptive statistics. The results were presented in the form of frequency tables, percentages and charts for variables such as age, occupation, household size, and income and education levels among others. The further analysis produced explanatory knowledge by means of cross tabulation. Cross tabulations were used to determine the relationship between variables. According to [51] inferential statistics are used to make inferential statements about a population. The Pearson correlation–coefficient was used to measure correlation for independent and dependent variables in the interval, while multiple regression analysis was used to determine the social economic factors that influence adoption of wood fuel conservation technologies. A similar method of analysis was used by [52] in analysing factors that influence forest dwellers participation in reforestation and development of forest areas. Descriptive statistics for example; use of bar graphs, tables and percentages were used to analyse the Likert scale questions. Spearman correlation was also used to analyse the responses to various statements.

4. RESULTS AND DISCUSSION

4.1 General Social and Demographic Characteristics of the Respondents

Data was collected from 323 respondents of the 350 expected, giving a response rate of 92%. The high rate of return was attributed to the approach whereby the respondents were requested to fill the questionnaires as the research assistant waited and this ensured a high return rate as there were little or no worries to be clarified. Three council areas (Maroua I, II and III) were chosen for the study. The council areas and distribution frequencies are represented in Fig. 2.

Fig. 3 reveals that, 34, 33, and 33% of the respondents came from Maroua III. Maroua II and Maroua I respectively. Maroua I had a lower percentage because it is in the heart of the town that is characterized by people of all professions and most especially civil servants and business people. 'Socio-demographic' information was collected on gender, level of education, occupation and age of the respondents. This describes the status of the household members along major demographic variables for enhanced explanation of determinants of adoption of energy efficient stoves. 67.2, 22.3 and 10.5% of the respondents were married, single and divorced respectively. From the study, it can be deduced that most of the households had families to cook for and therefore the need to observe the kind of stove in use.

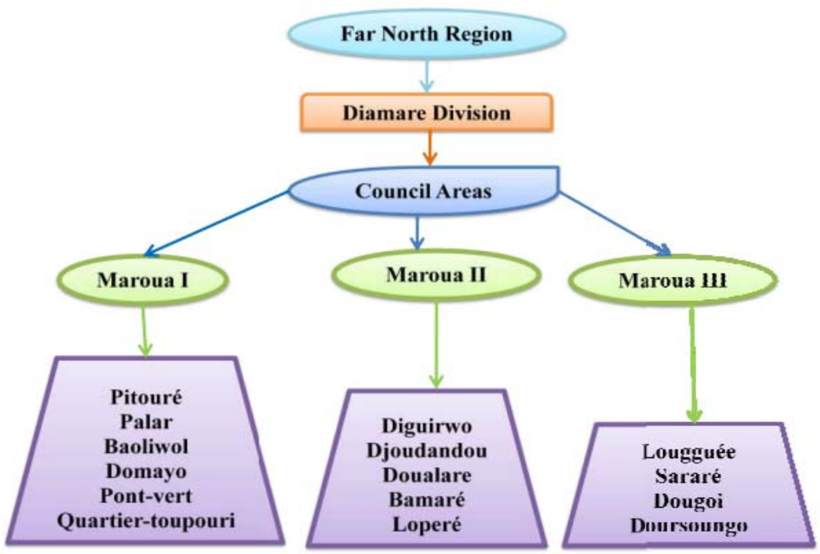

Fig. 2. Representation of study area (councils and quarters)

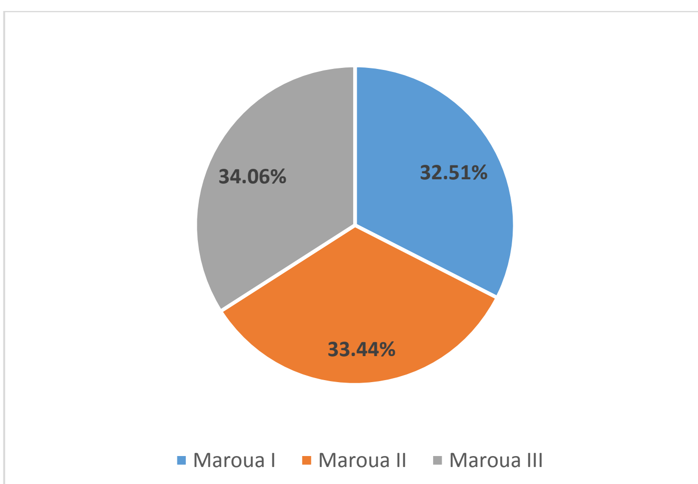

Fig. 3. Representation of respondents by council areas

4.2 Age Group and Use of EES

The study sought to know the age of the respondents. This was necessary for highlighting the age bracket of those who have adopted the EES. The role of age in explaining technology adoption is somewhat controversial. It is usually considered in adoption studies with the assumption that older people have more experience that help them to adopt new technologies. On the other hand, because of the risk adverting nature older age, people are more conservative than the youngest ones to adopt new technology. Thus, it was necessary to highlight the age bracket of those who have adopted the EES in the three council areas of the Diamare division. Fig. 4 represents the frequency distribution of the respondent's age groups.

It can be seen from Fig. 3 that 41, 30, 14, 12 and 6% of the respondents were of age group 21-30 yrs, 31-40 yrs, 41-50 yrs 50 yrs and above and 6 % respectively. The age groups of 21-30yrs and 31-40yrs are highly represented and this may be likened to the fact that most girls get married at an early age in the northern regions of Cameroon. These early marriages can be attributed to 'socio-cultural' factors and religious beliefs of the northerners and the fact that they drop out from school upon completion of primary school.

Cross tabulating age and use of stoves, the findings indicated that 21-30 yrs (19.8%) and 31-40 yrs (14.5%) are the age groups that are using EES. This may be because older people are found to be more conservative towards accepting new technologies. They prefer to continue using the technology they are accustomed to. This finding is in harmony with the works of [53,54] that found a statistically significant relationship between age and Mirt stove adoption decision.

4.3 'Physico-Technical' Characteristics of Stoves and Use

Several types of cook-stoves are used by households and these stoves are often associated with specific energy types. In order to determine the stove type that is frequently used in the study area, the respondents were asked to indicate the type of cooking stove they frequently use in their households. The frequently used stove in the Diamare division is the traditional three stone fireplace (44.3%), closely followed by gas cooker (26.6%). 50% of the population in this area rely on these two stove types for cooking and heating. The Metallic Stove (10.2%), improved three-stone fireplace (8%), Kerosene stove (7.1%), are not frequently used. The '*Foyer Centrafricain* '(2.5%) and Biogas/solar (1.2%) seems not to be

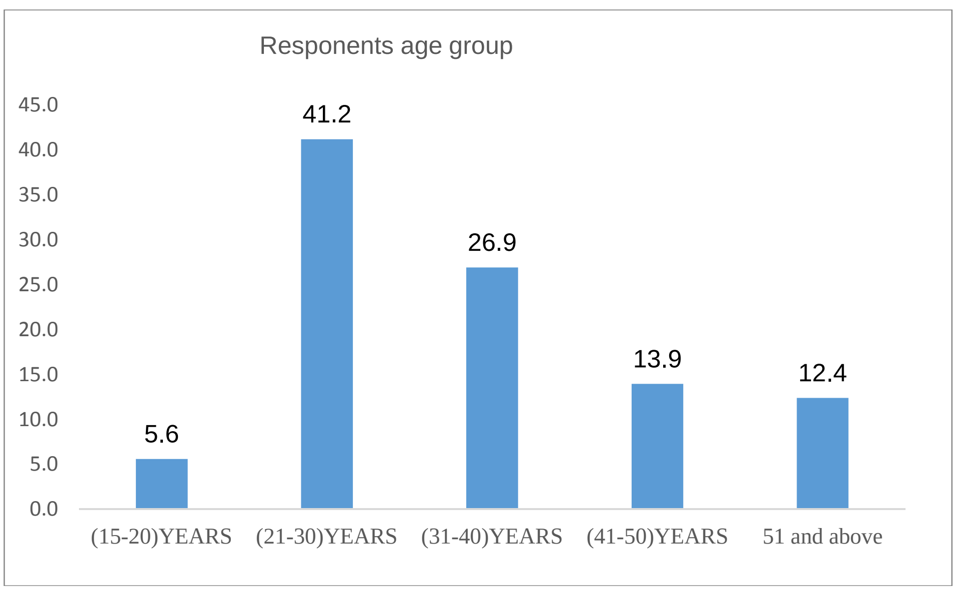

Fig. 4. Distribution of respondent's age group

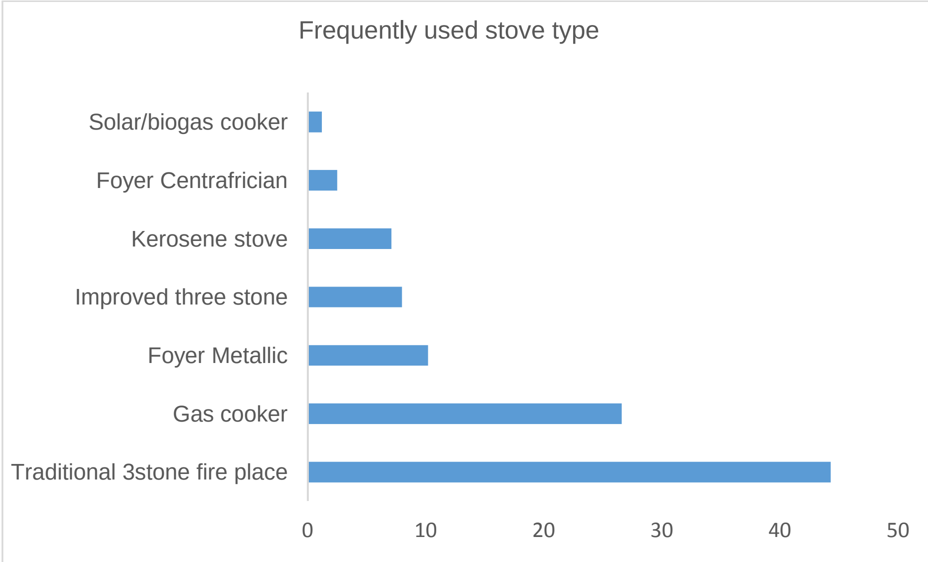

Fig. 5. Representation of Stove types commonly used in Maroua Municipality

popular. In fact, the traditional three stone fireplace and gas cooker are the most widely used stove types in the study area. This can be explained by the fact the that, majority of the respondents are from Maroua I and II which is the administrative and business centers of Maroua town. There are mostly civil servants and business people who can afford domestic gas which does not really affects their monthly income. Fig. 5 illustrates the frequencies of the stoves that are mostly used in the study area.

These stove types vary in their physical and technical characteristics (such as portability, energy efficient, ease of use, emits less smoke, size and ability to use various pot sizes to cook local dishes) They are propagated by international and local NGOs, women's groups and government institutions as can be seen in Table 1. The efficiencies vary from 25-50% in the material of fabrication and durability.

Picture 4, 5 and 6 in Table 1, are the different types of EES disseminated in the study area. Picture 4, is the 'Foyer Centrafricain', Picture 5, Improved industrial mud stove and finally Picture 6, improved cone shaped mud stove for households.

According to government institutions and NGOs, these stoves are highly efficient and recommended to the population of Diamare.

Between 2008 and 2016, more than 86,895 'Foyer Centrafricain' stoves have been distributed in the region in an operation known as green Sahel campaign. Even though these stoves are highly efficient, the physical characteristics are not friendly. From our observation in the field, the stoves were abandoned for the following reasons: Low durability: cracks off after persistent use during local dish preparation Tins are made of flimsy metals. Limited to clay pots and cannot support very large pots. Based on our findings and discussions, technical characteristics of EES do not really attract users. There are other reasons that attract adopters to particular EES type. The reasons are based on appearance rather than technicality. In order to determine whether the 'physico-technical' characteristics of stoves could affect adoption of EES, the respondents were given a series of responses to choose from. The feedback can be observed in Fig. 6.

Despite these preferences advanced by respondents, the rate of adoption of EES in the Diamare Division is still low and slow. The rate of adoption varies from council area to another as can the seen in the geospatial distribution of the EES in the Maroua Municipality.

From the geospatial map, Maroua II represents the highest frequency of use of EES. Thus implying efforts put in place by the various stakeholders (Ministry of Environment, Nature's protection and Sustainable development, Heifer International and a host of NGOs) are still not enough and needs to be enhanced.

Table 1. Different types of stoves in use in the Maroua Municipality

N0.	Stove type	Characteristics	Stakeholders involved
1	 Traditional 3stone fireplace	Affordable and used by all, irrespective of social status. Poor combustion High risk Made of sizeable stones depending on the individual	House wives and young ladies
2	 Improved C-shaped mud stove	20 to 25% energy efficient Mostly used by road side restaurants Made of mud Easily cracks off	Local common initiative groups, women and road side restaurants

N0.	Stove type	Characteristics	Stakeholders involved
3	 Simple metallic Stove	Suitable for light cooking Available in local markets. Overall thermal efficiency is about 20%, Portable. Can be moved or used indoor or outdoor Suitable for charcoal	Local Blacksmiths, Women’s groups
4	 *Foyer Centrafricain*	Uses 2 kg of fire wood in 1 hr 55 min It is hot at the exterior, maximum life span of 2 years if continuously used. It also blackens the pot and necessitates a second party when preparing the traditional dish (fufu). It cannot support extra-large pots and limited to flat bottomed pots.	Ministry of Environment, Naturs’s protection and Sustainable Development (Diamare).

N0.	Stove type	Characteristics	Stakeholders involved
5		Made from soil, Good for commercial purpose(Bil-Bil) Good for clay pots. Little and oriented smoke. Good for outdoor use	Women's Groups, HEIFER International
6	Improved cone shape 	Locally made It is 25% to 50% fuel efficient and saves time in cooking, Little and oriented smoke, Helps in building women's capacities. Low durability: cracks by the sides with frequent use especially during local dish preparation.	HEIFER International. Center for Appropriate Technology (CAT) Maroua.

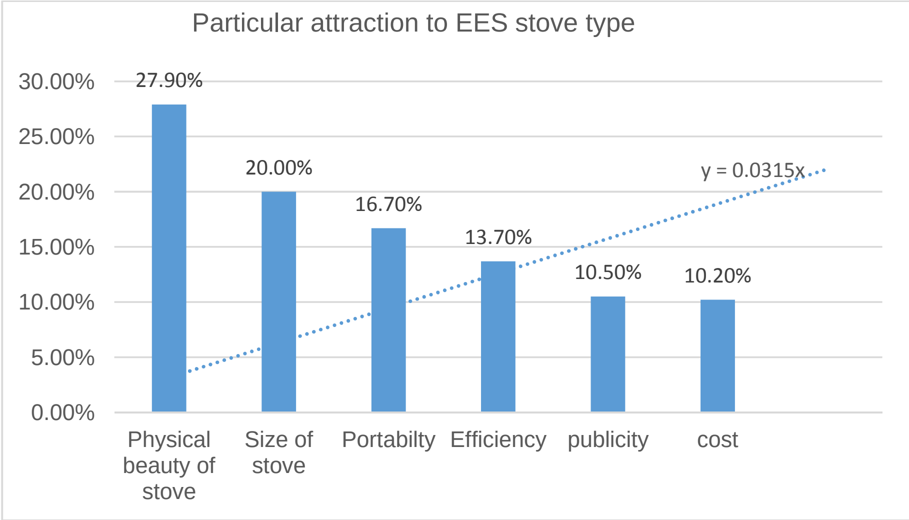

Fig. 6. EES preferences

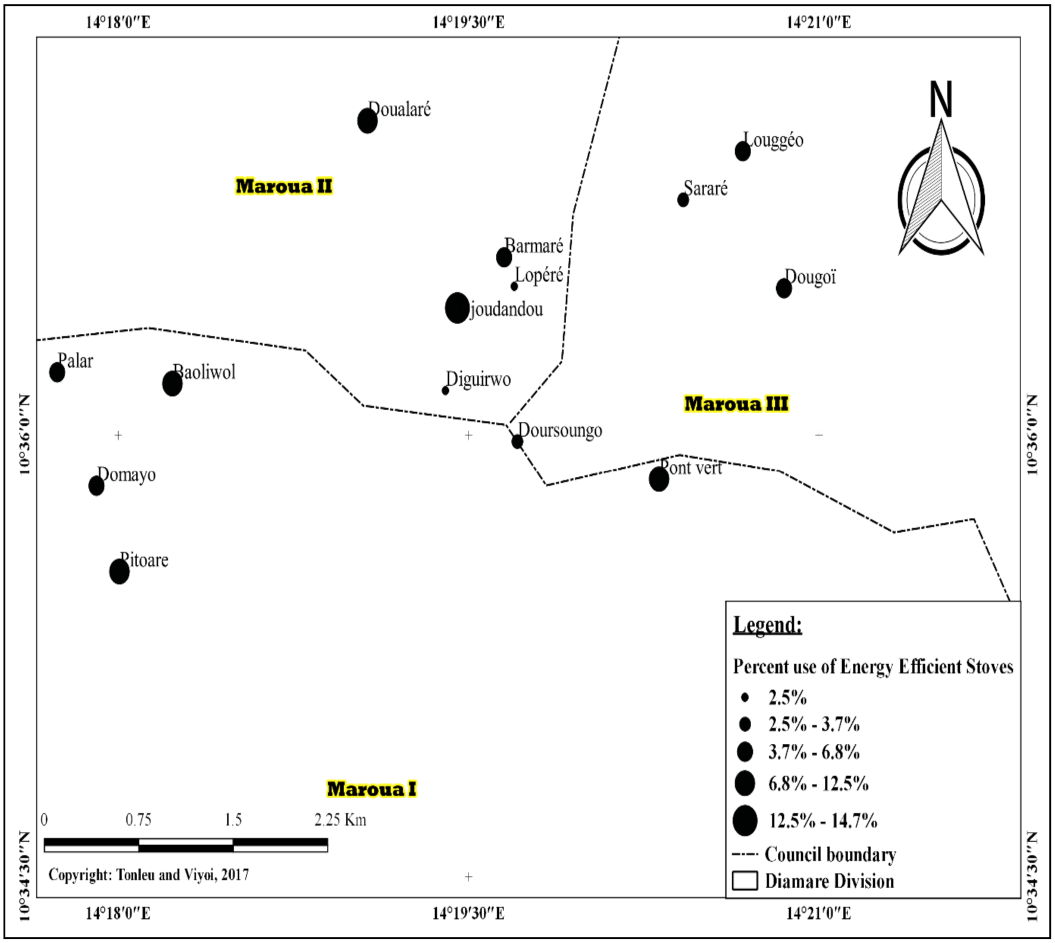

Fig. 7. Geospatial distribution of EES in Diamare

4.4 Cultural Perspective and Use of EES

4.4.1 Household size and Use of EES

Household size in the study is considered as the number of individuals who reside in a house. Large household size is assumed to influence adoption of EES. The respondents were asked to indicate the number of persons living in that household. The various responses were grouped as can be seen in Table 2 indicating the frequencies and percentages.

Table 2. Representation of Household Size

Number of persons per household	Frequency	%
1-5	188	58.2
6-10	103	31.9
11-15	30	9.3
>20	2	0.6
	323	**100**

Table 2 indicates that 58, 32, 9 and 0.6% constitute household size of 1-5, 6-10, 11-16 and 15 and above respectively. From our literature review, it was hypothesized that, large households will influence the adoption of EES. This is due to the fact that large households will want to reduce expenditure and save some time. This contradicts our findings as it shows that larger households do not adopt EES and even when they do, they associate it with the traditional three stone stove fireplace. From our study, large households do not have the tendency to use EES. This confirms [55] who advanced, that it is possibly due to the low value assigned to time and labor used to collect firewood and/or the need to cook for more people. Household size negatively affects adoption of energy efficient stoves. That is, when household size increases, the probability of using improved cook-stove drops. This was not consistent with [56] who argued that an increase in the size of households reduced the choice of non-solid fuel. The difference here is that the study did not query the type of cook stove and associated fuel-type that households were prepared to use in place of improved stove. Furthermore, our study shows that larger households are a barrier to adoption of EES for cultural reasons: many at times the stoves do not support large pots, the traditional dish of the northerners (fufu) needs constant turning with the exertion of force and thus becomes too strenuous when using EES. It is believed larger household need stoves which support cooking for large family sizes and consequently large pot sizes**.** The traditional 3 stone fireplace can easily be adjusted to fit the size of the pot and the purpose. It can therefore be deduced that large families can end up becoming poor managers of environmental resources and thus the need for awareness creation to larger families on the benefits of energy conservation when energy saving technologies are adopted. Fig. 8 shows a cross-tabulation of household size and use of EES. From this figure, larger households do not use EES.

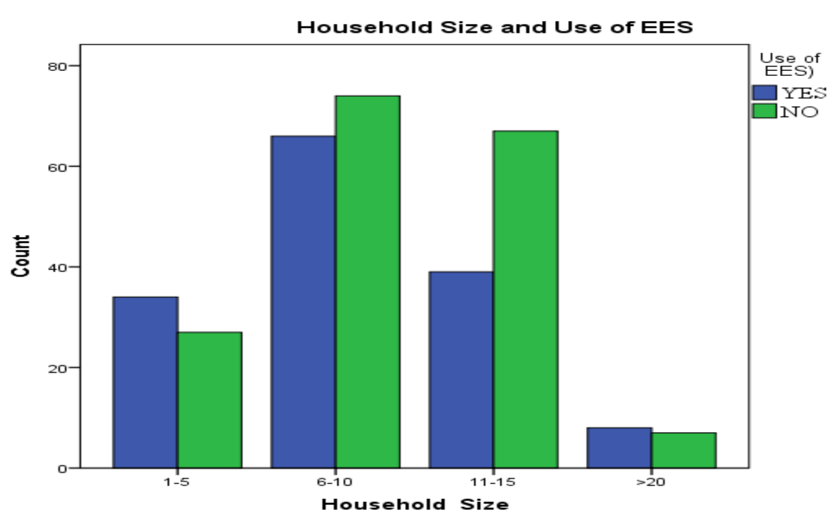

Fig. 8. Household size and use of EES

Although no study in the empirical literature was cited as proffering concrete explanations for the relationship between household size and fuel-type utilization; this study could attribute it to traditional cultural antecedent that over the years have shaped the traditional practices associated with cooking to feed large households. These antecedents may include the mode and volumes of cooking for many people as well as rigidity associated with adapting to new cooking practices. If energy efficient stoves on the market were not large enough to optimize process of cooking for large households, it may affect adoption negatively. That is if energy efficient stoves sizes compel large households to cook in batches, then it would not be worthy for large households to adopt it.

4.4.2 Cooking as a social activity and use of EES

Cooking is not a single activity, but rather, the aggregation and interaction of different cooking tasks. Each task (e.g. boiled rice, fufu and okra soup, boiled water, etc.) has specific energy demands (fuel consumption, energy output), characteristics (household preferences) and relevance for the households (cultural traditions). The definition of the tasks themselves is dynamic in nature, and their changes have different time scales. This is in line with [57]. This view point does not differ from what we observed during the ethnographic study. Cooking goes along with many other activities and the art of cooking is performed by women and young girls [58]. Food is usually prepared by more than one household and different members of households gather and socialize in the yard. While cooking takes place, mothers tend to their children. Other activities do take place during cooking hours (laundry and cleaning). Apart from socializing during cooking, it was worth noting that kitchen utensils also mattered. The pots varied in sizes and shapes (specific cooking needs), usually large pot sizes were used, as to cook for large family and thus three stone firewood stoves were most suitable for large pots.

Due to the fact that cooking time is a medium for interaction within households and gender biased, the aspect of time saving in EES is not of utmost importance to women. According to them, EES will not give them the opportunity to socialize with other households within the "Sare". This confirms Rogers's adoption theory illustrates that; people rarely adopt innovations without good reason. When not considering socio-cultural aspect, it may inevitably lead to project failure in the long run.

4.4.3 Use of EES and cultural attachments

The extensive use of traditional three stone fireside can be attributed to the fact the traditional three- stone fireplace can be located anywhere in the yard, with sizable stones readily available. The energy source which is firewood, can be bought in small quantities and tree branches from trees around the yard can serve as firewood. In addition, the three stone fireplace can support varying pot sizes (which ranges up to 20 liters and above) favorable to large household as they require large pots to cook for all.

Furthermore, from a cultural point of view, it is believed that foods prepared on three stone fireplace tastes better (nybe, surghom/corn fufu, Moringa soup) and also the fact that these staple foods needs constant and rigorous stirring at very hot fire. This exercise becomes more tedious and/or impossible when using an energy efficient stove (especially metallic stoves). In addition to household preferences, food tastes, cooking practices, the fact that traditional three stone fireplace has been passed down from generation to generation also affects cooking stove choice.

One can say that majority of people prefer to use the traditional three stone fireplace. Varying reasons were advanced for this choice as most respondents chose the three stone fire not because of its effectiveness but rather because it is cheap and available. The respondents preferred the three stone fireside and gas cookers because they are cheap and fast respectively. To prefer a stove type does not necessarily guarantee one's interest in using it as many factors come into play. This is because one could prefer a stove type but because of lack of finance and access to fuel type, resorts to using a much cheaper one. However, the results show that for the most preferred stove types, the three stone fire and gas cookers were the most frequently used although the frequency of use of the three stone is higher.

However, if one were to consider stove efficiency in the strict sense of the word, then, the three stone fireplace would be out of the picture because most of the heat produced

Table 3. Summary of correlation table

	Independent variables	The dependent or control variable : appropriation or adoption of energy efficient stoves		
		Mean	**Standard deviation**	**Pearson's Correlation Coefficient**
1	**Socio-cultural environment of Adopters**			
	Gender roles (women's influence)	2.71	1.37	0.078
	Level of awareness	3.83	0.97	0.089
	Influence of Friends and social class	3.90	1.04	0.047
	Influence of the community	3.56	1.04	-0.054
	Influence of family members	3.24	1.13	-0.003
2	**Personal and household characteristics of adopters**			
	Age composition of adopters	2.86	1.12	0.094
	Gender of adopters	1.53	0.50	-0.009
	Level of Education	2.99	1.59	0.008
	Marital status of adopters	1.43	0.67	0.025
	Household type(cement, thatched tailed)	1.38	0.75	-0.14
	Household size	2.28	0.81	0.101
	Household situation(renting or personal house)	0.59	0.59	-0.005
3	**Economic situation of adopters**			
	Main occupation	2.07	1.04	-0.042
	Monthly income	2.86	1.32	-0.080
4	**The physical environment of Adopters**			
	Temperature Fluctuations	4.17	0.857	-0.26
	Changes in Rainfall Patterns	4.24	0.775	0.109
	Flood Frequency	3.68	1.024	0.026

during combustion is lost. This means more fuel is being used with less heat transfer efficiency during the process of cooking or heating. The issue of sustainability now sets in as appropriate technologies have to be employed such that less fuel is used for maximum stove performance. This approach can greatly mitigate the pending issue of deforestation and desertification which are now major problems in the Sudano Sahelian area of Cameroon.

From the above analysis a Pearson correlation test was run to verify these factors. With respect to socio-cultural factors such as gender roles (C=0.078), level of awareness(C=0.089), and influence of friends and social class(C=0.047) affects the adoption of energy efficient stoves to an extent meanwhile family members(C= -003) and influence of the community(C=-0.054) have a negative influence.

Adding to the socio-cultural and environmental factors, socio-demographics such as age(C=0.094), level of education(C=0.008), marital status(C=0.025) and household size (C=0.101) have a positive correlation with the adoption of energy efficient stoves. Factors such as household type(C=-0.14) and house situation(C=-0.005) have negative correlation with adoption of energy efficient stoves. Details of this can be seen on Table 3.

5. CONCLUSION

This paper aims at examining the social and cultural factors complicating the adoption of energy efficient stoves in the Diamare division of the Far north region of Cameroon. Adoption of EES in Cameroon still faces some challenges. These challenges stem from the fact that some social and cultural factors do not favor the adoption of EES despite the role-played by the government, NGOs and CIGs. This negatively affects the vast Cameroonian Savannah (highly productive in terms of woody biomass) as it is being depleted. The continuous use of firewood by households in the northern region of the country will negatively impact the economies: through deforestation and a declining agricultural productivity. The implications of this on the environment are obvious: deforestation, soil erosion and declining agricultural productivity and destruction of the ecological system leading to loss in the natural habitat for the country's wildlife.

A solution to these challenges requires that EES be made more culturally friendly (gender consideration, cooking arts), accessible and affordable. Also, firewood collection and use be made sustainable. Firewood use can be made sustainable by the cultivation of fast maturing tree varieties and encouraging local communities to have woodlots. The family woodlot will provide needed firewood and at the same time be a useful source of improving soil fertility.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Wolf J, Mäusezahl D, Verastegui H, Hartinger MS. Adoption of clean cookstoves after improved solid fuel stove programme exposure: A cross-sectional study in three Peruvian Andean Regions. International Journal of Environmental Research and Public Health. 2017;14(7): 745.

   DOI: 10.3390/ijerph14070745
2. World Bank. Household Cookstoves, Environment, Health, and Climate Change: A New Look at an Old Problem. The World Bank; Washington, DC, USA: 2011. World Bank 2011.
3. WBIR 2010. Modernizing Energy Services for the Poor: A WBIR – Fiscal 2000–08. ESMAP, Washington, D.C. P 1-9.
4. Jan I, Sabir U, Waqar A, Noor PK, Syed MA, Zafar M, Muhammad NA, Shaikh SA. Adoption of improved cookstoves in Pakistan: A logit analysis. Elsevier: Biomass and Bioenergy. 2017;103:55-62. (Consulted 23/03/18)

   Available:https://www.sciencedirect.com/science/article/pii/S0961953417301708
5. Ezzati M. Indoor air pollution and health in developing countries. The Lancet. 2005; 366(9480):104–6.

   DOI: 10.1016/S0140-6736(05)66845-6
6. WHO, World Health Organization, Editor. Indoor air quality guidelines: Household fuel combustion. Geneva, Switzerland; 2014.
7. Vulturius G, Wanjiru H. The role of social relations in the adoption of improved cookstoves. Stockholm Environment Institute Working Paper no 2017–01. 2017.
8. WHO 2005 Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update, Summary of risk assessment. Geneva, Switzerland.
9. Arnold JE, Michael G, Köhlin, Persson R. Woodfuels, livelihoods, and policy interventions: Changing perspectives. World Development. 2006;34:596-611.
10. Kurmi OP, Semple S, Simkhada P, Smith WCS, Ayres JG. COPD and chronic bronchitis risk of indoor air pollution from solid fuel: A systematic review and meta-analysis. Thorax. 2010;65:221–228.

    DOI: 10.1136/thx.2009.124644
11. Dherani M, Pope D, Mascarenhas M, Smith KR, Weber M, Bruce N. Indoor air pollution from unprocessed solid fuel use and pneumonia risk in children aged under five years: A systematic review and meta-analysis. Bull. World Health Organ. 2008;86:C390–C398.
12. WHO Health Organization. Global Health Observatory (GHO) Data.

    Available:http://www.who.int/gho/en/
13. WHO. Global Health Observatory (GHO) Data. WHO; Geneva, Switzerland: World Health Organization. Global Health Observatory (GHO) Data.

    Available:http://www.who.int/gho/en/
14. Bruce N, Dherani M, Liu R, Hosgood HD, III, Sapkota A, Smith KR, Straif K, Lan Q, Pope D. Does household use of biomass fuel cause lung cancer? A systematic review and evaluation of the evidence for

the GBD 2010 study. Thorax. 2015;70: 433–441.
DOI: 10.1136/thoraxjnl-2014-206625\

15. Wolf J, Mäusezahl D, Verastegui H, Hartinger MS. Adoption of Clean Cookstoves after Improved Solid Fuel Stove Programme Exposure: A Cross-Sectional Study in Three Peruvian Andean Regions. International Journal of Environmental Research and Public Health. 2017;14(7):745.
DOI: 10.3390/ijerph14070745
16. Wolf J, Mäusezahl D, Verastegui H, Hartinger MS. Adoption of Clean Cookstoves after Improved Solid Fuel Stove Programme Exposure: A Cross-Sectional Study in Three Peruvian Andean Regions. International Journal of Environmental Research and Public Health. 2017;14(7):745.
DOI: 10.3390/ijerph14070745
17. Bailis R, Ezzati M, Kammen DM. Mortality and greenhouse gas impacts of biomass and petroleum energy futures in Africa. Science. 2005;308:98–103.
18. Vulturius G, Wanjiru H. The Role of Social relations in the Adoption of Improved Cookstoves Stockholm. Environmental Institute, Stockholm; 2017.
Available:www.sei-international.org/publication?pid=3063 SEI Working paper.
19. Miah MD, Al Rashid H, Shin MY. Wood fuel use in the traditional cooking stoves in the rural floodplain areas of Bangladesh: A socio-environmental perspective. Biomass and Bioenergy. 2009;33(1):70–78.
DOI: 10.1016/j.biombioe.2008.04.015
20. Ramanathan V, Carmichael G. Global and regional climate changes due to black carbon. Nature Geoscience. 2008;1(4): 221–27.
DOI: 10.1038/ngeo156
21. Jeuland MA, Pattanayak SK. Benefits and costs of improved cookstoves: Assessing the implications of variability in health, forest and climate impacts. PLoS ONE. 2012;7(2):e30338.
DOI: 10.1371/journal.pone.0030338
22. Lewis JJ, Pattanayak SK. Who adopts improved fuels and cookstoves? A systematic review. Environmental Health Sciences. 2012;120:637–645.
23. Viyoi CT, Manu IN, Tchouamo I. Dynamics of household energy and cooking stoves in Maroua, Far North Region of Cameroon. Journal of Scientific Research & Reports. 2015;9:1-13.
24. Ministère de l'Environnement et de la Protection de la Nature (MINEP); Programme des Nations Unies pour le Développement (UNDP); Bureau des Nations Unies pour les services d'Appui aux Projets (UNOPS). Plan National de Lutte Contre la Désertification (PAN/LCD); MINEP: Yaoundé, Cameroun; UNDP: Yaoundé, Cameroun; UNOPS: Yaoundé, Cameroun; 2006.
25. Madi A. Étude sur la situation de référence du bois-énergie dans la région de l'Extrême Nord, Cameroun. GIZ, ProPSFE. 2012;120.
26. Njong MA, Tabi Atemkeng J. An analysis of domestic cooking energy choices in Cameroon. European Journal of Social Sciences. 2011;20(2):336-347.
27. Ndung'u M. Ministry of Agriculture: Home economics technical update. No. 3, August, 2009. Nairobi, Kenya. Neuman; 2009.
28. Rwiza M. Innovations and sustainability: The case of improved biomass stoves adoption and use in Tanzania. Unpublished maters thesis, Lund University, Sweden; 2009.
29. Reddy TS, et al. Domestic cooking fuel and lung functions in healthy non-smoking women. Indian Journal of Chest Diseases and Allied Science. 2004;46:85-90.
30. Jan I. What makes people adopt improved cookstoves? Empirical evidence from rural northwest Pakistan. Renewable and Sustainable Energy Reviews. 2012;16: 3200-3205.
31. Lewis JJ, Pattanayak SK. Who adopts improved fuels and cookstoves? A systematic review. Environmental Health Sciences. 2012;120:637–645.
32. Food & Agriculture Organization of the United Nations. Corporate Document Repository; World Energy; Wood for Energy; Problems and Promises; 2010. (Retrieved September 6, 2010)
Available:http://www.fao.org/dorcrep/Q4960e03
33. Viyoi CT, Manu IN, Tchouamo I. Dynamics of household energy and

cooking stoves in Maroua, Far North Region of Cameroon. Journal of Scientific Research & Reports. 2015;9:1-13.

34. Rogers EM. Diffusion of innovations. A Division of Macmillan Publishing Co., Inc. 866 Third Edition, Avenue, New York, N.Y. 10022. 1983;1-447.
35. Makame OM. Adoption of improved stoves and deforestation in Zanzibar, Management of Environmental Quality, [e-Journal]. 2007;18(3):246.
    Available:http://www.emeraldinsight.com/journals.htm?issn=1477-7835&volume=18&issue=3
36. Rollins T. Using the innovation adoption diffusion model to target educational programming. Journal of Agricultural Education. 2009;34.
37. Aneani F, Anchirinah VM, Owusu-Ansah F, Asamoah M. Adoption of Some cocoa production technologies by cocoa farmers in Ghana. Sustainable Agriculture Research. 2012;1:103-117.
38. Rogers EM. Diffusion of innovations. A Division of Macmillan Publishing Co., Inc. 866 Third Edition, Avenue, New York, N.Y. 10022. 1983;1-447.
39. Hiroki U, Ashok KM. Net effect of education on technology adoption by U.S. Farmer. Lousiana State University Ag center USA; 2001.
40. Feder G, Slade R. The acquisition of information and the adoption of new technology. American Journal of Agricultural Economics. 1984;66:312–320.
41. Caswell H. Matrix population models. John Wiley & Sons, Ltd; 2001.
42. Barnes D, Openshaw K, Smith K, Van der Plas R. What makes people cook with improved biomass stoves? A comparative international review of stove programs. World Bank Technical Paper 242; 1994.
43. Manyo-Plange N. The changing climate of household energy: Determinants of cooking fuel choice in domestic settings in Axim, Ghana; 2011.
44. Wijayatunga PD, Attalage RA. Socio-economic impact of solar home systems in rural Sri Lanka: A case-study. Energy for Sustainable Development. 2005;9:5-9.
45. Manyo-Plange N. The changing climate of household energy: Determinants of cooking fuel choice in domestic settings in Axim, Ghana; 2011.
46. Nfah EM, Ngundam JM, Vandenbergh M, Schmid J. Simulation of off-grid generation options for remote villages in Cameroon. Renewable Energy. 2008;33: 1064–1072.
47. Ngnikam E, Tolale E. Systèmes Energetiques: Vulnerabilite-adaptation-Resilience (VAR). Afrique Sub Saharienne-Cameroon, Helio International, Paris. 2009;45.
48. WHO. Global Health Observatory (GHO) Data. WHO; Geneva, Switzerland: World Health Organization. Global Health Observatory (GHO) Data.
    Available:http://www.who.int/gho/en/
49. Zou J. Elements of statistics: Lecture note. AMS 102.7 Spring 2006.
50. Schaffner B, ProPSFE. La demandeen bois-énergie à l'Extrême-Nord: Focus sur les foyers améliorés. Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ); 2013.
51. Damte A, Koch. Clean fuel-saving technology adoption in urban Ethiopia. University of Pretoria, Department of Economics, Working Paper Series. 2011; 1-27.
52. Smith GD. Random allocation of observational data: How small but robust effects could facilitate hypothesis-free causal inference. Epidemiology. 2011;22: 460-463.
53. Faham E, Hosseini SM, Darvish AK. Analysis of socio-economic factors influencing forest dwellers' participation in reforestation and development of forest areas. American Journal of Agricultural and Biological Sciences. 2008;3:438-502.
54. Lewis JJ, Pattanayak SK. Who adopts improved fuels and cookstoves? A systematic review. Environmental Health Sciences. 2012;120:637–645.
55. Gebreegziabher Z, Mekonnen A, Kassie M, Köhlin G. Urban energy transition and technology adoption: The case of Tigrai, Northern Ethiopia. Energy Economics. 2012;34:410-418.
56. Rehfuess EA, Puzzolo E, Stanistreet D, Pope D, Bruce NG. Enablers and barriers to large-scale uptake of improved solid fuel stoves: A systematic review. Environ

Health Perspectives. 2014;122(2):120–130.
Doi.org/10.1289/ehp.1306639

57. Mekonnen A, Köhlin G. Biomass fuel consumption and dung use as manure: evidence from rural households in the Amhara Region of Ethiopia. Environment for Development Discussion Paper-Resources for the Future (RFF). 2008; (08-17).

58. Ruiz-Mercado I, Masera O, Zamora H, Smith KR. Adoption and sustained use of improved cookstoves. Energy Policy. 2011;39:7557–7566.
DOI: 10.1016/j.enpol.2011.03.028

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