Solar Stove Usage Versus Charcoal for Sustainable Environmental Life Cycle of Madagascar Ecology

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***Abstract*—Deforestation poses an immense threat in Madagascar ecology and biodiversity. The vast majority of household recourse to the use of charcoal as a main source of energy. This study examines the advantages and drawbacks from using charcoal and the challenges faced by the Malagasy people. It aims to underpin the traditional cooking habits in hope to combat the non-resolvable deforestation leading into sustainable preservation and conservation of its environment. This research uses a qualitative descriptive method trying to assess the alternatives between the use of charcoal and solar stove based on surveys and questionnaires from various households. Our analysis focuses on the real environmental life cycle of both techniques. Our results indicate that charcoal use seems to be devastative but generally responds the community needs but in decline during dry season in certain areas whereas solar stove is hard to come by in the majority part of the island and less usable during rainy season despite it was evident that locals would consider to using it as an alternative source. It was noticed that there was an increase of 0.38% in the use of charcoal while solar stove spearheading to 0.55% compared to the last decade. Thus, it was perceived that less impacts on environment occurred due to the use of such technology.**

Keywords: Madagascar, Deforestation, Charcoal, Solar stove, Life cycle.

I. INTRODUCTION

Wood is the main source of fuel energy [1]. Charcoal represents the largest use of global fuel energy supply since it is viewed as an important biomass, showing an annual world-wide usage of 3.3 billion m2, and half of which is used for energy [2]. The use of natural wood charcoal is approximately dated back to 30,000 years ago commonly in cave drawings [3]. Over 2 billion people globally rely on fuel wood as their main energy supply, especially rural households in developing countries [4].

Being the fourth biggest island in the world, after Kalimantan, Madagascar, located in Indian Ocean, between latitude 20°S and longitude 47°E, possesses a tropical climate, with sub-temperate inland and arid soil in the south, where lots of environmental issues prevail, namely, soil erosion, semi-desert land, with hot burning climate and dry deciduous and spiny forest as well due to deforestation and overgrazing, traditional practices. Biomass provides 84.9%of total energy consumption of Madagascar while charcoal production rose from 0.65 to 1.03 Mt of charcoal from 2000 to 2008 [5]. Also, slash and burn practices, also known as deforestation is not a new practice for farmers in Madagascar, inducing the vast majority of its fauna and flora unique to the island at risk, critically endangered as well as ravaging various local habitats since the primary vegetation has been swiped out by such horrific fire.

The contribution of charcoal production to deforestation in tropical countries showed the highest rates of deforestation estimated at less than 7% [6].

Besides, rice is considered as the main source of food staple of whole Malagasy people every single day, using firewood as source of energy for cooking since 95% of locals rely upon the seize of wood as source of cooking. The southern of the country though does not possess tremendous assets obtaining such firewood easily due to its arid soil making it harder and harder to fetch. And thus, the locals recourse to another possibility, introducing solar energy as an ideal source because the area is granted 320 sunny days per year.

Such new technology remains a challenge since environmental impacts have to be undertaken thoughtfully, assessing its sustainability for it often brings about negative drawbacks other than its assets.

The purpose of this study is to characterize the consumption resources and the environmental assessment regarding the use of parabolic solar cook SK14 while some environmental life cycle impact assessment related to the production, the use of such technology has also been targeted, as well as comparing its impacts on the environment itself.

II. METHODOLOGY

The research was undertaken precisely from August till early November of 2016, while a detailed agenda had to be followed starting from the outline presented at the beginning of July 2018 until October 2018. This study took place in Madagascar mainly located in 6 major provinces. This research uses a descriptive qualitative method, with a phenomenological approach. Phenomenological approach is a research that attempts to explain or reveal the meaning of a concept or phenomenon of experience faced by several individuals [7]. The approach used is a cross sectional one namely the data collection independent variables and the

dependent ones collected at the same time (point time approach) [8]. The purpose of qualitative research with phenomenological approach is to understand the meaning of events, symptoms and interaction of human individuals/groups/communities, as well as the experience to understand the interaction [9].

This study was carried during 90 days as far as observation is concerned but a preliminary research had been carried out prior to field studies. Observations were conducted at three stages every day, and that is, in the morning at 07.00-09.00, then at noon at 11.00-13.00, and finally in the afternoon at 17.00-19.00. Note that heavy rain or any weather mishaps were not avoided when observation was to be carried out. Also, there were few important tools to be used during research including a camera, Sony Tape Recorder branded M-530 V, a thermometer, a Timer (using cell phone), pens, sheets of paper, and so on.

The research data source was both primary data and secondary data. Primary data is data obtained directly from the subject of research by measurement tools directly on the subject as a source of need of information [10]. Primary data in this study is focused on the habitat, and patterns description and based on the results of interviews to find out the name, place / date of birth, occupation, address, sex, age, and as well as based on the observation of hot environment. There were about 120 households taken as samples.

Besides, secondary data is data obtained from the other party, not directly obtained by the researchers of the study subjects [10]. Secondary data in the implementation of this study is the climate variables such as temperature and rainfall and humidity for the last 20 years at least.

In order to do these, it will be very important to demonstrate the best monitoring design that helps detect changes to these properties and geographical scales which are suitable for providing adequate and reliable metric for environmental conservation management efforts.

III. Result and Discussion

A. Usage of Charcoal Impacts

It is evidently undeniable that a single household in Madagascar consumes roughly 2.31 kg of wood for cooking a meal which is an equivalent of 108 grams. Such charcoal use releases a huge emission of carbon dioxide into the atmosphere. It is assumed that such CO_2 emission represents 3.21 kg of CO_2 emitted at each cooking time.

Table 1. CO_2 Emissions of Charcoal Usage

Energy Source	Energy (MJ/Meal)	CO2 Emission (kg/meal)	Cost in Ariary
Charcoal Stove	32.5	9.07	1200

Table above demonstrates that charcoal usage that causes carbon dioxide into the atmosphere. In fact, charcoal cooking costs quite expensive for the local community. It is estimated at US$ 446 including VAT where 1US$ is around 3000 Ariary, local currency. Such calculation is based on assumption after counting the average use of charcoal and its cost. It is worth mentioning that each single household cooks meals three times a day. Note that each cooking time is equivalent of 400 Ariary which is multiplied by three times in one day and 365 times for an annual bill that eventually gives a rough amount of US$ 446. Below is a figure demonstrating some kinds of traditional charcoal stove in Madagascar.

Figure 1. Traditional Charcoal Stove
Source: Primary Source

The figure above shows a certain type of charcoal stove used by the majority of households in Madagascar. Based on our results, it is expected that the core value of energy consumed at each meal time is approximately worth 32.5 MJ; the transportation of charcoal needs 0.35 MJ per meal and the manufacture needs 0,015 MJ per meal.

At each emission factory of about 110 kg/GJ, it provided 9.07 kg of CO_2 emitted per meal with charcoal cooking.

For instance, for charcoal ⇒9.07 kg CO_2 emitted per meal which is multiplied three times per day, it is equivalent to 25.10 kg of CO_2 emitted per day per household.

As a result, such figure would be ⇒25.10 kg × 365 days = 9,161.13 kg of CO_2 per year.

The figure below shows the frequency of charcoal usage during the past two decades and that is from 1998 until 2018.

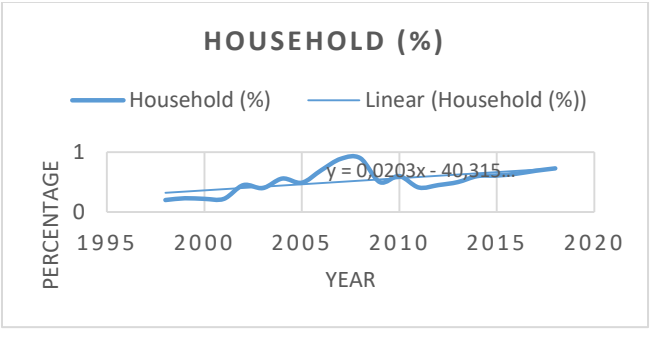

Figure 2. Household Frequency on Charcoal Usage
Source: Primary Source

According to the figure above, it is demonstrated that an increase of 0.38% among the samples taken in this research was noticed. This was due to the hardships and the high cost of solar stove. The non-resolvable political crisis during the past two decades also worsens the figure to dramatically

spearheading encouraging locals to use charcoal more often despite in rainy season it decrease.

Furthermore, among those 120 households, there were some respondents who were a bit reluctant in using traditional stoves given the fact that it induces further jeopardy upon the environment. However, they could not but had to use charcoal as in certain areas solar stoves are hard to come by.

The figure above shows that the highest percentage was in 2010. This could be explained by the fact that there were an increase of green vegetation supported by massive reforestation measures despite political upheaval seem to gain its peak encouraging people to grasp.

B. Usage of Solar Stove Impacts

Over the past decades, a new technology meant to combat the devastative impacts from the use of charcoal stove which consumed tremendous amount of woods while inducing a huge deforestation, is the use of solar stove. Madagascar alone represents very few and it is hard to come by especially in rainforest areas where humidity and rain prevail.

Below is a figure indicating a type of local solar stove used in the southern part, namely in Sakaraha district.

Figure 3. Solar Stove
Source: Primary source

The figure above shows a certain kind of parabolic solar stove used in few areas due to its expensive costs. For example, in one single household, a solar stove is estimated at 4.01 kg of CO_2 emitted per meal. It is generally used two times a day which gives a picture of roughly8.02 kg of CO_2 emitted per day per household.

As a result, such figure would be 8.02 kg × 365 days, which is an equivalent of 2,927.3 kg of CO_2 emitted each year. Besides, the value of consumed energy for solar stove is summed up a total of 0.072 MJ per meal. Finally, there can be obtained 32.5 MJ/meal × 0.45, which is the equivalent of 36.88 MJ per meal.

The figure below shows the frequency of charcoal usage during the past two decades, that is from 2000 until 2018.

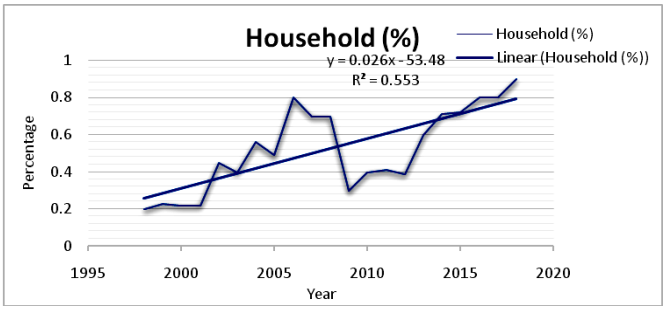

Figure 4. Household Frequency on Solar Usage

According to the figure above, it is demonstrated that there was a slight increase in the usage of solar stove compared to charcoal. The highest peak was in 2018 which can be explained by the recent change and awareness of the local community in their common fight against global warming and a palpable increase of temperature.

When seeing the number of respondents who recourse to the use of solar stoves, the majority of them would love to but because of the cost and few demands, just quite an average increase was noticed especially in 2018. In general, such increase was 0.55% compared to charcoal which was only 0.38%.

It is undeniable that solar energy technologies provide positive assets not only for the environment but also for human health [11]. It was perceived that carbon dioxide omission has lessened over the past year despite a fear of global concern over a probable high increase of temperature. Its advantages remain to the fact that solar stoves possess additional positive implications for the reduction of greenhouse gases emissions, toxic gas particles, water quality improvement and so forth.

However, charcoal usage has gained massive monopoly worldwide, especially in developing countries, like Africa and Sri Lanka. A study indicated that an increasing demand for large farms for wheat and other agricultural activities is the major driving force for forest cover destruction and charcoal production is one of the factors leading to forest destruction. It was asserted that charcoal producers have limited knowledge of impacts of their activities on forest status. Only 24% believed charcoal production activities was a factor responsible for forest degradation in the area, a study supported by few researchers in Africa. They attributed the change in forest status to other causes (76%) namely land clearance, grazing, and forest fires. In Africa, for instance, charcoal producers admitted that deforestation was associated with negative impacts on their day to day livelihood activities.

In addition, biomass and petroleum consumption in Sri Lanka was 5%, 70% and 25% respectively in 1972 while it was 8%, 45% and 47 % respectively in 2006, with a dramatic drop in the share of biomass and a rise in petroleum products [12].

IV. Conclusion

In Madagascar, solar stove is less usable compared to charcoal stove. This research indicates that there has been a quite positive reduction on the environmental impacts when using solar stove. It is hard to come by though in remote areas and especially in rainforest patches. It was perceived that solar stove was only used as back-up since the majority of local households use of charcoal remain prevalent despite social perception indicate an increase of understanding on the benefit of solar stove for environmental conservation. Its life cycle though remain unpredictable and poses a challenge due to its costs and certain parameters. Meanwhile, its usage cannot thoroughly put into an end the use of charcoal or other traditional energy in spite of its effective mitigation tool in tackling deforestation, global climate change, and economic debasement of the Malagasy people. It is expected that the use of solar stove would increase over the past coming decades since there remains very few amount trees left in Madagascar while an ineffective governmental regulations against illegal logging seem to be far from happening to halt and thwart the dire impacts of deforestation upon ecology and the population as a whole.

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