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The Potential of Efficient Improved Mud-Brick Cookstove in Cameroon: An Exploratory Study

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Abstract

In most Africa countries, cooking is a dirty and time-consuming job that involves feeding some pieces of fuel such as wood, charcoal, or coal for a fire. Globally, some 500 million households with more than 70% in Africa depend on burning solid fuel to meet their cooking, heating, lighting, and other household energy needs. The wanton exploitation of wood fuel is having so many negative impacts on many households in Cameroon. Some of the impacts include: the

depletion of the forest leading to environmental degradation, health impacts, etc. In the Central Africa region including Cameroon about 80-90% of the population has limited access to modern forms of energy such as electricity, and relies on traditional biomass (e.g. wood and agricultural residues) for cooking and heating. There is an urgent need to investigate more efficient cook stove technologies that have very minimal or no impact on the environment and households. In this study, an improved mud-brick cook stove was designed and tested in a typical family house in Cameroon. To ensure the acceptability and sustainability of the technology, the rural dwellers were involved in the design and implementation. The performance of the stove was compared with that of traditional 3-stone fireside common in most rural households in Cameroon. The mud-brick cook stoves are large and permanently built into a kitchen and easy to use. The mud-brick cook stove construction materials are available in communities that have clay soil and can be made using limited tools.

Keywords: Cameroon, Cook stove, Efficiency, Improved stove, Solid fuel

1. Background

Global increase in population has also led to an increase in the demand for basic services such as water, energy, houses and infrastructure. Amongst these, energy is one of the most pressing needs in developing countries. In most African countries, cooking is a dirty and time-consuming job that involves feeding some fuel types such as like wood, charcoal, or coal to produce fire. About some 500 million households in the world, with more than 70% in Africa depend on burning solid fuel to meet their cooking, heating, lighting, and other household energy needs (ARPEDAC, 2014). Compared to other regions of the continent, Central Africa region has limited basic infrastructure. Access to electricity remains precarious and falls far short of Africa's average. The energy consumption is 12.5 kWh per inhabitant in the Central African region against 17.3kWh for the continent (ECCAS 2025 Vision, 2014). Also, electricity provided by the main electricity supplier has been noted for regular and constant power cuts. This is further exacerbated by high electricity cost that is often not affordable. In some regions, there is total lack of gridlines to supply electricity and the cost to pay for it is usually exorbitant and cannot easily be borne by an individual. Perhaps partly because of these challenges, Cameroon is one the countries with a high dependence on solid fuels. Some examples of solid fuels include wood, charcoal, peat, coal, hexamine fuel tablets, and pellets made from wood. It has been reported in GAFCC (2013) that 83% of the Cameroonian population use solid fuels for cooking meals daily. The use of solid fuel has so many health related impacts. Furthermore, wood-the most commonly used solid fuel is not sustainably harvested and there are reports of scarcity and women now have to travel very long distances to fetch for wood. About 2.7 million families, who depend on this quickly depleting resource, often walk an average of 3 hours a day to collect wood or spend up to 1/3 of their annual income to cook for their family (EFC, 2012). Cooking over a 3-stone fire (see Figure 1: a) in a home is the equivalent of burning 400 cigarettes an hour that releases toxic smoke and emissions which mostly effect women and children (EFC, 2012). A recent study by Global Health revealed, inefficient cook stoves to be the largest environmental threat (GEC, 2012).

It has become imperative to investigate alternative ways of providing energy that is environmentally-friendly, affordable and socio-culturally accepted. Clean cook stove technologies have emerged and are gradually being supplied in Cameroon. However, some of these technologies have not been documented in academic literature. As such many aspects or factors (e.g. efficiency) which are important in regards to making decisions about their uses are scarce. The aim of this study is to report on a recently design mud-brick cookstove for use in Bafut, a village located a few miles from Bamenda, the North-West regional capital of Cameroon. To achieve this aim, the following objectives have been set:

- Investigate the design of a mud-brick cookstove;
- Investigate the performance of sustainability factors;
- Compare the performance of the mud brick cookstove to traditional 3- stones fireside;
- Propose recommendations for future study.

2. An Overview of Solid Fuel Consumption Studies and Projects

Studies about solid fuel consumption in Cameroon are scarce. Njiti and Nkemcha (2003) conducted a survey about fuel wood and service wood production and consumption in Garoua and its rural environs. Feka et al. (2009) used fuel wood consumption rate and duration to smoke fish in the Douala-Edea Wildlife Reserve as criteria to determine the efficiency of two fish-smoking systems (i.e. traditional smoke system and improved smoke system). Feka and Manzano (2008) investigated how the use of mangrove wood for fish smoking by local people in some localities of the South West region of Cameroon may be in conflict with the conservation and sustainability of mangrove ecosystems. Nfotabong-Atheull et al. (2011) assessed forest products usage and local residents' perception of environmental changes in peri-urban and rural mangroves of Cameroon. Neba (2010) investigated the challenges of wood fuel yield, availability and harvest in the Tubah mountain forest, Cameroon. Vitali et al. (2013) investigated the efficiency of rice husk stove in rural Logone Valley (Chad/Cameroon). Vaccari et al. (2012) conducted a comparative study to determine the fuel and cost savings of two Centrafricain wooden stove models, traditional 3-stone fire and a gas stove. Vitali and Vaccari (2014) examined the various dissemination models of improved stove in the Logone Valley (Chad, Cameroon).

Based on the literature there are many different types of solid fuel technologies in use in Cameroon. The traditional 3-stone fireside is quite common in Cameroon. Clay firesides are also common in the North-West region of Cameroon (UNAFAS, 2007). Rice-husk stove are also common in the Logone Valley. While the 3-stone fireside is the defacto solid fuel and easy to use, local dwellers have been trained to use more improved cookstoves. In Mbouda, Dschang and Yaoundé cities in Cameroon, around 90% of people use wood for cooking on traditional 3 stone fires that are both highly inefficient and a cause of indoor air pollution. Most people in these cities purchase their wood for cooking, which means that very little of household budget is left over to invest in a cleaner, more efficient cook stove. ACREST and ARPEDAC have made efforts to address this issue by developing a locally made improved stove (Figure 1: f and g), based on simple, effective cleaner technology made of ceramic insulation and metal frame. ACREST and ARPEDAC stoves were compared with the

traditional 3-stone fireside cook-stove and the results revealed that these stoves are energy efficient and can save up to about 60% of firewood and could last more than 5 years with little maintenance (ACREST, 2014). The University of Yaoundé1 in Collaboration with ARPEDAC has carried further scientific investigations on ARPEDAC's improved stove using the modified version of the well-known Water Boiling Test (WBT) in ARPEDAC's laboratory (Figure 1: g), the kitchen indoor air quality (IAQ) checks and the flue gas analyser measures and logs ambient carbon monoxide (CO) and carbon dioxide (CO_2) levels were also investigated and compared with the conventional 3- stone fireside cook-stove (Mbieji, 2013). Also, there are other improved stoves being imported into Cameroon. However, there is no local scientific data to support their advantages over traditional 3-stones stove.nInformation about the amount of local energy saving and environmental benefits of improved cookstoves are scarce. Also, Envirofit is one of the major suppliers of clean stoves (e.g. Figure 1: d and e) in Cameroon (Calvert Foundation, 2013). It is estimated that 50 000 Envirofit stoves can prevent 570 000 tons of CO_2 from being emitted, save 700 000 of trees from being cut 5.5 million hours of women's time spent in collected wood, $14 million reduced fuel consummation and 270 000 livelihoods improved (EFC, 2012). Other improved cookstoves available in Cameroon are depicted in Figure 1: b and c.

(a) 3-side firestone Source: Vitali (2011)

(b) Centrafricain improved stove Source: Vitali (2011)

(c) Improved charcoal burners with ceramic linings Source (Nienhuys, 2010)

(d) M-5000 Wood Source (Envirofit, 2014)

(e) CH-2200 Charcoal Source (Envirofit, 2014)

(f) ACREST's improved stove under testing condition, source: (ACREST, 2014)

(g) ARPEDAC's improved stove under testing condition, source: (ARPEDAC, 2014)

Figure 1. Some selected sample solid fuel cook stoves in Cameroon

What emerges from the preceding paragraphs is that, there is a lack of systematic and coherent studies about the different solid fuel cook stoves in Cameroon. Also, there are a variety of improved wood cookstoves amongst others. However, there is paucity of data and information about solid fuel consumption technologies that can be used to make informed decisions about their uses. While a few studies have conducted comparative studies about different improved cookstove technologies, such studies are often technical with focus on efficiencies or technical performance. Although, this is already great, there is however a greater need to consider other local constraints especially if the needs of the local dwellers have to be met. Vitali and Vaccari (2014) concluded that the dissemination of stove models should consider local constraints. Other softer factors than technical efficiency should be considered. For example, are the wooden cookstove acceptable and affordable?

In addition to the findings from the literature review as discussed in the preceding section, observational studies were conducted in some households in Bamenda, the capital of the North-West region of Cameroon. It emerged that, women use large, heavy cast pots daily to prepare large quantities of food for their families. In their kitchens, the walls are blackened and dark during cooking. Even modern homes have an outside open-fire kitchen, in addition to a gas burner. There is a huge amount of energy loss as a result of cooking in the open. Also small energy efficient stoves are inadequate for the big pots used by households in Cameroon. Our proposed mud-brick stove takes into account all these challenges.

3. The proposed Ndanifor Permaculture Eco-village Project

Better World Cameroon[1] is working with Bafut Council in supporting the development of a plan for sustainable growth and development of the region. The organisation's aim is to strike a balance relationship between farmland, housing, and commercial areas. Ndanifor Permaculture Eco village (NPE) is a Permaculture Demonstration Site and Center for environmental education and sustainable food production. NPE is a demonstration site and constitutes part of the Eco-Village Vision for 2020 of Bafut. The improved cookstove project is one of the projects on NPE. One of the cookstove is the innovative mud-brick cookstove (Figure 2) recently built in some homes in Bafut.

4. Apparatus and Procedure

4.1 Description of the Mud-brick-cook-stove

The concept of the mud-brick cookstove is enshrined in the permaculture principles (Holmgren, 2011). The materials used for building the stove are mud-bricks, clay soil, saw dust and sand. Other than sand, brought from a different location, all the other materials are sourced from the NPE yard. Water is used for mixing mortar for binding the bricks. The mud-brick cookstove construction materials are available in any community that has clay soil and can be made using limited tools, only requiring a knife, a metal pot and a small hole.

4.2 Description of the Design Process

The main tools used for the construction of the stove are: a tropical hoe to dig and mix clay, a cutlass (machete), buckets and measuring tape. If a measuring tape is not available, body measurements techniques (e.g. width of hands) are used. The key design steps are:

- The volume of the largest pot that will be used on the stove is determined;
- The volume relates to the size of combustion chamber and heat path through the stove. This can be looked up from a simple chart by Kabuleta (2004);
- The width of the stove is determined from the diameter of the pot plus insulation plus bricks;
- The length of the stove is the sum of the first pot plus a second, smaller pot, plus chimney plus edges and channels;
- Finally the height of the stove as illustrated in Figure 2.

[1] http://betterworld-cameroon.com/what-we-do/projects/ndanifor-permaculture-eco-village/

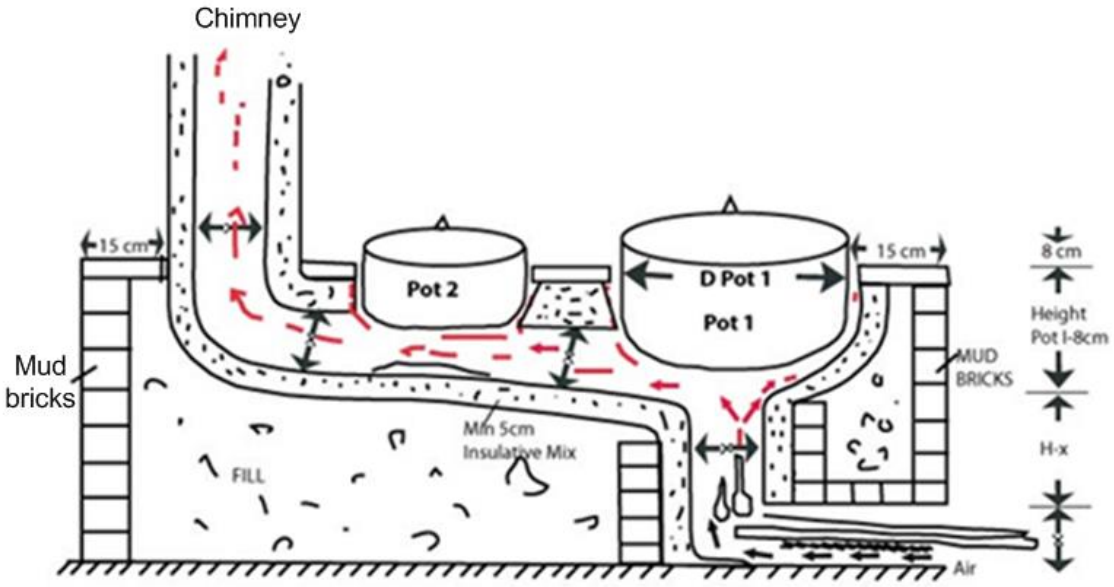

Figure 2. Cross-section of mud-brick cookstove

The steps in the building of the stove are as follows:

- Prepare a 1:1 (by volume) mix of clay and fine sawdust (estimated 4 wheelbarrows of clay) and a clay mortar mix;
- Layout on the ground: position pots;
- Set edges with bricks and configure firewood feed and combustion chamber (considering 5cm insulation);
- Build up edges and combustion chamber.

Figure 3. Initial stages-Building edges and combustion chambers

- Insulate combustion chamber. Banana stems as guides were used, but was later on removed rather than to leave them to get rotten in-situ;
- Fill voids with compacted earth or bricks;
- At appropriate height set the first (larger) pot in place and fill around it with insulation mix.

Figure 4. Placing pot to shape the size of the opening

- At the same height the channel to pot 2 will be built with insulation mix, followed by pot 2 set into place;
- Continue building up around the pots to desired height;
- Make a channel to the chimney and set up a form to build the pipe (banana stem works here too);

Figure 5. Complete stove depicting the chimney

- Remove the pots and smooth all edges and surfaces inside, scraping down the surface around the pots to create hot air circulation. Place three clay supports to lift the pot- allowing heat to move under and around the pot.

Figure 6. Smoothened stove

Figure 7. Complete stove ready for use

5. Comparison of the Proposed Mud-brick cook-stove and Traditional Wooden-cook-stove

There is a general lack of consensus about performance metrics of cookstoves. Based on most literature, the units of certain output metrics are often unclear. For example, while grams of

pollutant emitted per kilogram of wood combusted (g/kg) is a common and widely applicable emissions output metric, the data sources do not always specify whether the emission factor is gram per kg wet wood, dry wood, or dry wood equivalent, resulting in a significant lack of clarity and comparability (Berkeley Air Monitoring Group, 2012). In addition to the above challenges related to paucity of data, it is important to note that any comparative study should consider the type of pot used for cooking, characteristics and dimensions, type of food cooked, type of wood used, type of water and/or ingredient used in cooking. These are extremely challenging given the lack of standardisation of sources of these materials in Cameroon. However, given the exploratory nature of this study, we will report brief comparisons (see Tables 1) between mud-brick and 3-stone fireside stove. The three criteria considered are technical, environmental and economic.

Table 1. Comparison of mud-brick and 3-stone fireside cook stoves

Technical			
	Mud-brick cook-stove	3-stone fireside	Comments
Easy to find material to construct	yes	yes	
Ease to construct	with short training	yes	
Skills requirement	easy	none	
Ignition method	match	match	
Time to boil water			
Time to cook standard Bafut meal	women report 1.5 hour for beans	no data available	Further experiments with other foods will be conducted.
Environmental			
Amount of wood used to cook a meal per household (it is important to state average family size)	3 pieces	6 pieces	Anecdotal (Further experiments will be conducted. The relationship between the number of wood and family sizes will be discussed)
Amount of kerosene used lighting	none except a little for ignition	none except a little for ignition	
Economic			
Capital cost	labour	none	

As earlier discussed, this study is still in its preliminary stages. In the future more parameters especially with regards to environmental (e.g. amount of wood used per day per household (it is important to state average family size, emissions (CO_2) generated), economic (e.g. average life span, cost payback time) will be investigated. The Better World Cameroon in Collaboration with ARPEDAC will conduct further investigations on the innovative mud-brick cookstove recently built in some homes in Bafut using the modified version of the well-known Water

Boiling Test (WBT) in ARPEDAC's laboratory in Yaoundé, Cameroon. The experimental rig is summarised in the Figure 8 and the following keys parameters for performance evaluations will explored: the kitchen indoor air quality (IAQ) checks, the flue gas analyser, logs ambient carbon monoxide (CO) and CO_2 levels. The results will then be compared with the conventional 3-stones stove and others existing stove in Bafut council.

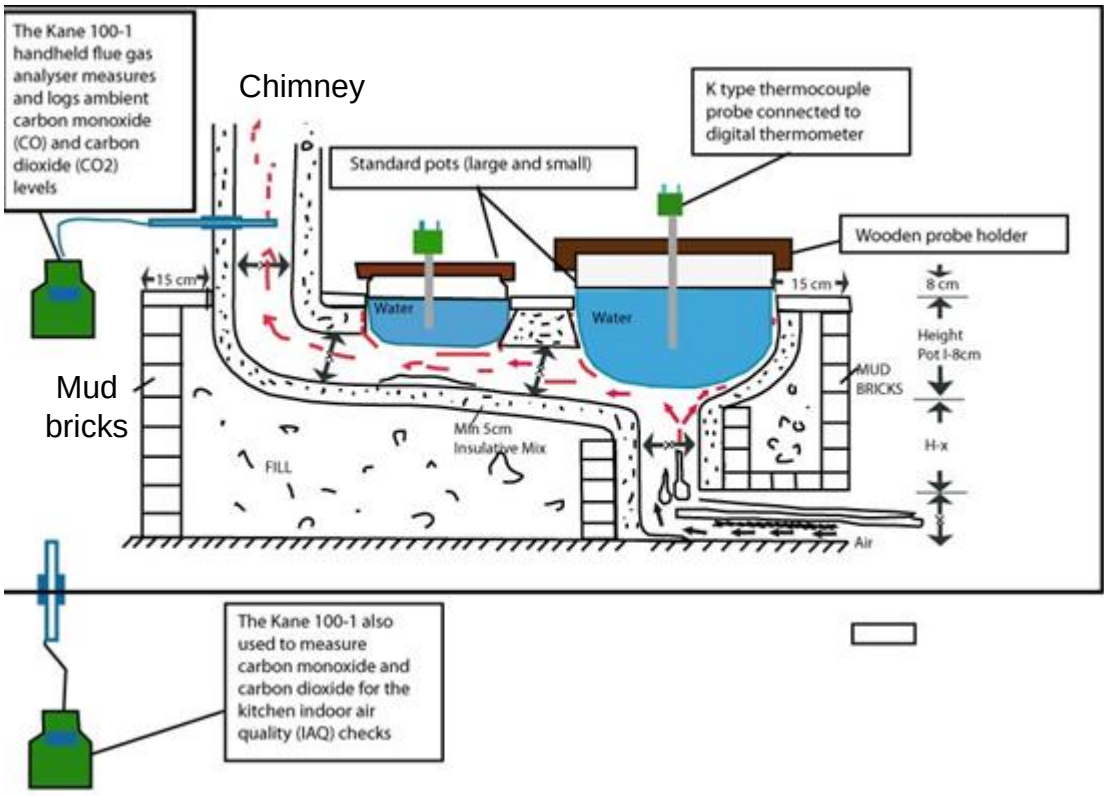

Figure 8. Testing Rig of the proposed mud-brick cook-stove

6. Conclusions and Future Studies

The aim of this study is to report on a recently mud-brick cookstove designed for use in Bafut, a village located a few miles from Bamenda, the North-West regional capital of Cameroon. To achieve this aim, we investigated and discussed the design of a mud-brick cookstove. Furthermore, the initial performance of the mud-brick stove vis-à-vis some selected sustainability criteria and a comparison with traditional 3-stone fireside was examined. Although there was no significant difference between both (as indicated in Table 1), there are two major advantages of the mud-brick cookstove over 3-stone fireside. Firstly, the former offers great stability during cooking, as most households tend to use big pots as shown in Figure 7. Secondly, smoke in the mud-brick cookstove is contained and controlled in such a way that it does not spread in the kitchen which can hinder visibility and blacken the walls. Thirdly, there is a potential of energy being conserved in the mud-brick cookstove than in the 3-stone fire side. As part of future studies, further experiments will need to be conducted to determine the performance of the proposed mud-brick cookstove. For example, the amount of heat conserved, the amount of CO_2 generated or conserved and the level of health impacts

compared to other common stoves used in Cameroon.

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References

ACREST, (2014). Project Case Study for ACREST, Cameroon: A co2balance initiative to improve access to carbon markets for all project. [Online] Available: http://www.co2balance.com/projects/case-studies/consulting_case_study.pdf (August, 2014).

ARPEDAC, (2014). Association pour la Recherche et la Promotion de l'Energie Durable en Afrique Centrale (ARPEDAC). [Online] Available: http://www.facebook.com/arpedac (August, 2014).

Berkeley Air Monitoring Group ,(2012). Stove performance inventory report. Prepared for the Global Alliance for Cookstoves. [Online] Available: http://www.cleancookstoves.org/resources_files/stove-performance-inventory-pdf.pdf (Januay, 2014).

Calvert Foundation, (2013). Summary. [Online] Available: http://www.calvertfoundation.org/impact/stories/433-envirofit-international (December, 2013).

ECCAS 2025 Vision, (2014). Central Africa - regional integration strategy paper. [Online] Available: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/RISP%20CENTRAL%20AFRICA-ECCAS%20English%20FINAL.pdf (August, 2014).

EFC, (2012). Carbon programs: Cameroon. [Online]: Available http://www.envirofit.org/images/carbon/carbon_program_cameroon.pdf (December, 2013).

Envirofit, (2014). Cookstoves. [Online] Available: http://www.envirofit.org/products/?sub=cookstoves (January, 2014).

Feka, N.Z., Chuyong, G.B., & Ajonina, G.N. (2009). Sustainable Utilization of Mangroves Using Improved Fish-Smoking Systems: A Management Perspective From the Douala-Edea Wildlife Reserve, Cameroon. *Journal Tropical Conservation Science.* 2 (4). 450-468.

Feka, N. Z., & Manzano, M. G. (2008). The Implications of Wood Exploitation for Fish

Smoking on Mangrove Ecosystem Conservation in The South West Province, Cameroon. *Tropical Conservation Science*. *1*. 222-235

GAFCC, (2013). General information. [Online] Available: http://www.cleancookstoves.org/countries/africa/cameroon.html (December, 2013).

GEC, (2012). Cookstove smoke is "largest environmental threat," Global Health study finds. [Online] Available: http://energyblog.nationalgeographic.com/2012/12/13/cookstove-smoke-is-largest-environmental-threat-global-health-study-finds/ (December, 2013).

Holmgren, D. (2011). *Permaculture: Principles and pathways beyond sustainability.* Permanent.

Kabuleta R. K. (editor), (2004). How to build improved household stoves. Ministry of Energy and Mineral Development, Uganda. [Online] Available: http://stoves.bioenergylists.org/stovesdoc/apro/guide/HOUSEHOLD%20Stoves%20Construction%20Manual%20Nov%202004.pdf (February, 2014).

Mbieji, K. C. (2013). Evaluation des Performances des Foyers Am éliores et Impacts sur la Dégradation de l'Environnent: CAS DE LA REGION DE YAOUNDE, Thèse de Master Professionnel en Sciences de l'Environnement, Option: Assainissement et Restauration de l'Environnement. Universit é de Yaound é 1, 2013.

Neba, N. E. (2010). Implications of Fuel Wood Yield, Availability and Harvest in the Tubah Mountain Forest, Cameroon. *Global Journal of Human Social Science*. *10*(3), 49-55.

Nfotabong-Atheull, A., Din N., Koum, L. G. E, Satyanarayana, B., Koedam, N., & Dahdouh-Guebas, F. (2011). Assessing Forest Products Usage and Local Residents' Perception of Environmental Changes in Peri-Urban and Rural Mangroves of Cameroon, Central Africa. *Journal of Ethnobiology and Ethnomedicine*. 7(41). http://dx.doi.org/10.1186/1746-4269-7-41

Nienhuys, S., (2010). Improved cooking stove (ICS): Cameroon-clay soil wood cooking stoves. [Online] Available: http://www.nienhuys.info/mediapool/49/493498/data/ICS-Cameroon-Jan-2010.pdf (January 2014).

Njiti, C. F., & Kemcha, G. M. (2003). Survey of fuel wood and service wood production and consumption in the Sudano-Sahelian region of Central Africa: The case of Garoua, Cameroon and its rural environs. Actes du colloque, 27-31 mai 2002, Garoua, Cameroun

UNAFAS, (2007). The impact of improved clay firesides on our household in Bamenda town, North West Province. [Online] Available: http://www.unafas.org.uk/files/article%201st%20impressions%20of%20improved%20clay%20cookstoves.pdf (December, 2013).

Vitali, F., (2011). The Centrafricain improved stove as appropriate technology for household cooking in the Logone Valley (Chad-Cameroon). [Online] Available: http://www.ing.unibs.it/~cetamb/images/stories/SmartCookingVA%20-%20Vitali.pdf

(January, 2014).

Vitali, F, & Vaccari, M. (2014). Appropriate Technology for Household Energy Access: The Case of the Centrafricain Stove in the Logone Valley (Chad, Cameroon). *Technologies for Sustainable Development*. 129-140. http://dx.doi.org/10.1007/978-3-319-00639-0_11

Vaccari, M.; Vitali, F.; & Mazzù, A. (2012). Improved Cookstove as an Appropriate Technology for the Logone Valley (Chad-Cameroon): Analysis of Fuel and Cost Savings. *Renewable Energy*. *47*, 45-54. http://dx.doi.org/10.1016/j.renene.2012.04.008

Vitali, F., Parmigiani, S., Vaccari, M., & Collivignarelli, C. (2013). Agricultural Waste As Household Fuel: Techno-Economic Assessment of a New Rice-Husk Cookstove for Developing Countries. *Waste Management.* *33*(12). 2762-2770. http://dx.doi.org/10.1016/j.wasman.2013.08.026

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