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Multi-criteria assessment of the appropriateness of a cooking technology: A case study of the Logone Valley

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ABSTRACT

The choice of fuel for cooking, particularly in rural areas, can lead to significant socio-economic and environmental impacts amongst households. Using the Logone Valley on the border between Chad and Cameroon as the case study region, this study sought to evaluate appropriate cooking technologies for the case study region. Several alternatives to traditional three-stone fire were evaluated, including the: ceramic stove, Centrafricain stove, parabolic solar cooker, biodigester, LPG stove, and mlc rice husk stove. Four main clusters were investigated, structuring quantifiable indicators for financial, environmental, social and health related impacts of the use of a certain energy technology. The findings suggest that the Centrafricain stove alone or in combination with the mlc stove, was the most appropriate cooking technology for use in the case study region. These technologies were more appropriate than the traditional cooking system of the three stone fire. The use of four clusters of criteria, within a weighted system, coupled with the views of users, experts and literature, as well as the scope of the criteria employed enabled a reliable and valid approach to understanding the most appropriate cooking technology to recommend.

1. Introduction

The three-stone open fire is the most prevalent fuel-using technology to cook in sub-Saharan Africa and many other developing countries like Peru and India (IEA, 2015; Leavey et al., 2015; Kucerova et al., 2016; WEO, 2016). Indeed, firewood is the primary source of energy amongst households in many developing countries and can be used for cooking even in the absence of a'stove' (Sosa et al., 2014; Mensah and Adu, 2015). However, use of such cooking technologies are not without disadvantages, including smoke, public health risks – primarily related to respiratory illnesses, low efficiency and high fuel consumption (Venkatamaran et al., 2010; WHO, 2016). On the other hand, there are significant benefits from the use of improved cookstove (ICS) approaches including the emission of warmth and light, the ease of use, the production of (clean) smoke useful to preserve food or to chase away mosquitoes in malaria-infested areas and the improvement of family living conditions (WHO, 2016).

Previous models of households switching between different types of fuels for cooking, largely dismiss the importance of active (and strategic) decision making by consumers and their responsiveness to structural factors such as relative fuel prices (e.g. Hiemstra-van der Horst and Hovorka, 2008). Indeed, previous studies and models have tended to link household energy choice mainly to a kind of neoclassical consumer behaviour basing their preference primarily on economic convenience (Arnold et al., 2006; Patel et al., 2016). However, the energy transition is often driven not by an emerging desire for modern fuels, but rather by socio-economic conditions (Correa et al., 2014). This is particularly true in rural contexts, where an integrated approach to understanding household energy choice is required, given the number of endogenous (e.g. lifestyles and incomes) and exogenous (e.g. fuel prices) factors affecting such a choice (Kowsari and Zerriffi, 2011; Li et al., 2011; Bruce et al., 2013; Debnath et al., 2016).

Financial and technical criteria have generally been employed in understanding the decision-making process for fuel choice. However, these processes are multidimensional, involving a range of economic, technical, environmental, political and social factors (Karanfil, 2009; Li et al., 2011). Thus understanding the decision-making processes of householders choice of fuel requires a multi-criteria decision support approach that combines technical and non-technical criteria (Vaccari et al., 2012; Vitali et al., 2013; Vitali and Vaccari, 2013; Kahraman and Kaya, 2010; Parmigiani et al., 2014). Therefore, the key innovation of the study was the multi-criteria approach, which unlike previous

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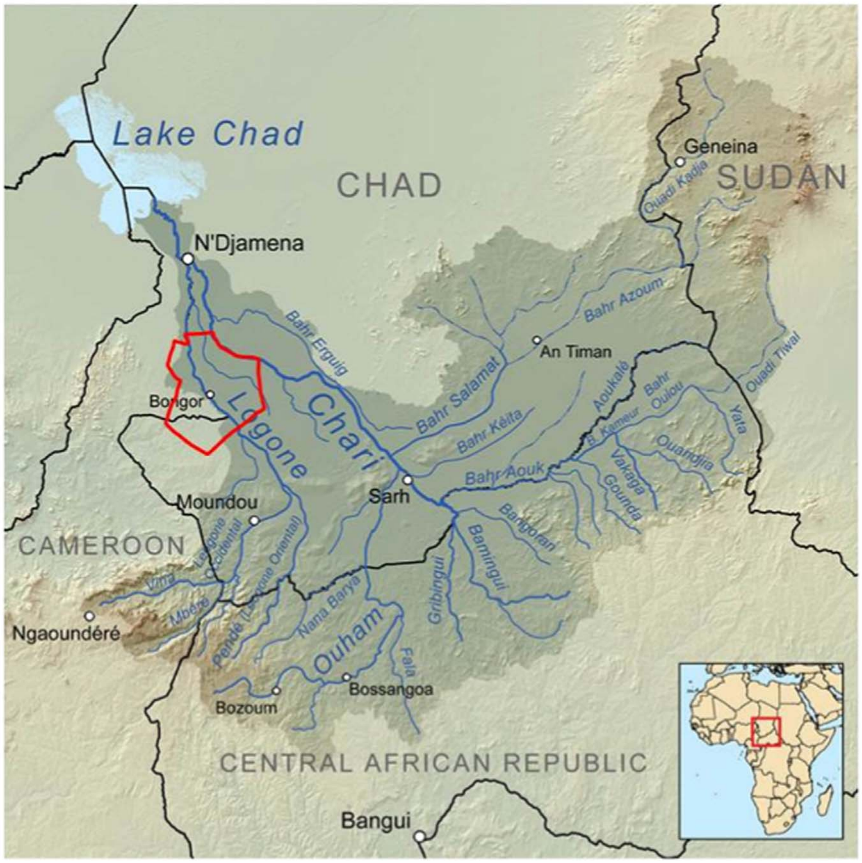

Fig. 1. The geographical location of the project Source: Vaccari et al. (2012).

studies, enabled a more holistic evaluation and conclusions to be reached.

Using the Logone Valley on the border between Chad and Cameroon as the case study region, this study aimed to evaluate and suggest appropriate cooking technologies for the case study region. This is the first empirical study known to the authors that evaluates the main cooking technologies within a Sub-Sahara setting, using a multi-criteria approach. As illustrated in Fig. 1, the Logone Valley forms part of the international boundary between Chad and Cameroon. The project was focused around the towns of Bongor and Yagoua.

2. Methods

Four main clusters of criteria were investigated, structuring quantifiable indicators for financial, environmental, social and health related impacts of the use of a certain energy technology. The weight systems adopted were chosen in order to consider the features of each technology according primarily to their relevance to the local needs.

The technological alternatives selected were among options available on the local market at the time of the study. The ranking criteria considered were adopted in order to use quantifiable variables and representative clusters of the sector impacted at household level by the cooking technologies. In addition to the households, 10 experts in the field were also surveyed. The selection of these experts was based on their knowledge of the: (1) technologies being evaluated and (2) energy needs of households in the geographical area. Their views therefore served to contextualise the key findings from the households.

2.1. Technological alternatives evaluated

Based primarily on Vitali et al. (2013), six alternative cooking technologies were evaluated against the traditional existing three-stone fire: ceramic and Centrafricain ICSs, which are fed with wood, LPG stoves, biodigesters, parabolic solar cookers and, finally, a rice husk stove. The energy recovery of rice husk (a locally available waste biomass), served as a renewable natural resource that was free, and therefore could provide especially low income classes in peri-urban areas with a cheap substitution fuel for wood (Oanh et al., 2005; Vitali et al., 2013; Parmigiani et al., 2014). However, the use of rice husk can be an unreliable option due both to the unavailability of sufficient quantities and their unverified adaptability to all local cooking practices. There has been extensive work on the parabolic solar cooker as an alternative technology in developing countries, which has been shown to work well (e.g. Pohekar and Ramachandran, 2006; Harmim et al., 2014; Sosa et al., 2014). However, given the evident limitations caused by dependence on weather conditions, it can serve only as a partial substitutive energy source for traditional fuels.

2.2. Choice of criteria

There are a number of potential indicators that might be considered in the evaluation of the appropriateness of a household energy technology. For example, these might include air quality, feasibility, income generation, Disability-adjusted life years (DALYs), efficiency, and capital and operation costs (Johnson et al., 2009; García-Frapolli et al., 2010; Vitali et al., 2013; Harijan and Uquaili, 2013; Bruce et al., 2013). These indicators have differing levels of significance and influence, which can make modelling a challenge. Moreover, the ease of gathering the data largely depends on the level of the evaluation to be done (i.e. from global and national, to local, down to household level), and the material barriers posed by the project/action being assessed (e.g. the time and financial resources available, availability and reliability of historical local data, support and collaboration of local authorities and institutions, and the active participation of the local