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# The influence of an improved firewood cookstove, *Chitetzo mbaula*, on tree species preference in Malawi

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ABSTRACT

With fuelwood arguably being the most important product from local forests for rural people in developing regions, its scarcity is an issue of very real importance. One strategy to simultaneously alleviate pressures on forest resources and increase the sustainability of its use has been the promotion of improved cook stoves (ICS). While ICS have been promoted as a means to reduce indoor air pollution and improve health in rural areas, or to reduce demand for fuelwood as a means of halting forest degradation, there is a dearth of research that links the influences of ICS on preferences for firewood species. From a sustainable forest management perspective, this is an important area of inquiry. The purpose of this study was to illuminate the potential impacts of an ICS on firewood use and tree species preference in several Malawian study sites. From a sustainable forest management perspective, the results are intriguing. The introduction of an ICS – in this case, the *Chitetzo mbaula* earthen clay cookstove – in several villages in two southern Malawian districts/study sites appears to translate to a greater preference for slow-growing indigenous firewood species (e.g., *Brachystegia* spp.) over fast-growing exotic alternatives (e.g., *Eucalyptus* spp., *Mangifera indica*). A reasonable application of these results would be to assist rural people to plant a variety of firewood (and ideally multi-purpose) trees that offered a phased succession whereby faster-growing exotics would still be required and planted in the near term with a transition to slower-growing indigenous trees over the longer term.



## Introduction

A quiet revolution may be brewing in the forests of developing countries, one in which the adoption of new technologies may inadvertently be encouraging a return to indigenous tree species. In this paper, we discuss this phenomenon in the context of influences that improved firewood cookstoves are having on Malawian people's preferences for firewood tree species.

Biomass energy is produced using materials of tree origin, and includes wood fuel, charcoal, twigs and leaves (Alam and Chowdhury, 2010). Biomass energy consumption in developing regions throughout Africa, Asia and Latin America is typically high, with 80% of the wood harvested in developing countries (90% of the wood harvested in Africa) used for fuelwood (Maes and Verbist, 2012), primarily for cooking (Brinkmann, 2008). Broadly, wood energy accounts for 27% of total primary energy supply in Africa, 13% in Latin America and the Caribbean and 5% in Asia and Oceania (UN FAO (Food and Agriculture Organization of the United Nations), 2014). In spite of these high volumes, the study of traditional biomass has received little attention in the current biomass debate because it is considered as primitive and unsustainable (Maes and Verbist, 2012).

In Sub Saharan Africa, energy from fuelwood or firewood is essential to sustain livelihoods (Dresen et al., 2014). Yet, it is becoming increasingly scarce in many areas due to forest degradation and deforestation stemming from industrial, agricultural and private overuse of wood (Brinkmann, 2008). Environmental degradation has disproportionate impacts on the poor, who often rely on the natural resources in their immediate surroundings for their day-to-day subsistence and livelihoods (Rehfuess et al., 2006). With fuelwood arguably being the most important product from local forests for rural people in developing regions, its scarcity is an issue of very real importance (Cooke et al., 2008). Thus, increasing the sustainability of traditional biomass use – and firewood in particular – should be a top priority for addressing the energy needs of the poorest of the poor, those who are excluded from the use of alternative energy sources such as gas or electricity. This is a particularly salient issue in Sub Saharan Africa as alternatives to fuelwood as cooking fuel are generally expensive and not readily available (Dresen et al., 2014).

One strategy to simultaneously alleviate pressures on forest resources and increase the sustainability of its use is the promotion of improved cook stoves (ICS). ICS can conserve fuelwood and forests, while also removing smoke from the kitchen, reducing drudgery associated

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with firewood collection for women, and improving the health of all household members, most especially around respiratory and eye diseases for women and children who tend to spend the most time cooking (Alam et al., 2006). These characteristics are important as indoor air pollution, inefficient energy practices and unsustainable fuelwood harvesting have been recognized as obstacles to the achievement of the Millennium Development Goals (Garcia-Frapolli et al., 2010; Rehfuess, 2006).

However, while some promote ICS as a means to reduce indoor air pollution and improve health in rural areas [see, for example, (Alam and Chowdhury, 2010; Alam et al., 2006; Bailis et al., 2009; Garcia-Frapolli et al., 2010; Rehfuess, 2006)], and others promote ICS to reduce demand for fuelwood as a means of halting forest degradation [see, for example, (Cooke et al., 2008; Garcia-Frapolli et al., 2010; Amacher et al., 2004)], there is a dearth of research that links the influence of ICS on household preferences for firewood species. This is in spite of the promotion of ICS across the globe. While Alam et al. (2006) found that certain types of fuel worked better in the cookstoves in their study, they did not provide insight into how the stoves may have changed users' preferences for fuel types, in general, and firewood species, in particular. Likewise, Alam and Chowdhury (2010) noted that people used different types of fuels and had preferences for wood over branches, leaves and cow dung, but provided no analysis of how preferences for firewood tree species came to be. Finally, while important firewood characteristics of preferred tree species for rural people in Uganda and Malawi have been investigated (Abbot et al., 1997; Abbot and Lowore, 1999; Tabuti et al., 2003), these studies did not incorporate the use of any ICS.

From a sustainable forest management perspective, this is an important area of inquiry. Expectations are that biomass energy will, of necessity, remain the most widely used fuel in the near- to medium-term, with alternative energy sources, such as gas or electricity, not reaching low-income, rural populations widely as they are neither available nor affordable (Brinkmann, 2008). The global promotion of wood-burning ICS shows no signs of slowing down, and we should expect that their use would continue to influence local preferences for firewood species. Therefore, any role that ICS have in influencing preferences for firewood species needs to be better understood as these preferences will not only have household-level economic and social repercussions, but potentially large-scale ecological implications, as well.

This paper aims to address this knowledge gap by illuminating the potential impacts of an ICS on firewood use and species preference in several Malawian study sites. The purpose of the study presented in this paper was to characterize how the uptake of an ICS, namely the *Chitetzo mbaula* stove, by rural case study households affected their overall use of firewood, willingness to plant firewood trees on homesteads, and most especially their use of, and preference for, specific firewood species.

## Methods

### *Selection of case study sites*

Malawi is an ideal case study country for this investigation given its predominantly rural population, high poverty rates, and high dependence on biomass fuels, particularly firewood. With a population of over 10 million people and a land area of 94,000 km$^2$, Malawi is one of the most densely populated countries in Sub-Saharan Africa, and is also one of the world's poorest, ranking 160th (23rd from last) on the Human Development Index (HDI) (UNDP, 2009). Approximately 90% of Malawi's population lives in rural areas, and depends largely on small-scale farming for their livelihoods and on traditional fuels for cooking and heat (UNDP (United Nations Development Programme), 2009). The main sources of fuelwood in Malawi are forest reserves, customary forests and plantation forests (Jumbe and Angelsen, 2011). Miombo woodlands, characterized by species of *Brachystegia*, *Julbernadia* and *Isoberlinia*, account for approximately 70% of Malawi's total indigenous forest area and 97% of all forest species (Government of Malawi, 1996). These woodlands are generally used for grazing and as sources of wood and non-wood forest products, while also providing cultural, social and other forest services (Kayambazinthu et al., 2003).

Malawi also has one of the highest annual deforestation rates in Africa and biomass fuels comprise over 90% of the country's total energy demand (Brinkmann, 2008). The most commonly used biomass fuels in the country are firewood (used by 97% of the households in rural areas), tree waste, charcoal, as well as agricultural residues and animal dung (Malinski, 2008). This high dependence on firewood and charcoal for energy, combined with a high population density and extreme poverty can potentially have negative impacts on the environment and on its inhabitants (Malinski, 2008). Previous research in this domain has demonstrated that rural Malawian households perceived the availability of firewood to have decreased, leading them to pursue riskier livelihood coping strategies such as eating less foods or no foods that require cooking (Timko, 2013a, 2013b). With fuelwood being the primary source of energy for heating and cooking (Malakini et al., 2013), and the use of ICS not yet becoming widespread, Malawi is well positioned for a study of the impacts of ICS on firewood species preference and use.

Study sites in two southern Malawian districts were included in this study: Zomba (Domasi) and Chiladzulu (Milepa) (main rural town names appear in brackets). Respondents came from various villages surrounding the rural towns, specifically eight villages in Zomba and 11 in Chiladzulu. The people in Zomba tend to rely on woodlands located on public lands and protected by the government, also called protected forest reserves, while people in Chiladzulu tend to rely on village forest areas (VFAs) for forest resources.

As part of the study, the participants attended a two-day stove-making workshop near their villages and in close proximity to a suitable clay source (for making the stoves). At this workshop they constructed their own improved firewood cookstove, known locally as the *Chitetzo mbaula* ('the protecting stove'; herein referred to as the *Chitetzo* stove) in Chichewa (Orr et al., 2013) (Fig. 1). The *Chitetzo* stove is a fired, portable clay stove suitable for rural households. It that has been found to reduce fuelwood consumption by 43% compared to the three-stone fireplace per kilogram of food (Malakini et al., 2013). The *Chitetzo* stove was chosen for this study as it can be made locally and, therefore, has potential to catalyze small-business enterprises should someone choose to produce them. Additionally, the stoves are ideally suited for impoverished people as it would be virtually free for participants – once they have the knowledge – to remake them should they break.

### *Structured interviews*

The data for this study were obtained from 78 *ex ante* and 72 *ex post* questionnaires administered at the household level. The difference in sample sizes is a result of respondents dying or moving away between the *ex ante* and *ex post* portions of the study. The *ex ante* questionnaires were administered in November 2012, after which all the respondents attended a workshop in mid-December 2012 to make their own one-pot portable *Chitetzo* stove. The stoves were cured for about 1 month, and were ready for use by late January 2013. The *ex post* questionnaires were administered more than 1 year later, in February 2014.

The questionnaires were administered in Chichewa by a Malawian research assistant and at a time and location deemed safe and convenient to the respondents. Structured questionnaires that consisted of both closed and open-ended questions [adapted from 20], were used to collect the data. The *ex ante* questionnaire comprised five sections: personal information; household stove use; cooking information; firewood information; and expectations for new stoves. The *ex post* questionnaire collected data in three sections: household stove use and cooking information; firewood information regarding *Chitetzo* stove; and impacts of the stove. It must be noted that not all respondents answered each question, and therefore, the number of responses for each question is given in the "Results" section.

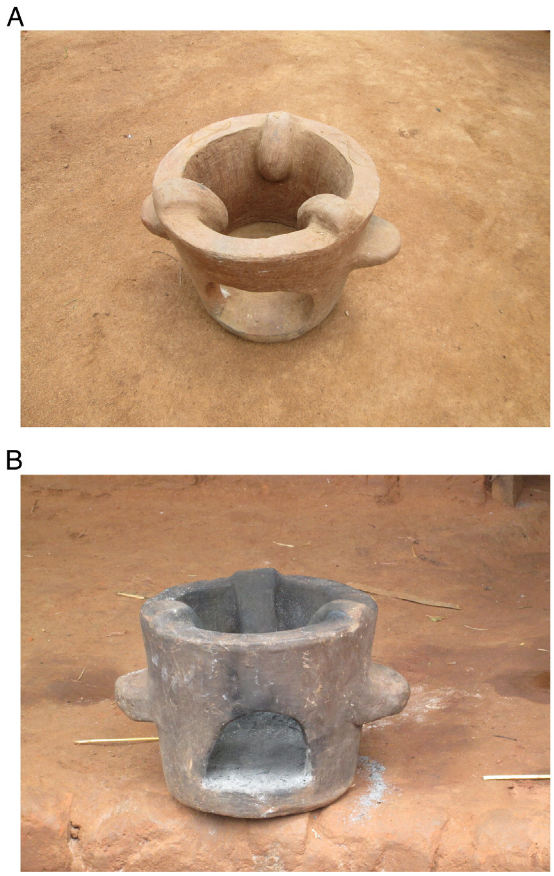



**Fig. 1.** Image of *Chitetzo mbaula* stove constructed by a local Malawian respondent for the purposes of this study.

*Data analysis*

Both closed and open-ended responses were recorded directly onto the interview forms by the research assistant. These were later transcribed into Microsoft Excel spreadsheets for each site, and then collated into one master spreadsheet. All questionnaire data were summarized using descriptive statistics. The data analysis software, NVIVO 8, was used to store the qualitative responses to the open-ended questions to enable qualitative thematic content analysis (Creswell, 2003) and coding according to the main emergent themes. More nuanced sub-codes within each theme enabled us to assess the interview data at a finer resolution. For example, the respondents were asked why their household's use of firewood had increased or decreased. Sub codes for their responses included: household size reduced; household size increased; older/less energy to collect firewood; firewood harder to find; etc. Most of the data are presented using simple descriptive statistics, except where the respondents were asked to rank each firewood tree species according to three important characteristics: easy to find, burns longer/hotter, and produces less smoke. Here, we used arbitrary evaluation points to analyze these data by ascribing '3' to the most important and '1' to the least important characteristic. We then took an average for each of the three important characteristics to get a sense of their overall importance, with the higher overall values indicating a higher importance (although not having a true statistical meaning).

## Results

*Firewood availability and use*

All (100% of $n = 78$) of the respondents perceived the availability of firewood in their region to have decreased over the previous 5 years. To cope with this scarcity, people are planting trees on their homesteads, field boundaries and in common lands, leaving trees standing to regenerate and using substitute fuels such as plastic or agricultural residues. Regarding firewood use, 59% ($n = 78$) of the *ex ante* respondents reported that their household's use of firewood had decreased in the previous 5 years (Fig. 2). The most common reason given was that firewood has become increasingly difficult to find due to deforestation and forest degradation. The second most mentioned reason was that the household size had been reduced due either to death, divorce or grown children leaving home. Approximately 29% ($n = 78$) of the respondents did note that their household's use of firewood had increased in the previous 5 years, the most common reason cited being that children were growing up, and hence, more food needed to be cooked to meet their appetites. The remainder of the respondents noted no change in their household's use of firewood. In the *ex post* analysis 1 year after the stove's introduction, 89% ($n = 71$) of the respondents commented that their household's use of firewood had decreased (Fig. 3), alluding to the fuelwood savings offered by the ICS.

The manner in which people acquired firewood did not significantly change between the *ex ante* and *ex post* interviews. *Ex ante*, 88% ($n = 69$) of the respondents collected firewood, while 9% both collected and bought firewood (data not shown). *Ex post*, 83% ($n = 70$) of the respondents collected firewood, while 16% both collected and bought firewood (data not shown). While the respondents' own farmlands were the main sources of firewood before and after the introduction of the stoves, there was an increase in the number of respondents seeking firewood from public forests and open lands after the introduction of the stoves (Fig. 4). Only a very few respondents reported collecting firewood from private woodlots.

*Three-stone fireplace and Chitetzo stove use*

While all of the respondents used the three-stone fireplace daily prior to the study commencing, this number decreased after the introduction of the *Chitetzo* stoves as the respondents reported using these stoves in place of the three-stone fireplaces (data not shown). At the time of the *ex post* interviews, most of the respondents had been using their stoves for 7–12 months. The average length of time per day that the participants kept a fire lit increased slightly from 4.03 h in the three-stone fireplaces to 4.89 h in the *Chitetzo* (data not shown).

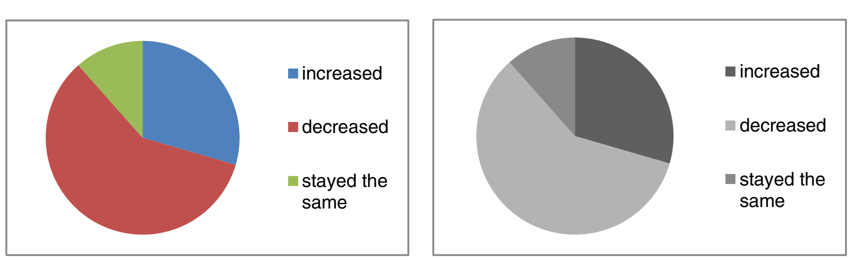



**Fig. 2.** Proportions of the *ex ante* respondents indicating whether household firewood use had increased, decreased or stayed the same in their household for the 5 years prior to the introduction of the *Chitetzo* stove ($n = 78$).

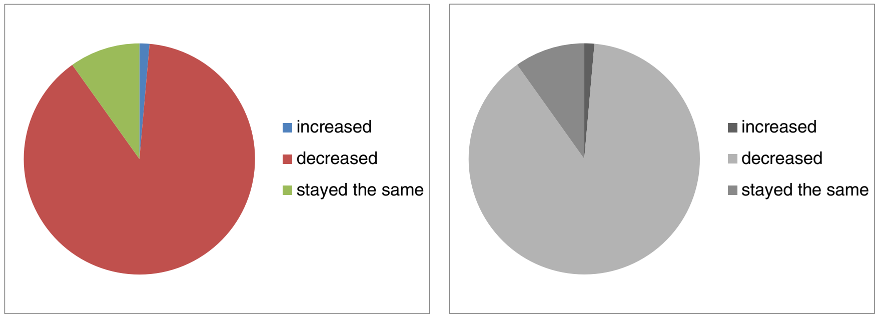



**Fig. 3.** Proportions of the *ex post* respondents indicating whether household firewood use had increased, decreased or stayed the same after introduction of *Chitetzo* stoves ($n = 71$).

However, the frequency in which the three-stone fireplaces were used changed dramatically after the introduction of the *Chitetzo* stoves (Fig. 5). *Ex ante*, most of the respondents ($n = 78$) used their three-stone fireplaces every day. *Ex post*, fewer, though still most, of the respondents (n = 71) almost entirely stopped using the three-stone fireplaces and appear to have substituted their use with the *Chitetzo*.

Likewise, the *Chitetzo* stove appears to have virtually replaced the use of the three-stone fireplace to cook food, boil water and heat the respondents' homes (Fig. 6). After the *Chitetzo* was introduced, some respondents reported that they did still use the 3-stone fireplace in tandem with the *Chitetzo* for these same purposes.

### *Willingness to plant firewood trees*

It is common practice for people in Malawi to have planted trees on their homesteads or farmlands as they try to maximize land use for fruit production, shade, shelter and wind breaks. For the most part, these trees eventually become sources of firewood. In most cases, the trees are not completely felled down for firewood but branches may be pruned, thinning may be done where there is more than one stem, and shoots pollarded for firewood use. Even with these efforts though, it is often difficult to produce enough firewood to meet a household's needs, hence these households are also affected by the fuelwood shortage.

Nearly all (96% of $n = 78$) of the respondents expressed an interest in planting firewood species on their lands, and 97% ($n = 70$) had considered planting firewood trees on their homesteads after the introduction of the *Chitetzo* stove as a means of providing wood for the stove (data not shown). The few respondents not interested in planting trees noted that their land was too small to plant trees; one respondent also commented that they were too old for energy demanding activities such as planting and managing trees.

The respondents were asked which firewood species they would most prefer to plant. In both the *ex ante* and *ex post* interviews, two fast-growing exotic trees, *Eucalyptus* spp. and *Senna siamea*, were the most preferred tree species. However, in the *ex ante* interviews,

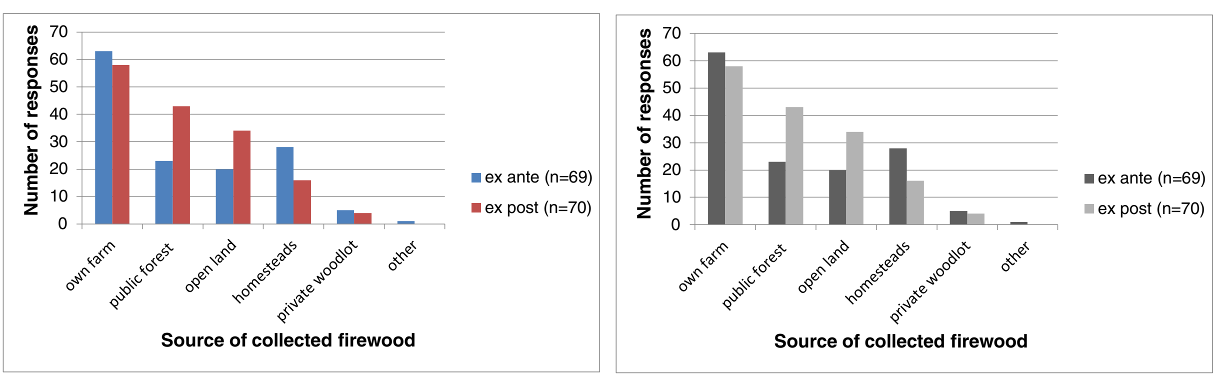



**Fig. 4.** Main sources of collected firewood.

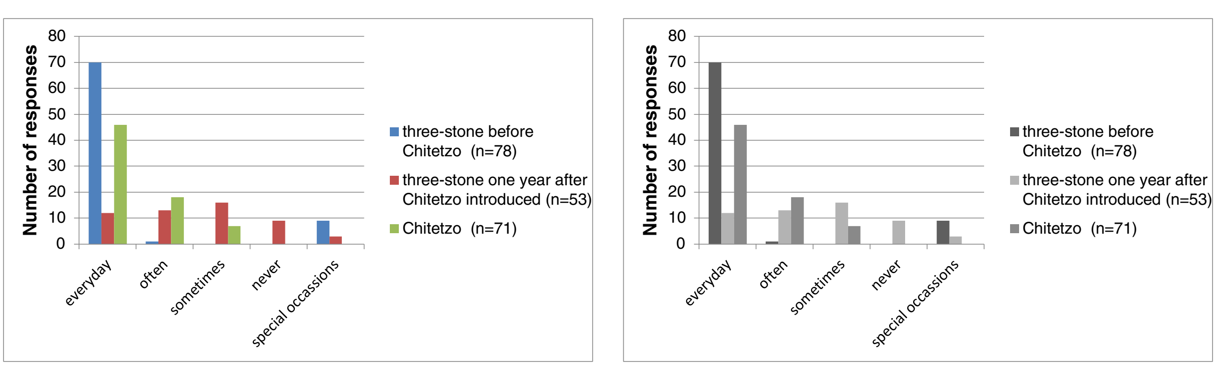
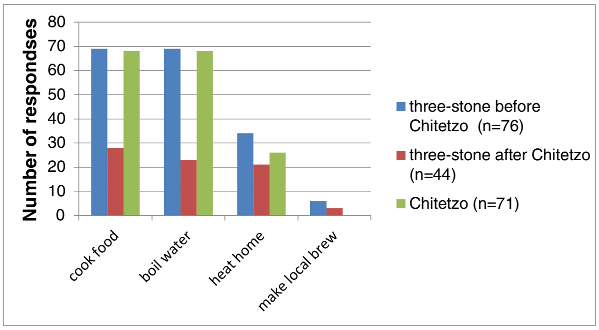



**Fig. 5.** Respondents' frequency of use of the *Chitetzo* stove and three-stone fireplace (before and after introduction of *Chitetzo* stove).



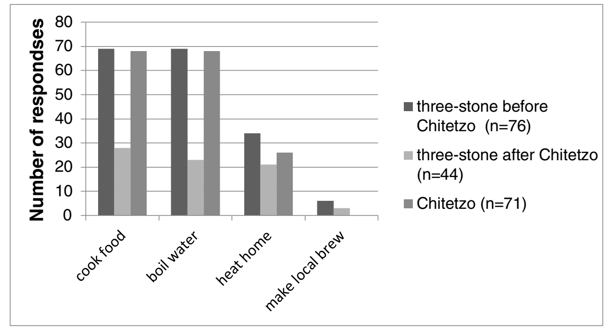




**Fig. 6.** Reasons for using the *Chitetzo* stove and three-stone fireplace (before and after introduction of *Chitetzo* stoves).

*Mangifera indica*, *Melia azedarach*, *Toona ciliata*, *Khaya anthoteca*, and *Azadirachta indica* were also listed as preferred. In the *ex post* interviews, *T. ciliata* and *M. azedarach* were preferred in addition to the two fast-growing exotics. Notably, these are all multi-purpose trees which contribute other services in addition to firewood, such as shade, fruit, construction materials or medicine.

*Use of and preference for firewood species*

While *Eucalyptus* spp. and *S. siamea* were the firewood species that the respondents preferred to plant, these differed from the firewood species that the respondents most preferred to use and the species that they actually used the most. In the *ex ante* interviews, the respondents reported that the firewood tree species that they most preferred to use was *Brachystegia* spp., a slow-growing, multi-purpose, indigenous tree common in Miombo woodlands (Fig. 7). Other species (in order of preference) included *Eucalyptus* spp., *M. indica*, *Bauhinia thonningii*, and *M. azedarach*. The species actually used the most however, was *Eucalyptus* spp., followed by *M. indica*, *M. azedarach*, and *Brachystegia* spp. (Fig. 8).

In the *ex post* interviews, the respondents were asked to comment on the firewood species that work best in the *Chitetzo* stoves. *Brachystegia* spp. was perceived to work better than other fuels in the stoves, followed by *Eucalyptus* spp. and *M. azedarach* (Fig. 9). The respondents were then asked what species they actually used the most in their stoves. *Eucalyptus* spp. was used the most, followed by *M. indica*, *Brachystegia* spp., *M. azedarach* and *S. siamea* (Fig. 10).

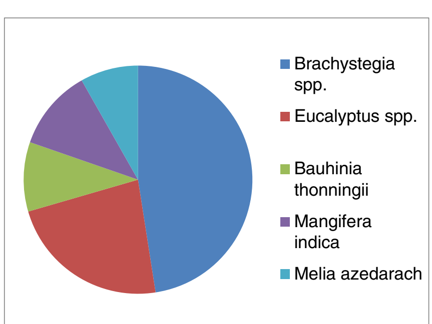
The respondents were asked to prioritize several key characteristics related to their preferences expressed above (Table 1). *Brachystegia* spp. is the species that most of the respondents prefer to use (Fig. 7) and is perceived to be the species that works best in their stoves (Fig. 9) because it burns longer and hotter than the other firewood species, while producing less smoke (Table 1). However, it is scarcer than the other less preferred species of firewood (Table 1) and, therefore, not used frequently (Fig. 10). For all but *Brachystegia* app., the fact that the trees are readily available and easy to find appears to be the most important characteristic impacting species preferences. For instance, while *Eucalyptus* spp., *M. indica*, and *M. azedarach* were each less preferred than *Brachystegia* spp., they were considered readily available (Table 1).

## Discussion and conclusions

The purpose of this study was to characterize how the uptake of an ICS, namely the *Chitetzo mbaula* stove, by case study households in two rural districts of Malawi affected households' overall use of firewood, willingness to plant firewood trees on homesteads, and most especially their use of, and preference for, specific firewood species. The results are intriguing and, from a sustainable forest management perspective, their implications for renewing local interest in establishing and maintaining indigenous tree species, at least in Malawi, could be profound.

Nearly all of the study participants expressed an interest in planting firewood species on their land; actively growing trees for firewood is one way for households to cope with increasing firewood scarcity (Cooke et al., 2008). Indeed, the vast majority of the respondents considered planting firewood trees on their homesteads after the introduction of the stove as a means to provide wood for the stove. However, this is where it gets interesting. The species that the respondents most preferred to plant are not the tree species they most preferred to use or the species that they actually used the most. In general, the respondents are understandably concerned about the near-term provisioning of firewood, hence favoring the faster-growing exotics. In both *ex ante* and *ex post* interviews, *Eucalyptus* spp. and *S. siamea* – both fast-growing exotics – were the tree species that respondents preferred to plant.

However, the tree species that respondents most preferred to use was *Brachystegia* spp., a slow-growing, multi-purpose, indigenous tree common in Miombo woodlands. Its uses include apiculture, nitrogen fixation, firewood, charcoal, fiber (rope), fodder and medicines (Hines and Eckman, n.d.; ICRAF (The World Agroforestry Centre), n.d.). The tree is prized as a good source of firewood and charcoal, and the respondents note that it works best in the stoves as it burns longer and hotter



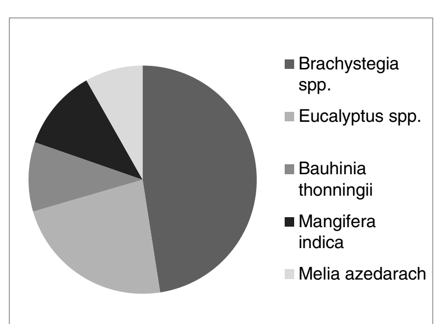




**Fig. 7.** Proportions of firewood tree species most preferred to use before the introduction of the *Chitetzo* stove ($n = 78$).

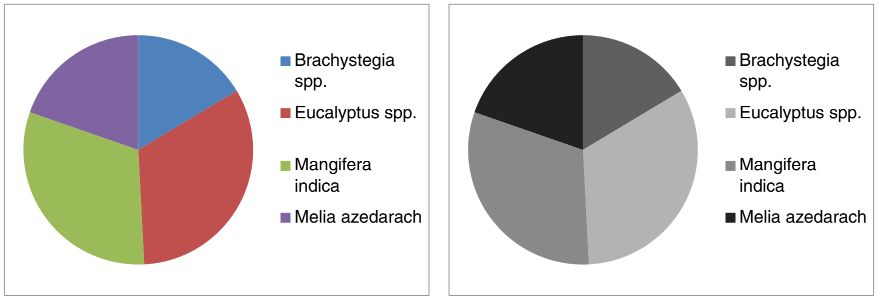



**Fig. 8.** Proportions of firewood tree species actually used the most before the introduction of the *Chitetzo* stove ($n = 78$).

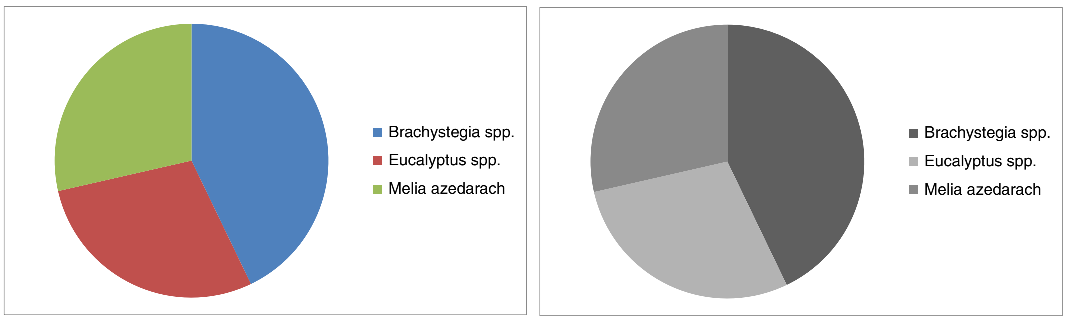



**Fig. 9.** Proportions of firewood tree species that work best in the *Chitetzo* stove ($n = 71$).

than other firewood species. Unfortunately, due to its desirability, it is more difficult to find than other, less preferred species of firewood. One finding of this study is that the most important characteristic impacting species preferences is often simply that they are readily available and easy to find (Table 1). It is interesting to note that *Brachystegia* spp. was not the most preferred firewood species over 15 years ago (Abbot and Lowore, 1999). *Julbernardia paniculata* was, followed by several species of *Combretum*, an *Acacia* spp. and *Pericopsis angolensis*. Yet these other species were hardly mentioned in our study. This is possibly because they are extremely scarce, and could be indicative of the extent of forest degradation that has occurred over the 15+ years since the study was conducted. While less preferred, *Eucalyptus* spp., *M. indica* and *M. azedarach* were considered more readily available (Table 1).

Before discussing the implications of these findings for sustainable forest management in the case region, and potentially beyond, it is important to acknowledge the two main limitations to this study. First, using a case study approach with a limited number of households ($n = 78$ *ex ante* and 72 *ex post* respondents) means that the external validity of these results cannot be assumed. These results could differ for people in other regions of Malawi, not to mention across countries and using different ICS. A larger sample size or more study sites across the country could increase the external validity of this research and is recommended for further studies in this domain.

Second, the use of the structured interview questions, while providing a degree of flexibility, did not, in some instances, probe deeply enough to enable a better understanding of the context within which the desired activity was occurring. Not surprisingly, the frequency with which the three-stone fireplaces were used changed dramatically after the introduction of the *Chitetzo* stoves, appearing as though the respondents may have simply replaced the former with the latter (Fig. 5). However, the data also demonstrate that the average length of time per day that the respondents kept a fire lit increased slightly from 4.03 h in the three-stone fireplaces to 4.89 h in the *Chitetzo*. Unfortunately, the survey instrument did not measure the amount (e.g., weight of the wood; number of sticks of split firewood) that was actually being used in this timeframe or the number of tasks being undertaken with this firewood. It is entirely plausible that the amount of firewood used in the more-efficient *Chitetzo* was less than that being used in the less-efficient three-stone fireplace, thus burning more efficiently and enabling stove users to burn a fire for longer and hence accomplish more tasks with less wood. Perhaps the respondents are able to cook more food than they were previously, or are able to cook more nutritious, calorically-dense foods (such as cassava) that require longer cooking times. This is particularly pertinent to HIV/AIDS-affected households as one of the common coping strategies that they use to deal with a decreased availability of firewood is to eat less food or eat foods that do not

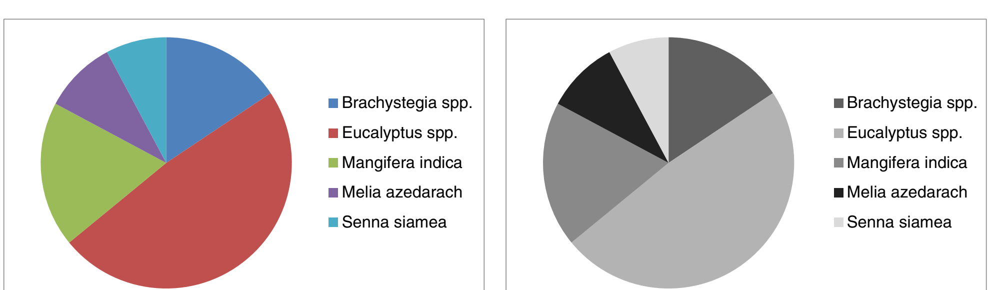



**Fig. 10.** Proportions of firewood tree species actually used the most in the *Chitetzo* stove ($n = 71$).

**Table 1**
Means of evaluation points describing the most important characteristics of the firewood species most used in the *Chitetzo* stoves (higher mean values represent more important characteristics up to a value of 3;refer to the text for a description of evaluation points).

| Species | | | Number of respondents | Evaluation points for firewood characteristics | | |
|---|---|---|---|---|---|---|
| | | | | Easy to find | Burns hotter/longer | Produces less smoke |
| *Eucalyptus* spp. | Ex ante | Most preferred | 14 | 2.79 | 1.71 | 1.5 |
| | | Most used | 20 | 3 | 1.6 | 1.4 |
| | Ex post | Works best in stove | 12 | 2.92 | 2.17 | 1.08 |
| | | Most used in stove | 31 | 2.97 | 2.03 | 1 |
| *Mangifera indica* | Ex ante | Most preferred | 6 | 2.17 | 2.83 | 1 |
| | | Most used | 20 | 2.9 | 2.1 | 1 |
| | Ex post | Works best in stove | 1 | 1 | 3 | 2 |
| | | Most used in stove | 12 | 3 | 2 | 1 |
| *Melia azedarach* | Ex ante | Most preferred | 5 | 3 | 2 | 1 |
| | | Most used | 11 | 2.8 | 2 | 1.2 |
| | Ex post | Works best in stove | 13 | 2.08 | 2.85 | 1.08 |
| | | Most used in stove | 6 | 2.67 | 2.33 | 1 |
| *Brachystegia* spp. | Ex ante | Most preferred | 28 | 1.21 | 2.96 | 1.82 |
| | | Most used | 10 | 2 | 2.7 | 1.3 |
| | Ex post | Works best in stove | 17 | 1.18 | 2.88 | 1.94 |
| | | Most used in stove | 10 | 1.4 | 2.7 | 1.5 |

require cooking (Timko, 2013b). Likewise, the surveys did not elucidate exactly which species are being gathered from which sources. With an increasing number of respondents seeking firewood from public forests and open lands after the introduction of the stoves, it would have been helpful to know if this was due to their preference for the slower-growing, indigenous *Brachystegia* spp.

Based on the results presented, the introduction of an ICS – in this case, the *Chitetzo mbaula* – in several villages in two southern Malawian districts/study sites appears to translate to a greater preference for slow-growing indigenous firewood species over fast-growing exotic alternatives. In this case, *Brachystegia* spp. is preferred over *Eucalyptus* spp., *M. indica* and *M. azedarach*. A reasonable application of these results would be to assist rural people to plant a variety of firewood (and ideally multi-purpose) trees that offered a phased succession. The faster-growing exotics would still be required in the near term (i.e., 3–8 years). However, if slower-growing indigenous trees were planted with exotics concurrently, a transition phase would enable local people to switch from using the faster-growing exotics to the slower-growing indigenous trees. In the case of *Brachystegia* spp., the rotation is admittedly very long at 15 years. However, several faster-growing indigenous species are also being used by the respondents in their stoves. These could be planted to bridge the gap between the maturation of fast-growing exotics and slow-growing indigenous species. In the case study regions, these include several species of *Acacia*, as well as *Uapaca kirkiana*.

Decisions regarding this type of long-term project would require the involvement of both local users as well as foresters and agroforesters since tree selection is both situated within the large contexts of household-level economic and social impacts, and would be expected to have both localized and potentially larger-scale ecological implications. Adapting local agroforestry systems to increase firewood production may make the most sense (Maes and Verbist, 2012). With organization such as The Global Alliance for Clean Cookstoves calling for 100 million homes to adopt clean and efficient stoves and fuels by 2020 (Global Alliance for Clean Cookstoves, n.d.), there is every reason to believe that the global promotion of wood-burning ICS will continue to influence preferences regarding local firewood tree species. Every effort should be made to understand these predilections and how we can utilize this information to help drive sustainable forest management. For the poorest of the poor in forest-dependent communities around the world, such as those living in the rural regions of southern Malawi, a holistic attempt to meet long-term firewood needs with the best species suited to ICS offers a genuine and tractable prospect at alleviating some of the hardship in their daily lives.

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