Rural Malawi

AMS IIG

Baseline Firewood Consumption Study

For C Quest Capital LLC

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- CONFIDENTIAL -

FINAL

11 December 2012

HED|Consulting

Household energy & development

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Contents

Acronyms

CI	Confidence interval
CQC	C Quest Capital LLC
HED	HED Consulting
HH	Household
SD	Standard Deviation
SE	Standard Error
PPS	Probability proportional to size

Exchange rate (approximate at time of report)

1 USD=253.9 MWK

Interpreting the statistical tables in this report

Mean values are presented in tables alongside Standard Deviation (in [square brackets]); standard errors; 90 and 95% confidence intervals (CI); and margin of errors (10 and 5% of the means).

The relationship between the CI and margin of errors are used to indicate the precision of the data as follows:

- Precision '90/10' requires the 90% CI to be ≤ 10% margin of error.
- Precision '95/5' requires the 95% CI to be ≤ 5% margin of error.
- Precision '95/10' requires the 95% CI to be ≤ 10% margin of error.

Document development record

Date	Content	
30 May 2012	Initial analysis of Malawi data completed and submitted to CQC	KJ
31 May 2012	Deeper analysis, including space heating and source of firewood weighed Preparation of final draft report	JR and KJ
1st June 2012	Submission to CQC, containing Malawi data only.	KJ
6th June 2012	Response to CQC and CQC comments	KJ JR
14 June 2012	Draft V5 - Addition of explanation of treatment of contradictory responses	
22nd June	Final version with outcome of data quality checks added	KJ
28th November	Revisions made and revised Final Report submitted following comments from CQC.	KJ JR

December 11th	Further revision made and submission of Final	KJ JR

1 Executive summary

This report provides a summary of the results from the baseline study of rural firewood consumption in Malawi, carried out during May 2012. The aims of the survey were to:

- estimate the average amount of firewood used per existing stove per day (kg/stove/day) in rural households (HH);
- account for seasonal variation and multiple stove use;
- investigate the differences in firewood consumption between different locations (i.e. the degree of homogeneity); and
- investigate other factors to validate findings and inform successful implementation.

The results of this study are applicable to AMS IIG projects. The study is further to a request from C Quest Capital LLC.

Methodology

This report describes the sampling methodology; presents the questionnaire and other methods for household fuel consumption measurement; and outlines analysis of the dataset including QA, data cleaning, assessing variability, and determining the precision of the key outcomes. The annexes present the survey tool used, as well as further detail on some of the key calculations.

The sampling strategy was designed in such a way as to be representative of any different firewood supply, consumption and economic aspects within the proposed area of dissemination of stoves (all of rural Malawi). A literature review and consultation with local partners CAPS Msukwa and Amulike Msukwa suggests that rural per capita wood consumption decreases from north to south (GoM, 2009 p31) in line with wood scarcity[1]. While consumption is similar in the Northern and Central Regions where wood supply is adequate, consumption decreases in the Southern region where wood is relatively scarce. Based on this, the baseline area was considered in two clusters as follows:

i) Northern and Central regions of Malawi where per capita fuel consumption is similar.

ii) Southern region of Malawi, where wood is relatively scarce and per capita wood use is lower.

Rural study samples were identified from each cluster. No locations within the project area have been excluded from the sampling frame.

Results

After cleaning and removal of outliers the unadjusted baseline firewood consumption was estimated at **8.12 kg/per household/per day**. Two adjustments were made to the daily household fuel consumption estimates: the first to account for reported seasonal variation in firewood consumption (resulting in an increase of 1.22kg to the baseline); the second to account for the simultaneous use of multiple stoves (resulting in a decrease of 0.42 kg to the baseline data adjusted for seasonal trends).

[1] Information taken from http://www.ecologyandsociety.org/vol13/iss2/art24/figure3.html

Other methodological issues were investigated including the prevalence of space heating with the firewood stove but no further adjustments were considered necessary to the data set.

Analysis of the data from all locations concludes that there is no statistically significant difference between them in terms of mean household firewood consumption, so they may be considered as a single homogeneous cluster. The mean baseline firewood consumption for the combined clusters is **8.92 kg/per stove/per day.**

The data for these calculations meets the precision requirements of the AMS IIG methodology (90/10) including for homogenous Programme of Activities (PoA) (95/10). The study and analysis were planned and executed to conform to the EB 65 Annex 2 and EB 69 Annex 4 and 5 guidance.

2 Methods

2.1 Roles

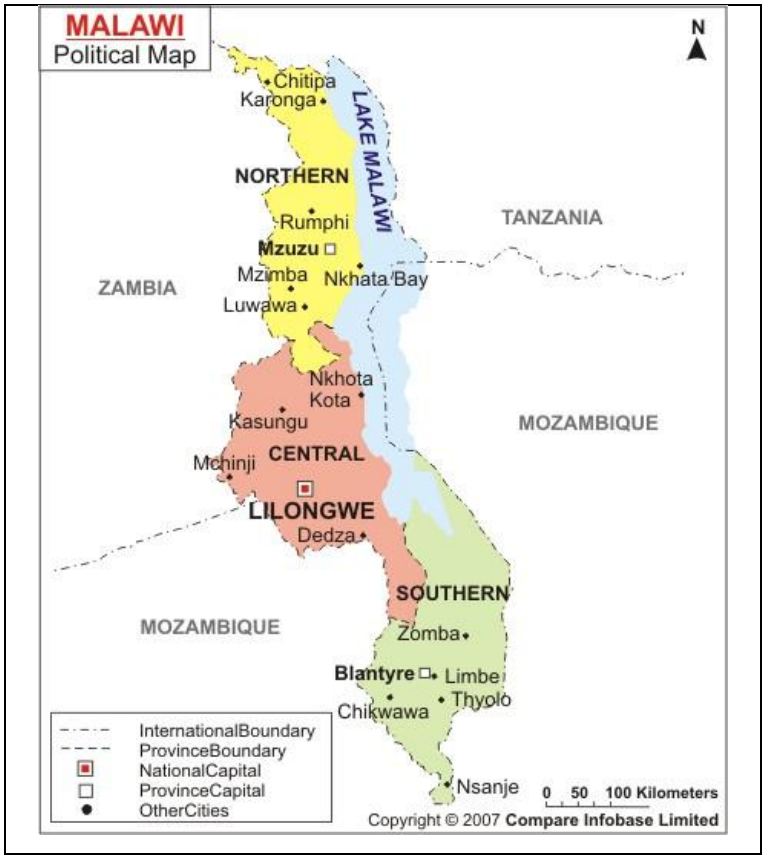
A HED Consulting (HED) team led the planning of this study. Aspects of the study design, such as questionnaire development, were carried out in collaboration with the team from DeTas in Malawi, who also trained and supervised the survey team in Malawi.

Analysis was undertaken using Excel and SPSS 16.0 by HED.

2.2 Sampling strategy

Malawi is divided into three administrative regions: Northern, Central and Southern. The following map[2] indicates the area described by this baseline study, which includes the southern region of Malawi shaded green, central (orange) and northern region (yellow).

Figure 1: Administrative regions of Malawi



The sample framework was designed to represent households from rural communities within these regions. Urban areas in Malawi are defined as per the United Nations Demographic Yearbook as "All townships and town planning areas and all district centres". In order to

[2] Malawi political map. http://www.mapsofworld.com/malawi/malawi-political-map.html

increase clarity, Rural rural communities are defined as areas outside of urban boundaries of towns, townships, district centers and cities of population greater than 4765 – the lowest population number found in the classification" cities, towns, villages" as per the website (http://www.citypopulation.de/Malawi.html (last visited on 14/12/2012). Rural areas are characterized by lack of infrastructure such as shops, hospitals, good roads. Therefore, only households residing in areas outside of the urban areas as described here will be considered rural households and therefore targeted and eligible for CERs under this SSC-PoA

There were no exclusions from the area defined by this baseline.

Defining likely clusters in the baseline area

Review of the literature suggests that rural per capita wood consumption decreases from north to south (GoM, 2009 p31) in line with wood scarcity[3]. While consumption is similar in the Northern and Central Regions where wood supply is adequate, consumption decreases in the Southern region where wood is relatively scarce. Although there is some variation in precipitation and poverty across Malawi, analysis of these factors concluded that they should not be used as a basis for clustering in Malawi. Annex 6.1 provides further information on the resources and references used for drawing these conclusions.

Based on this evidence two clusters within Malawi were identified as follows:

i) Northern and Central regions where per capita fuel consumption is similar, and

ii) Southern region, where wood is relatively scarce and per capita wood use is lower.

Sampling approach

The study sample was selected using probability proportional to size on the primary unit, i.e. districts. This entailed listing all districts by cluster, listing rural population data, and creating a cumulative population for each cluster. A random number generator was then used to select districts. This takes into account the size of the rural populations in each area, giving more populous areas a higher chance of being selected. The rural population data was taken from http://www.nso.malawi.net/index.php?option=com_content&view=article&id=106&Itemid=6T[4]

A constituency within the selected districts was then selected using simple random sampling.

Attempts were made to minimize the impact of bias associated with non-response. If the household cook was not available, an appointment was made for the following morning. If they were not available at that time, they were classed as unavailable. Any actual refusals to take part were also documented.

Northern/Central region

District selected: Kasungu (district 3 on the map below). Constituency: Kasungu West

Southern region

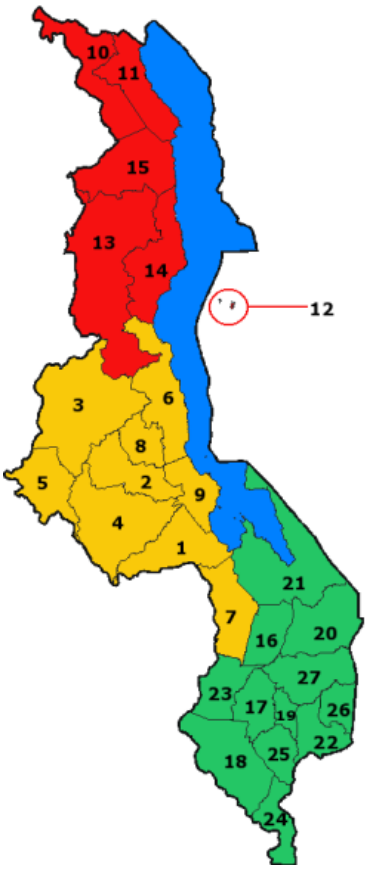
[3] Information taken from http://www.ecologyandsociety.org/vol13/iss2/art24/figure3.html

[4] This link subsequently broke and the data can now be found at: http://www.nsomalawi.mw/index.php?option=com_content&view=article&id=107%3A2008-population-and-housing-census-results&catid=8&Itemid=6

District selected: Thyolo (district 25 on the map below). Constituency: Thyolo East

These districts may be considered representative of their regions and, together, of all of rural Malawi as they have been randomly selected from two clusters each identified by literature review as relatively homogeneous in terms of firewood use and availability, and together representative of the entire country. Annex 6.1 provides further information on the resources and references used for drawing sampling conclusions.

Map showing districts



Each constituency selected contained multiple villages. To remove the potential for bias created by selecting only larger or smaller villages, local advice was taken to identify villages of different sizes within each of these rural communities (i.e. constituencies). No data on populations of villages was found, so this qualitative approach was deemed appropriate. The fieldworkers were requested to sample a minimum of 2 villages in each constituency, using the above approach, until the required sample had been met. In the Northern / Central Cluster 9 villages were visited; in the Southern cluster 8 villages were visited.

The district of Thyolo has a large number of tea and coffee estates, which provide household fuel for their employees. Provision of free easily accessed fuel could potentially increase the amount used per day. Following data collection, a check of locations of villages sampled was undertaken to establish whether any were located close to the estates and may therefore have been subject to free fuel. The villages included in this study were all located at least 4km from

the estates and no estate employees were knowingly interviewed. Therefore the sample should reflect fuel use in homes which procure their fuel using standard methods i.e. buying or procuring fuel themselves.

2.3 Methodological implications of household recruitment

To qualify for participation in this survey, households were asked 'Is most of your cooking done on a **traditional firewood stove?'** This identified households whose main fuel was firewood but did not exclude users of other stoves and fuels. 'Most cooking' is assumed to have been interpreted by households as 'more than half of cooking'.

Households were chosen at random within the villages selected (as per protocol outlined in Section 2.2) and, once it was established that the household met the inclusion criteria and were willing to participate, the survey was carried out. These protocols are available on request.

2.4 Sample size determination

Based on the variance seen using the same approach to measuring daily firewood fuel consumption in other Sub-Saharan African countries to meet the 90/10 precision, the target sample size was 80-90 HH for each cluster in order to give the required resolution to determine heterogeneity or homogeneity. Previous studies in other Sub-Saharan Africa countries, using the same approach to measure daily firewood fuel consumption, gave average variances of 40-45%.

Based on this variance the number of households required to meet the 90/10 precision requirements is approximately 60[5]. An additional 20 households were added as a contingency in case of missing or unusable data.

2.5 Questionnaire development

A questionnaire was developed to explore the many factors that can impact HH firewood use, including seasonal variation; uses of the stove other than for cooking; and use of more than one stove at the same time (see Annex 6.2 Final version of questionnaire).

The questionnaire was then piloted in the field, along with the data transcribing and reporting spreadsheet and process. After this, any aspects of the questionnaire that caused confusion and/or failed to collect the correct data were reviewed and edited.

2.6 Measurement of firewood

A screening questionnaire was designed to identify households that had sufficient fuel available to be able to show one full day's use. Households were asked 'How much firewood do you use in an average day? Please make a pile for me to weigh'.

2.7 Quality control

Local field staff received extensive training on how to administer the questionnaire and were given feedback on the pilot data to ensure that concise, complete data was collected. The team were then supervised daily by a trained field manager. The surveyors were given a field guide describing how to implement the survey and how to collect robust, accurate data.

The questionnaire was piloted as described in Section 2.5.

[5] n = [(90% Z score) * COV/.1)]^2 where z score for 90/10 prescison = 1.65

Double-entry of data was completed on a randomly selected 10% sample of transcripts. This was compared with the original dataset to identify the frequency and nature of data-entry error.

3 Analysis

3.1 Data checking

There was a minimal rate of refusal – <1% of the total sample – so this would not be expected to have introduced bias (for example, a significant proportion of a certain kind of household refusing to participate).

Examination of the double-entry data showed that there was 0.6% error in the key variables – i.e. firewood-weighing data. Therefore the data-entry process was deemed accurate.

Contradictory data

Data is analysed to identify contradictory data, for example between reported use of fuels in different sections of the questionnaire. In this dataset, a small number of minor discrepancies were identified between responses to question A1 ('Do you mostly use woodfuel on a traditional fire or stove for cooking in your home?') and section K (which investigates the amount of cooking done with other fuels at this time of year).

Of all households that reported wood as being their primary fuel in A1, in section K 42 households reported using crop residues for more than half of all cooking. However, because section K is asking specifically about this time of year, while question A1 is intended to reflect the year in general, more weight is given to the response in A1, and so these households are retained in the study population. Moreover, including households that report higher levels of usage of other fuels would tend to make the baseline estimation more conservative.

Seasonality data from Section S was also analysed alongside responses to question A1 and section K. The majority of households that reported currently using crop residues for more than half of all cooking in section K, also reported a seasonal pattern throughout the year that showed wood to be their primary cooking fuel. Only one household reported using mainly wood in A1, but then the seasonal fuel pattern suggested they used a wide range of fuels throughout the year, which may indicate that wood was not in fact their primary fuel. However, it is possible that the cook's response to A1 is still correct, as wood may indeed be used in *every season* but not as the primary fuel, meaning that *overall throughout the year* it is their most significant single fuel type. This household represents only around 0.5% of the dataset; removing it would have negligible impact on the dataset, and retaining it would tend to make the baseline estimate more conservative. Therefore the decision was taken to retain this HH in the dataset.

3.2 Unadjusted data from all sites

Data from 207 households was sent to HED Consulting. Northern/central regions: 104 households and Southern region: 103 households. 13 households were removed (8 from Northern/Central sample and 5 from Southern sample) as they were using non-traditional wood burning stoves.

3.3 Raw data nationally

The following table presents mean firewood consumption per household (HH) per day from the full raw dataset across all areas. This data has had no outliers removed, nor has it been adjusted in any way.

Table 3.1: National raw data for mean firewood use (kg /per HH/per day)

	National N=194
Mean [SD]	8.08 [2.99]
SE[6]	0.22
90% CI	0.36
95% CI	0.43
10% mean	0.81
5% mean	0.40

One household was removed from the dataset as their reported daily firewood consumption was deemed unreasonably low for daily domestic use (0.47kg) and therefore seen as not representative of this population.

Table 3.2: National raw data for mean firewood use: outliers removed (kg/ per HH/per day)

	National N=193
Mean [SD]	8.12 [2.95]
SE[7]	0.12
90% CI	0.20
95% CI	0.24
10% mean	0.81
5% mean	0.41

3.4 Accounting for seasonal changes in amount of firewood used

Purpose of step: to account for households using more or less firewood at different times of the year relative to current use.

Each participant was asked what she considered the current season to be and how long it lasted- as well we how long the 'other' seasons lasted. This information was then used to

[6] Standard Error (SE) this is the standard deviation of the sample mean and describes its accuracy as an estimate of the population mean. As sample size increases, the estimator is based on more information and becomes more accurate, so its standard error decreases.

calculate an adjusted daily firewood consumption that takes into account seasonal changes throughout the year (See Annex 6.4 for description of the calculation) (See table 3.3).

Table 3.3: National daily mean HH firewood consumption: adjusted for seasonal trends (kg /per HH/per day)

	National N=193
Mean [SD]	9.34 [3.59]
SE	0.26
90% CI	0.43
95% CI	0.51
10% mean	0.93
5% mean	0.47

The seasonal fuel use adjustment has resulted in an increase in the mean firewood fuel value of 1.22kg/day compared with unadjusted data.

76.7% (n=148) of respondents reported that their main fuel varied according to season. 95.9% **of these** HH used wood as their main fuel in the rainy season, 85.6% in the dry hot season but 69.9% and 66.2% used a combination of wood and crop residues during the post-rainy (current) and cold season respectively (see section 4.1 for further discussion)

3.5 Simultaneous multiple stove use

Purpose of step: to account for households using more than one stove simultaneously and ultimately to account for occasional continued use of traditional stoves alongside improved stoves as per the requirement of the methodology.

The questionnaire included a series of questions about the simultaneous use of more than one stove for cooking. These were designed to establish the proportion of cooking (and therefore firewood consumption) that could be attributed to a single improved stove introduced through an improved cookstove project.

The calculation of the average number of stoves used simultaneously for cooking per family unit took into account the frequency of simultaneous stove use as well as the number of times cooking took place per day. This was compared with the stated number of times households cooked (Que C1) and then adjusted for any seasonal changes in multiple stove use patterns to give a fraction adjustment (See Annex 6.5 for full description of this calculation).

Any household using its stove less than once per week was excluded from this adjustment as the impact of this may be considered negligible.

Table 3.4: Simultaneous stove use from full dataset

	National N=193

% Using stoves simultaneously > once per week	19.7%
Stoves used per HH/family unit mean [SD]	1.07[8] [0.20]

Overall the average (mean) number of stoves used simultaneously for cooking per household unit was approximately 1.07. Note that this mean value is presented to reflect the extent of second stove use but is not used to adjust baseline fuel consumption for multiple stove use; rather, each household wood weight is adjusted individually according to its individual pattern of multiple stove use.

All further steps in analysis use these adjusted daily firewood weight values. The result is presented in Table 3.5.

Table 3.5: National mean firewood consumption adjusted for seasonal changes and patterns of multiple stove use (kg/per stove/per day)

	National N=193
Mean [SD]	8.92 [3.54]
SE	0.26
90% CI	0.43
95% CI	0.51
10% mean	0.89
5% mean	0.45

This mean value meets the 90/10 and 95/10 precision requirements of the methodology.

The multiple-stove adjustment has resulted in a decrease in 0.42kg/day compared with data adjusted for seasonal trends.

This reduction in mean firewood consumption compared to mean firewood consumption adjusted for seasonal trends is equivalent to an adjustment of

(Value adjusted for seasons/ value adjusted for seasons and multiple stove use)

= (9.34/8.92) = 1.0471, which may be considered an adjustment factor for any calculations concerned with second stove use in the entire sample. This is close to, but slightly different from, the mean number of stoves used simultaneously per household unit (1.07), as this is applied to mean values; whereas the adjustment factor is applied to individual households.

Prevalence of multiple stove use will be monitored and an adjustment applied accordingly. An example questionnaire for this is included in Section 6.6 and the equation to be used to calculate the adjustment is described in Section 0.

[8] Rounded from 1.0649

3.6 Assessing the difference between regional means

Purpose of step: to establish whether the Malawi baseline needs to be described in a series of discrete clusters due to discernible difference, or if it may be described as a homogenous area.

An independent T-test was used to determine any statistical significance difference between the estimated means in each of the locations.

Table 3.6: Mean firewood consumption adjusted for seasonal changes and patterns of multiple stove use by region (kg/per stove/per day)

Region	Mean firewood [SD]
Northern/central (n=96)	9.22 [3.85]
Southern (n=97)	8.62 [3.21]

The P value for difference between regions [p=0.240] showed that there is no evidence that the means significantly differ.

3.7 Aggregating data for national mean

Purpose of step: to establish the mean baseline charcoal fuel consumption across the country, and to determine whether this meets the precision requirements of the methodology.

No significant difference was detected between the mean fuel consumptions in each of the two locations . They represent their respective zones (i.e. Northern and Central regions, and Southern region) and therefore collectively represent the entire country, so the mean baseline fuel consumption for Malawi as a whole can be presented as per Table 3.5.

Thus, the mean baseline household firewood consumption, adjusted for multiple stove use, across the whole of Malawi is 8.92 **kg/day/stove**. Table 3.5 presents the confidence intervals and margins of error, showing that this combined value meets both 90/10 and 95/10 precision requirements.

4 Other factors investigated

The questionnaire survey included a number of questions on other aspects of household energy behaviour, some of which may impact firewood consumption. This section presents the conclusions of analysis of this data.

4.1 Supplementing firewood with crop residues

95.3% of HH supplemented their firewood with crop residues during the season when the survey was carried out. Table 3.7 shows the mean kg/per stove/per day according to the proportion of wood was replaced with crop residues.

Table 3.7: Mean firewood consumption adjusted for seasonal changes and patterns of multiple stove use by crop residue use groups (kg/per stove/per day)

Current use of crop residues as cooking fuel	Mean firewood [SD]
None n=9	9.79 [5.30]
<1 meal per week n=27	10.25 [4.29]

A few meals per week n=76	9.54 [3.70]
About half meals per week n=42	8.08 [2.61]
More than half of all cooking n=39	7.49 [2.34]

The P value for difference between groups [p=0.003] showed that there is evidence that the means significantly differ. This is expected and demonstrates that an increase in crop residue use results in a decrease in firewood used.

Although 39 respondents reported *currently* using crop residues for more than half of all cooking, it is recommended that these households are retained in the baseline dataset as they stated in response to Question A1 that they primarily used firewood for cooking in their home. Thus it is assumed that the relatively high usage of crop residues in these homes is during the season in which the survey was carried out only.

Moreover, in case 'primarily use of wood in traditional stove or open fire' is used as a basis for including households in the project at future monitoring, it is recommended that these households are retained. Including them in the overall dataset also makes the baseline estimate more conservative.

4.2 Space heating

7.8% (n=15) of respondents reported using their wood cooking stove for space heating when not cooking during the season when the survey was carried out.

An independent T-test carried out showed that there was no statistically significant difference in the amount of fuel used per stove between the groups who currently space heat (i.e. heat their homes) with their firewood cooking stoves when not using it to cook (mean 10.0kg SD 3.93) and those that do not (mean 8.83kg SD 3.56) (p=0.221).

Conclusion

The use of firewood stoves for space heating may be disregarded as a factor affecting the integrity of the baseline measurement.

4.3 Impact of using all of a household's firewood for weighing

Analysis was carried out to explore if there is a difference between the mean amount of fuel in those HH which had *all available* firewood weighed and those which had some left in their original wood pile in addition to that weighed. For example, some households presented all the wood they had to hand in their home for weighing; others presented a fraction. This section investigates any impact of this on the dataset.

Analysis on national data**,** adjusted for seasonal trends and multiple stove use, showed that the mean firewood use for those HH where all available firewood was weighed was 7.96 kg/day/stove [n=54 SD=2.69] whereas in those HH where there was some firewood remaining in the original firewood pile the mean was 9.29 kg/day/stove [n=139 SD=3.77].

An independent T-test showed this difference to be statistically significant [p=0.019]. It is possible, therefore, that including data from households in which all firewood was weighed introduced bias to the mean and reduced it. This may be because if more firewood had been available, it would have been added to the amount indicated. However, it is possible that these are accurate measures, and represent a group of households who both keep less wood in their homes, and actually use less.

Conclusion

It is not deemed appropriate to exclude data from households in which all available firewood was weighed, even though there appears to be a slight difference in the mean values. This decision to include these households makes the dataset conservative.

4.4 Comparison of results with other studies

Comparison with household firewood consumption estimates from Malawi suggests that the baseline estimate presented (**8.92kg/day/stove**,) is a reasonable estimate. The Integrated Biomass Energy Conservation Project – Malawi (Hestian Innovation Ltd 2010 p29) presented estimates of baseline woodfuel consumption to be:

Southern region: **2.56** tonnes/stove/year.

Central region: **3.362** tonnes/stove/year

This HED study's estimate taken from the Southern region are as follows:

8.62kg/stove/day

8.62*365=3146.3kg

= **3.15** tonnes/stove/year

and for the Central/ Northern region:

9.22kg/stove/day

9.22*365=3365.3

= **3.37** tonnes/stove/year

The HED study estimate for national consumption of **3.256** tonnes/stove/year is also in close agreement with the BEST report (GoM, 2009) which presented a weighted national average of 601.10 per capita/kg/year. Assuming an average household size of 5 persons[9], each sharing one stove, the BEST study conclusions is equivalent to **3.005** tonnes/stove/year.

[9] Based on the finding of the survey undertaken for this baseline study

5 References

1. GoM, 2009. *Malawi Biomass Energy Strategy*, Lilongwe: Government of Malawi. P31

2. Integrated Biomass Energy Conservation Project – Malawi Hestian rural innovation Development. Project Design Document Form (GS-VER-PDD) Downloaded from:https://gs2.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=613

6 Annexes

6.1 Supporting information for sampling approach

Literature review: Patterns in Malawi Household Firewood Consumption

Malawi is divided into three administrative regions: Northern, Central and Southern (Figure 1). While each region is roughly the same size, population is concentrated in the Central (42%) and Southern (46%) regions. Population density increases from north to south as do environmental degradation and wood energy shortages[10].

Figure 1: Malawi political map
http://www.mapsofworld.com/malawi/malawi-political-map.html

Firewood supply and consumption
As a whole, Malawi has an adequate forest base to more than meet its biomass fuel needs. However, much of this supply is in the north of the country and is not accessible to population centers in the center and south of the country. Overall, the Northern region has an abundant supply of wood. Demand in the Central region is 95% of the sustainable supply while the Southern region demand exceeds supply. Urban catchments around Lilongwe and especially Blantyre and Zomba are being harvested unsustainably[11] (Figure 2).

Figure 2: Malawi forest cover, population density, and poverty rates
http://www.ecologyandsociety.org/vol13/iss2/art24/figure3.html

[10] Government of Malawi. Malawi Biomass Energy Strategy. January 2009.

[11] Ibid.

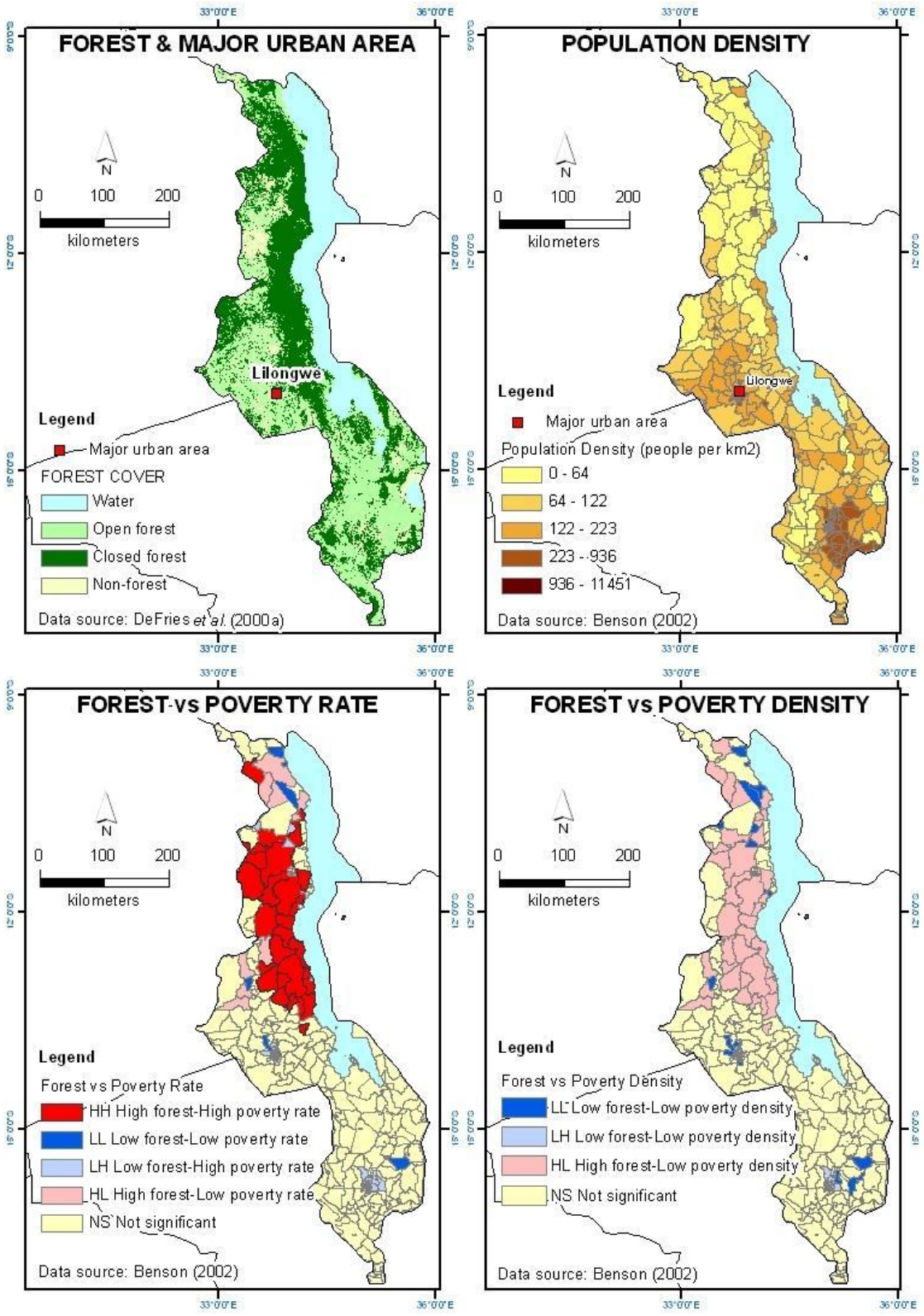


Figure 2 tends to indicate a greater supply of wood fuel in the Northern and Central regions compared with the Southern Region. This is corroborated by other data, for example the World

Bank[12] presents a study estimating biomass availability in Malawi from satellite data. It states 'Malawi's forests are mainly in the North region, with 41 percent of the country's biomass, followed by the Central region with 38 percent of biomass. The South region has the least' - i.e. just 21%.

Other data indicates that rural per capita wood consumption decreases from north to south along with wood abundance. While consumption is similar in the Northern and Central Regions where wood supply is adequate, consumption decreases in the Southern region where wood is relatively scarce (Table 1).

Table 1: Rural per capita fuel consumption by region[13]

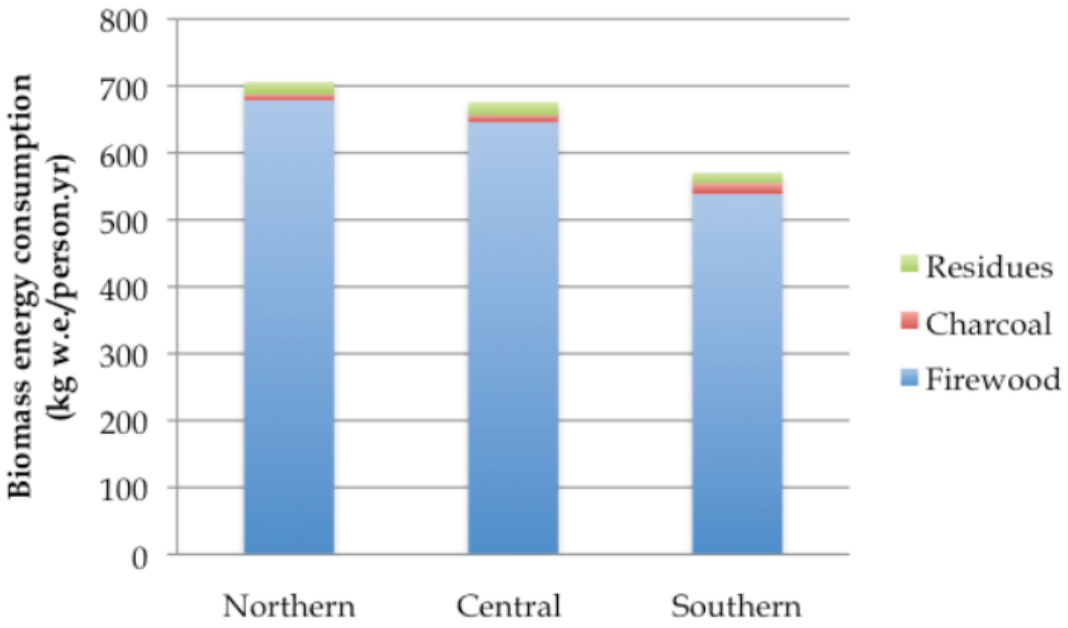
Region	Wood	Charcoal		Residues		*Total*	
	kg/yr	kg/yr	kg (w.e.)	kg/yr	kg (w.e.)	*kg (w.e.)/yr*	*cu.m.*
Northern	678.56	5.22	9.77	22.44	18.10	*706.43*	*1.06*
Central	646.28	5.93	11.09	23.13	18.65	*676.02*	*1.01*
Southern	538.62	8.92	16.69	18.85	15.20	*570.51*	*0.86*
Weighted average:	***601.10***	***7.21***	***13.49***	***21.10***	***17.02***	***631.61***	***0.95***

Furthermore, the BEST report 2009 corroborates this data, as shown in Figure 3 below.

Figure 3: Rural per capita household consumption of biomass energy by region

[12] Malawi Poverty and Vulnerability Assessment: Investing in Our Future, World Bank and GOM June 2006 (p37)

[13] GoM, 2009. *Malawi Biomass Energy Strategy*, Lilongwe: Government of Malawi. P31



(Malawi Biomass Energy Strategy (BEST), Government of Malawi, 2009)

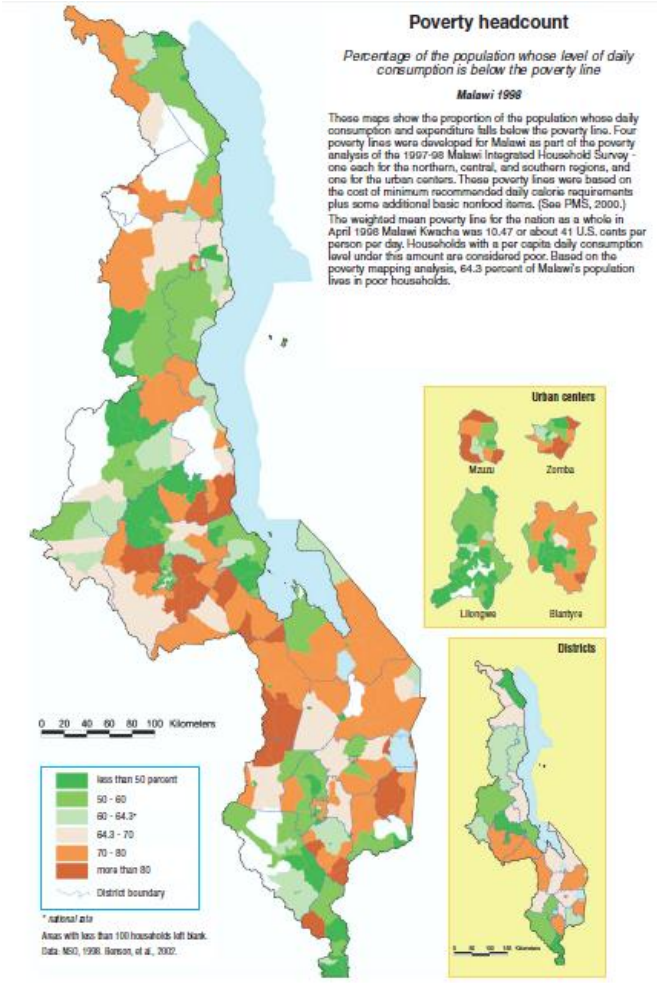
Poverty

Malawi is among the poorest countries in the world. Out of the 187 countries ranked, the 2011 Human Development Index ranks Malawi number 171 [14]. Rural communities are highly dependent on fuelwood. 94% of rural inhabitants cook with wood mostly on open fires.

Figure 4 presents poverty headcount data, which indicates the proportion of the population falling below the poverty line, from less than 50% (green) to more than 80% (dark red).

Figure 4: Poverty headcount in Malawi

[14] UNDP. Human Development Report 2011. Available at http://hdr.undp.org/en/statistics/hdi/.



http://www.ifpri.org/sites/default/files/pubs/pubs/cp/malawiatlas/malawiatlas_03.pdf

It is apparent that there is no clear trend in poverty across Malawi, nor clear large geographical areas defined by higher or lower rates of poverty.

Other data indicates a weak trend towards higher rates of poverty in the North and Central regions, compared with slightly wealthier Southern region. Notably:

- More professional and skilled jobs held by men in the South compared with North and Central, with more employed in agriculture in the North and Central regions.
- 7.3 and 6.4% of households in the North and Central regions have access to electricity, compared with 11.0% in the Southern region[15].

These data indicate that the North and Central regions tend to share higher levels of poverty, and that the South may be somewhat less poor (though still poor nevertheless).

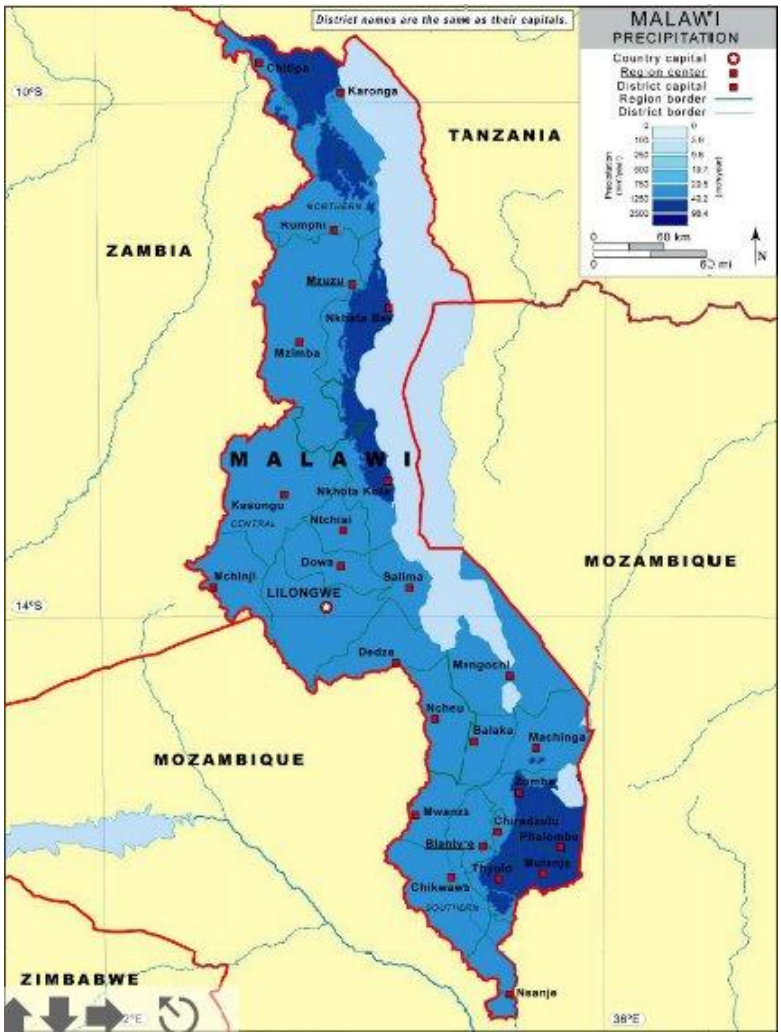
[15] Demographic and Health Survey, Malawi 2010. P35 and 280.

In many sub-Saharan countries one of the most powerful indicators of poverty is fuelwood consumption. These findings corroborate the conclusions drawn about the pattern of usage across Malawi – i.e. higher in the North and Central areas, and lower in the wealthier South.

Climate

Precipitation patterns were also considered for their potential impact on woodfuel consumption in Malawi. However, no evidence was found that rainfall had an impact on biomass consumption habits, and although some areas indicate higher rainfall, there are no distinct wet / arid areas in Malawi. Figure 5 shows precipitation patterns across the country.

Figure 5: Malawi Precipitation



http://www.atozmapsdata.com/zoomify.asp?name=Country/Modern/Z_Malawi_Precip

In light of this, precipitation was not considered a factor for clustering.

Proposed Clusters

It is proposed that the primary consideration for clustering should be woodfuel supply and consumption, giving rise to two clusters in Malawi. Precipitation was not considered as a basis for clustering, and although some patterns of poverty may be discerned from regional data,

these were not strong, though do corroborate the conclusions of the woodfuel supply and consumption.

One Malawi cluster would include the Northern and Central regions where per capita fuel consumption is similar while the Southern region, where wood is relatively scare and per capita wood use is lower, would comprise the second cluster.

These clusters may be considered homogeneous as they represent areas where there is evidence of similar biomass consumption and supply, with no further variation in other factors that may impact on wood fuel consumption.

6.2 Malawi Baseline Firewood Consumption Questionnaire

Baseline Fuel Use Assessment: Malawi

- This survey is designed to be administered to the **primary cook** in selected households
- The objective of this survey is find out how much woodfuel is used on the MAIN COOKING STOVE on a daily basis in households
- Please note: Unless stated otherwise, all questions refer to general household cooking during the **present season.**

Italic text in [square brackets] are instructions for fieldworkers. This text should not be read out to respondents.

Bold underlined text should be read out to respondents as well as the questions

[IMPORTANT:** Before starting the survey, please ask the respondent if she/he is the main cook in the family unit. If it is not the main cook, ask to speak to the main cook, and arrange a convenient time when she/he will be available for interview**.]

Introduction			
READ: Good morning/afternoon, my name is_____. Thank you for making time for us. I am here today to talk to you about your family cooking practices and fuel use. If you agree to participate in this survey, we would like to ask you a few questions; it will take about 25 minutes. There are no 'right' or 'wrong' answers and the information you provide will be very useful to help use improve cooking practices throughout Malawi. All the information will be kept private and your name will not appear anywhere publically. We will however keep it in our records so that we can contact you in future. Do you have any questions?			
	A. Participation criteria & participant information		
A1	Do you mostly use **woodfuel on a traditional fire or stove** for cooking in your home?	1=Yes 2=No [*terminate interview*]	
A2	Do you use your household cooking stove to cook commercially (use it in a small enterprise)?	1=Yes [*terminate interview*] 2=No	
A3	Do you agree to participate?	1=Yes 2 = No [*terminate interview*]	
A4	Have you enough wood in your home to show me how much you need to cook for a whole day?	1=Yes 2 = No [*terminate interview*]	
A5	ID number [XX-YY-NN]		
A6	Date of interview [DD/MM/YYYY]		
A7	Start time of interview [Use 24-hour clock]		
A8	Interviewer's name		
A9	Respondent's name		
A10	Respondent's telephone number [if available]		
A11	Region / district		
A12	Group village/local community		
A13	Today's weather [to be adapted to country]	1 = Hot and dry 2 = Hot and wet 3 = Cold and dry	

		4 = Cold and wet 5 = Mixed	

	B. Household structure					
B1	How many people live in your **household** in total?					
B2	Within your **household**, do different family units or groups cook separately (for example in different locations or near each other but using separate fires or stoves	1=Yes 2 = No [*go to B5*]				
B3	How many **family units** live within your household?					
B4	How many people are in your own family unit					
B5	On average, how many people do you usually cook meals for each day, at this time of year?					
	Children 14 year or younger	Female adults 15 years and older	Male adults 15 - 59 years	Male adults 60 years or older	Total [NN] [add up B5_1 to B5_4]	
	B5_1	B5_2	B5_3	B5_4	B5_5	
B6	[Check: Is the total in B5_5 the same as B4?]			1=Yes [Go to C] 2 = No [Ask B7]		
B7	Why is there a difference between your family unit size and the number cooked for? *[Write down everything the respondent says]*					
	C. Cooking					
C1	On average, how many times each day do you use your stove to prepare food for your family?					
C2	What is your <u>main</u> type of <u>woodstove</u> at this time of year? *[use list below]*					
	Three stone fire	1	Chitetezo Mbaula	2	Trad. metal stove	3	Other_____	4
	D. Simultaneous stove use for cooking using woodfuel					
D1	Do you ever cook on more than one woodfuel stove **<u>at the same time</u>** <u>at this time of year</u>? *[Make sure the respondent is **<u>not simply talking about multiple pots]</u>***	1 = Yes 2 = No [*Go to Section E]*				
D2	Do you do this at least <u>once per week</u>?	1 = Yes 2 = No [*Go to Section E]*				

D3	How many days each week do you use two **woodfuel** fires or stoves at the same time		
D4	How many meals do you use them for on those days?		
D5	During which seasons do you use more than one **woodfuel** fire or stove at the same time for cooking [*include as many seasons as required*]	1. Rainy season 2. Post-rainy season 3. Cold season 4. Dry hot season 5. All year	
	E. Stoves with more than one pot hole		
E1	Do you own a woodstove on which you can cook two dishes at the same time?	1 = Yes 2 = No [go to Section F]	
E2	Do you use both burners at the same time once a week or more?	1 = Yes 2 = No [go to Section F]	
E3	How many days do you use it to cook two dishes in two pots at the same time		
E4	On those days, how many meals do you use it for to cook two dishes in two pots at the same time		
E5	During which seasons do you use this stove to cook two dishes in two pots at the same *time [include as many seasons as required]*	1. Rainy season 2. Post-rainy season 3. Cold season 4. Dry hot season 5. All year	
	F. Space heating		
F1	Do you use a wood fire or woodstove for room heating at **any time of year**?	1 = Yes 2 = No *[Go to Section G]*	
F2	Is it the same stove as you use for cooking	1 = Yes 2 = No *[Go to Section G]*	
F3	Do you use it for heating when not cooking?	1 = Yes 2 = No *[Go to Section G]*	
F4	During which seasons do you use a wood fire or woodstove for room heating? *[include as many seasons as required]*	1. Rainy season 2. Post-rainy season 3. Cold season 4. Dry hot season 5. All year	
	G. Additional uses of fires/stoves		
G1	At this time of year do you use **woodfuel** fires or stoves for purposes other than cooking and heating your house at least once per week? [*Get the respondent to list all the **other** tasks for which they use **woodfuel** and the frequency of the*		

	task. If one or more task is not listed, use boxes G1.4 and G1.5.					
	No other purpose	1	Heating water	2	Burning incense	3
	Brewing tea	4	Cassava drying	5	Ironing	6
	Roasting	7	Drying meat	8	Other [describe]	9

	Use [use coding]	**Number of days per week?**
G1.1		
G1.2		
G1.3		
	[Record any other tasks that are not on the list]	
G1.4		
G1.5		

	J. Woodfuel		
	[This question is very important *– please take time to ensure the question is understood and your measure reflects wood used for the respondents* ***family unit*** *in an* ***average day]*** **Ask:** How much woodfuel do you use in an **average day**? Please make a pile for me to weigh. [*If the respondent uses a large log over a few days, ask them to pile up the equivalent wood used in a day*]		
J1	[Weight of **woodfuel** including bag or binding ***[****Include decimal places]*		__ __ __ . __ __**Kg**
J2	[Weight of bag/binding weighed without the woodfuel]		__ __ __ . __ __**Kg**
J3	[Did you weigh all the woodfuel available in the household, or was some left besides that weighed?]	1= Weighed all available woodfuel 2= More wood remained	
J4	Do you buy **any** of your woodfuel?	1 = Yes 2 = No *(go to section K)*	
J5	About what proportion of total wood used do you buy at this time of year?	1 = I buy most of my fuel 2 = I buy about half my fuel 3 = I buy a small amount of fuel	
J6	How much do you spend each time you buy **woodfuel**?		MWK
J7	How many days would this amount of **woodfuel** last		days
J8	*[Add any other observations that you think are relevant about the woodfuel used by this family]*		

K. Other fuels

How much of your cooking is done with the following fuels at this time of year? [*Ask about each fuel in turn and circle the most appropriate response*]

		None	Less than one meal per week	A few meals per week	About half of all cooking	More than half of all cooking
K1	Dung	1	2	3	4	5
K2	Charcoal	1	2	3	4	5
K3	Kerosene	1	2	3	4	5
K4	LPG [gas]	1	2	3	4	5
K5	Crop residues	1	2	3	4	5
K6	Other [*describe*] _____	1	2	3	4	5

[Check with the respondent that you have discussed all of the fuels the household uses for cooking]

S. Seasonality

Season codes	**Rainy season**	**Post-rainy season**	**Cold season**	**Dry hot season**
	A	**B**	**C**	**D**

S1 How would you describe the current season? *[Read names of seasons from list above and enter code]*

S2 Ask: **Over which months does each season occur?**

[Mark the calendar below using the letter codes above, putting one letter only in each box – e.g. if rainy season lasts from August to December, put an A in each box for August to December – similarly for each season]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Ask: How do each of these factors change with season compared to the current season**?**

[If things change, put '1 'in the second column, and fill in the sentences in the third column. If it does not change put '2 'in the second column and do not fill in the third column.]

	Factor	Does it vary? 1=yes 2=no	[IF YES go through all seasons with participants and record how the factors changes]
S3	Number of **people** for whom meals are	S3_1	In Rainy season I usually cook for [..... S3_2] people In Post-rainy season I usually cook for [.....S3_3] people

	cooked		In Cold Season I usually cook for [..... S3_4] people In Dry Hot season I usually cook for [.....S3_5] people
S4	Number of **meals** cooked per day	S4_1	In Rainy Season I usually cook [.....S4_2] meals / day In Post-rainy season I usually cook [..... S4_3] meals / day In Cold season I usually cook [..... S4_4] meals / day In Dry Hot season I usually cook [..... S4_5] meals / day
S5	Main **type of fuel** used for cooking *[use list below]*	S5_1	In Rainy Season the fuel I generally use is [.....S5_2] In Post-rainy season the fuel I generally use is [.....S5_3] In Cold Season the fuel I generally use is [.....S5_4] In Dry Hot Season the fuel I generally use is [..... S5_5]
	Wood =1	Charcoal=2	Crop residues=3	Kerosene=4
	LPG=5	Wood/ crop residues in equal quantities=6		Other=7
S6	[If answered yes to S5_1] Why do you use another fuel to replace wood fuel during other seasons?	1 = Wood to wet to burn 2 = It can be used indoors 3= Wood too expensive/scarce 4= Crop residues are available 5= Other [describe]	

S7 READ using the diagram on separate sheet: **Here is a diagram showing the amount of woodfuel you use currently each day *[point to the all-black circle]*. If this cross is 'no fuel at all' *[point to the cross]* and this big circle is 'twice as much woodfuel as you use now' *[point to the largest circle]* please show us the amount of woodfuel you think you would use in EACH season.**

*[First **underline** the current season in the column below and circle number 5;*
*THEN circle the number that refers to the amount of woodfuel the participant indicates **for each season**]*

	Underline current season in column below	No woodfuel	Quarter	Half	Three quarters	Current	One & a quarter	One & a half	One & three quarters	Twice as much woodfuel
S7_1	Rainy	1	2	3	4	5	6	7	8	9
S7_2	Post-rainy	1	2	3	4	5	6	7	8	9
S7_3	Cold	1	2	3	4	5	6	7	8	9
S7_4	Dry Hot	1	2	3	4	5	6	7	8	9

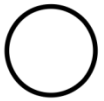
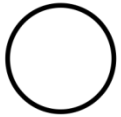
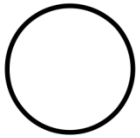
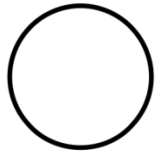
	N. Other observations

N1	Is there anything else you would like to tell us about how you use your fuel for household purposes? [*Write down everything the participants says*]
	Thank you for your time and help in providing us with this useful information
N2	*[Write down any observations of your own that you feel would be helpful and relevant]*

6.3 Proportional seasonal fuel change diagram

Baseline fuel Assessment: Malawi May 2012

READ: **Here is a diagram showing relative sizes, with the amount of wood you currently use each day *[point to the all-black circle]*. If this cross is 'no fuel at all' *[point to the cross]* and this big circle is 'twice as much wood as you use now' *[point to the largest circle]* please show us the amount of wood you think you would use in the XXX season [work through all seasons other than the current and record responses on survey form].**

X								
No wood	Quarter	Half	Three quarters	Current	One and a quarter	One and a half	One and three quarters	Twice as much wood
1	2	3	4	5	6	7	8	9

6.4 Calculation of adjustment for seasonal fuel use

The participants were asked 'How would you describe the current season?' and 'When does each season fall in the year?' This information was used to calculate the length of the current season and the 'other' seasons for each participant.

The participants were asked how much firewood they use in the 'other' seasons compared to their current use (see question M6.1 in Annex 6.2/6.3). Each response provided a fraction related to the current firewood use as per the table below.

Relative amount of firewood	Adjustment fraction
No firewood	0
A quarter of the amount	0.25
Half of the amount	0.5
Three quarters of the amount	0.75
No change	1
A quarter more	1.25
A half more	1.5
Three quarters more	1.75
Double the amount	2

The current daily firewood consumption was multiplied by this fraction to give a daily amount during the 'other' seasons.

For example: If the HH currently using 10.08kg of fuel per day reported using a quarter more during the 'other' season, the daily fuel consumption for the 'other' season was calculated by:

10.08*1.25= 12.6kg

The overall daily firewood consumption was adjusted to reflect the reported length of the current season and that of the 'others'. For example, if the participant said the current season was 'rainy' and it carried on for 4 months of the year and the 'other' season was 'dry' which lasted 8 months the following calculation was applied:

((10.08*4)+ (12.6*8))/12 = 11.76 kg/day

6.5 Calculation of simultaneous stove use

This section outlines the process of gathering and analysing information on simultaneous stove use in Malawi as part of the baseline assessment.

The survey provides the following information:

- Average number of meals cooked per week
- Average number of 1 stove meals cooked per week
- Average number of 2 stove meals cooked per week.
- Average number of months per year this occurs

Using this information and assuming equal amounts of fuel used on each stove (which is the most conservative approach), the fuel correction factor is calculated as follows:

(2*total meals per week with 2 stoves)+total meal using 1 stove= stove meals

Stove meals/7= stove meals per day

Stove meals per day/number of meals per day= Household (HH) mean stoves used /day

Fuel correction factor= 1/ (HH mean stoves used /day)

The table below shows the calculations for various combinations of simultaneous stove use.

Total meals/week	Total meals with 2 stoves /week	Total meals with 1 stove /week	Stove meals total /week	Stove meals/day	HH mean stoves used per day	Fuel correction factor
21	21	0	42	6.00	2.00	0.50
21	18	3	39	5.57	1.86	0.54
21	14	7	35	5.00	1.67	0.60
21	10	11	31	4.43	1.48	0.68
21	7	14	28	4.00	1.33	0.75
21	4	17	25	3.57	1.19	0.84
21	1	20	22	3.14	1.05	0.95
21	0	21	21	3.00	1.00	1.00
14	14	0	28	4.00	2.00	0.50
14	12	2	26	3.71	1.86	0.54
14	10	4	24	3.43	1.71	0.58
14	8	6	22	3.14	1.57	0.64
14	7	7	21	3.00	1.50	0.67
14	4	10	18	2.57	1.29	0.78
14	3	11	17	2.43	1.21	0.82
14	2	12	16	2.29	1.14	0.88
14	0	14	14	2.00	1.00	1.00

These adjustments are further refined according to seasonal variation. Based on the wet season lasting three months and the dry lasting nine months, adjusted fuel consumption for a HH reporting multiple stoves during the dry season but not during the wet season would be calculated as follows:

((3*1) + (1*fuel correction factor))/4

Example

Total meals per week: 21 Total 1 stove meals: 17 Total 2 stove meals: 4

Daily HH firewood use: 12.32kg

Calculation

(2*4)+17= 25

25/7= 3.57 stove meals per day

3.57/3 meals per day= **1.19 stoves per day**

1/1.19= a fuel correction factor of 0.84

Therefore a HH with a daily firewood use of 2.32kg would be adjusted to

12.32*0.84 = 10.35kg of firewood used per day per stove.

If this HH **only used multiple stoves in the wet season** this would be adjusted to:

((3*1) + (1*0.84)/4 = 0.96

Any HH reporting simultaneous stove use less than once per week was given a default adjustment factor of 1.

6.6 Example monitoring questionnaire

Stove Use Patterns and Operation Monitoring Survey

Prepared by HED Consulting

Example key question to determine the percentage of households that use more than one stove at the same time at least once per week (monitored data parameter SSy): Question B3

	C. Identifying house and cook				
A1	Sales record number	A2	Village		
A3	Ward	A4	District		
A5	Participant telephone number				
A6	Date of interview [DD/MM/YYYY]				
A7	Start time of interview [Use 24-hour clock]				
A8	Interviewer's name				
A9	Date of stove installation				
	D. Stove use				
B1	Do you still use your '[INSERT INTERVENTION STOVE NAME]' for most cooking tasks?	1=yes 2=no [*go to C1*]			
B2	Do you use any other cooking stoves at least once per week?	1=yes 2=no [go to D1]			
B3	Do you use this other stove <u>at the same time</u> as your primary stove at least once per week?	1=yes [go to D1] 2=no [go to D1]			
	E. Reasons for stopping use of '[INSERT INTERVENTION STOVE NAME]				
C1	Why do you no longer use the '[INSERT INTERVENTION STOVE NAME]? [*Write down everything the participant says]*				
C2	Which stove do you use as your primary stove now?				
	F. **Stove breakage and repair**				
D1	Since starting to use your '[INSERT INTERVENTION STOVE NAME] stove has anything broken on it?	1=yes 2=no [*go to E1*]			
D2	If yes, please describe what broke [*Write down everything the respondent says*]				
D3	Did you repair the break?	1=yes 2=no			

	G. **Observations and comments**			
E1	[O*bserve the* '[INSERT INTERVENTION STOVE NAME] *and note any signs of recent use or otherwise]*			
E2	[*Please check the stove for all components- enter a 1 if present and if in correct position. Enter a 2 if not.]*	1=yes 2=no	Present	Correct
		[ENTER COMPONENT		
		[ENTER COMPONENT		
E3	[*Please note any comments from the stove user*]			
E4	[*Interviewer note and observations*:]			

6.7 Adjusting for prevalence of simultaneous multiple stove use in future monitoring

The following formula is proposed by CQC for calculating the $B_{old,adjusted}$ to account for different prevalence of significant levels of simultaneous stove use compared with that determined at baseline:

$$B_{old,adjusted} = B_{old} \cdot \left[\frac{1.0471}{1 + \left(SS_y / 0.197\right) * (1.0471 - 1)} \right]$$

where:

- B_{old} is the baseline value presented in this report after adjustment for seasonal variation and multiple stove use *as determined at baseline;*
- SS_y is the percentage of households that continue to use baseline stoves (second stoves) at least once week in addition to ICS *as determined at monitoring*;
- 0.197 is the percentage of households in the baseline study who use a second stove at least once per week;
- 1.0471 is the multiple stove adjustment factor, calculated as follows:

$$Multi\ stove\ adjustment\ factor = \frac{B_{old\ adjusted\ for\ seasons}}{B_{old\ adjusted\ for\ seasons\ and\ multiple\ stove\ use}} = \frac{9.34}{8.92} = 1.0471$$

Where:

- $B_{old\ MEAN\ adjusted\ for\ seasons}$ is the mean biomass consumption of all HH from the survey adjusted for seasonal variations
- $B_{old\ MEAN\ adjusted\ for\ seasons\ and\ multiple\ stove\ use}$ is the mean biomass consumption of all HH from the survey adjusted for seasonal variations AND multiple stove usage

Note that each HH surveyed may have different fuel consumption, different seasonal patterns of fuel use, and different second stove usage. Therefore, the $B_{old\ MEAN\ adjusted\ for\ seasons}$ is estimated by multiplying each HH's stated fuel consumption by its corresponding adjustment to seasonal variations and taking the mean of the results. A similar approach is taken to estimate $B_{old\ MEAN\ adjusted\ for\ seasons\ and\ multiple\ stove\ use}$, where each HH's stated fuel consumption is multiplied by its corresponding seasonal variation and multiple stove use adjustment, and the mean is taken of all the HH results.Applying this formula to the two known scenarios, we test its performance:

- where future monitoring determined zero prevalence of simultaneous stove use, $B_{old,adjusted}$ = 9.34 kg/ stove/day.
- where future monitoring determined the same prevalence of simultaneous stove use, then $B_{old,adjusted} = B_{old}$ = 8.92 kg/ stove/day