# Kenya-Malawi Biomass Energy Project

# Summary Report

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## Introduction

### *Aims of project*

This project is intended to carry out an engineering, social and economic evaluation of food processing in the rural areas of Malawi and Kenya. The aim is to collect the information necessary for designing a clean and low-cost energy system for cogeneration of heat and electricity from agricultural waste to support food processing.

Agricultural activities are major contributors to many African economies. These activities require efficient downstream processes such as drying, roasting, boiling and refrigeration, which are all energy intensive and demand heat, electricity or both. Yet, severe energy issues in sub-Saharan Africa continue to hamper modernisation of these processes, stressing the economy, environment and public health of many African nations.

As a remedy, advanced technologies for thermochemical conversion of biomass are proposed to be combined with the state-of-the-art power-generation techniques. This results in a cost-effective integrated energy system, which takes biomass in the form of agricultural waste and converts it to heat and electricity with high efficiency and low emissions. The engineering applicants have strong track records in these areas. Nonetheless, knowledge of the local capacities, demands and challenges related to food processing industries in ODA countries remains as an imperative unknown. This calls for gathering information from the regional partners and evaluating the technical and social factors of the technology accordingly. Hence, the objective of this proposal is to find out the following:

#### Technical

1. The existing energy-intensive food processing industries in the partner countries.
2. Energy requirements of the current and modernised processes, regional energy resources, demands and infrastructure, local manufacturing and maintenance capabilities.
3. Performance estimation of the integrated energy system based on the collected data.

#### Social

4. Current and historic social resources: e.g. the designers, operators and beneficiaries of the existing processes.
5. Locally available skills for designing and operating alternative energy solutions.

#### End-user

6. Current and historical regional usages of the agricultural products.
7. Local views on existing problems and their desired goals.

**Economic**

8. Funders and beneficiaries.
9. National policies on energy and agriculture.

To achieve these, the project involved collaboration between partners in Scotland, Malawi and Kenya to collect and analyse data in the latter two countries. Questionnaires were designed and the partners supervised local students to gather data in different regions. Objectives 3 and 4 were met through numerical modelling in the School of Engineering, and an analysis of the data in the School of Interdisciplinary Studies to understand socio-technical constraints.

1. A report on the basis of the conducted regional surveys to meet objectives 1, 2, 4-9 of section 1.
2. An analysis of the sociotechnical contexts of energy supply and usage for food processing in Kenya and Malawi, focusing on objectives 4-9. This will focus on the social groups who currently contribute to high-energy food production and the social implications for proposed innovative solutions. The key deliverable will be identification of social factors that are likely to shape practical engineering solutions.
3. A list of regions in which the system is needed with the type and size of energy requirements (heat, electricity, a combination of both).
4. A modified numerical model of the basic characteristics of the integrated energy system on the basis of deliverable1.
5. The basic specifications of the integrated energy system including the range of generated thermal and electrical power, the most likely heat to electricity ratios and the tolerable variations in the feedstock (biomass).
6. An initial list of the system components that can be manufactured in Kenya and Malawi with an approximate costing.
7. An evaluation of locally available skills and expertise for the maintenance and further development of the systems, detailing the requirements for how such expertise can be made culturally and economically sustainable according to principles of the appropriate technology.
8. A forecast of how local social contexts shape the implementation of the engineering solution.

**Contributors**

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Ruth Mumba, Abundance, Mbando Village, Machinga District, Malawi

Devine Matare, Renew'N'Able Malawi (RENAMA).

## Survey questionnaire design

The survey questionnaire (Appendix 1) was designed by Nader Karimi and Sean Johnston, with further refinements by Clifford MKanthema, Ruth Mumba and Zachary Siagi. Johnston oversaw ethical approval by the Ethics Committee of the University of Glasgow School of Engineering (Appendix 2).

## Survey management, Kenya

Surveys were organized and reported by Siagi Zachary. Survey sites in Kenya are shown in Appendix 3A.

## Survey management, Malawi

Surveys were conducted by Abundance and by Renew'N'Able Malawi

Abundance conducted the surveys in the Eastern and central region of Malawi in the Districts of Zomba, Balaka, Machinga, Dedza, Dowa and Lilongwe respectively. These districts were chosen based on economic function thereby classifying areas within a district into rural and urban setting. Rural areas are having farming as the main economic function while urban areas have the service industry as the main economic function.

Four undergraduate students, one masters student from the University of Malawi, and three members from Abundance conducted the surveys. All surveyors were equipped with the tool before the interviews were conducted. A training was conducted on how the questionnaire should be answered by following ethics, asking every participant to sign a consent form to agree to voluntary participation. The questionnaire was also translated into Chichewa (Malawi National Language) for easy communication with the general population. Every surveyor had to possess the ability to understand both English and Chichewa and use them interchangeably as the responses would have to be translated on the response sheet.

Below is the List of Surveyors from Abundance:

Hopeson Mumba

Beauty Kambewa

Grace Moyo

Irene Banda

Stewart Paul

Clifford Mkanthama

Raymond Thupa

Respondents were selected randomly in all the districts that the data was collected from. These respondents were asked to participate in either individual surveys or Focus group discussions. Community coordinators from different villages were tasked with

organising participants for the Focus group discussions to include dynamic group of nine people representing the community. Interviews with government officials or other service industry individuals were conducted after booking appointments.

On average, the individual questionnaires took 30 minutes to complete. In Focus Group discussions, it took about 45 minutes to an hour to complete the interview. The responses were directly translated and recorded onto the questionnaire. However, for focus group discussions, the surveyors had to use extra paper to record all the responses. Surveyors also used their phones for audio recordings with respondents that agreed to be recorded. However, the sound quality in some recordings was compromised due to low quality recording devices, the wind blowing over the voices for the interviews that were conducted outside and some recorded files ended up being corrupt by computer malfunction.

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Survey sites in Malawi are shown in Appendix 3B.

**Survey collation and summaries**

The survey results were collated and summarised by University of Glasgow research assistants who were postgraduate students in the School of Interdisciplinary Studies on two programmes, the MSc in Environmental Change and Society, and the MLitt in Environment, Culture and Communication. They were:

Daniel Pettersen (undertaking spreadsheet design, data management and national summaries)

Lila Nathania

Dion Dobryzynski

Ayla Fudala

Lucy Woods

**Summary of data acquired**

Some 394 individual surveys were received from Kenya, and 137 from Malawi. A further 20 surveys were received from Kenya too late for inclusion in this report.

***Regions sampled***

As indicated in Appendix 4, and maps shown in Figures A-1 and A-2, Kenyan survey sites were distributed across the south-western quadrant of the country. Surveys were conducted by Moi University.

Figure A-3 shows the distribution of survey sites across the southern half of Malawi, conducted by Abundance and Renew'N'Able Malawi.

**Summary of survey responses**

***National comparisons***

In Appendix 5, data in the form of pie charts and histograms summarise the responses to questions that asked about quantifiable matters. Not all responses could be reduced to numbers, so the following section provides overviews, and describes and discusses qualitative responses to these and other questions on the questionnaire.

The brief summaries below identify the most significant features of the answers, and are supplemented by examples of additional survey responses in some cases. Note, however, that these whole-country averages tend to blur any variations such as differing home/industry, rural/city and geographical differences.

***Part A: Fuel demands***

*Q1 – What fuels do you burn?*

Malawian responses were notable in identifying chiefly wood and wood products (firewood and charcoal comprising 92% of fuel usage reported). Corn cob burning represented a further 5%. Hydrocarbon fuels and electricity amounted to only 3% of overall consumption.

By contrast, Kenyan responses indicated less firewood burning, so wood products amounted to an overall two-thirds (66%), with gas and diesel (29%) making up most of the remainder. Again, electricity represented only 1% of overall consumption.

Biogas from cow dung was reported by some respondents (e.g. at Kaimbu and Eldoret).

*Q2, Q3 – Do you burn fuel for anything other than cooking? For what?*

Fuel for cooking was the most common usage

Malawian responses showed only 12% using fuel for other things – mainly lighting and heating. In Blantyre, some reported using electricity to iron clothes for Church. In that community, some high fuel usages were reported, presumably for operating businesses such as charcoal production. Other respondents there reported burning other, less desirable, fuels: plastics, used clothing, charcoal dust and sawdust, with consequent health effects.

Kenyan responses were more varied, with 38% reporting other usages – but again dominated by lighting and heating.

*Q4, Q5 and Q6 – How much do you burn, does it vary over the year and how much does it cost per month?*

Quantities were variously reported: e.g. one deep hole of cow dung burned every three days (Kiambu); one sack of charcoal per three months (Homabay); four litre kerosene canister per 10 weeks (Homabay).

Differing usages for fuels complicates interpretations here. For example, charcoal burners, generating charcoal from collected wood for sale, may burn significantly more fuel to support this livelihood; one (Phalombe, Malawi) reported 25kg/day.

Costs, too, are difficult to interpret, with one Kiambu respondent noting that wood collection from estates was not permitted: 'if they get caught, they pay'. At Phalombe, one reported getting firewood free, but paying 15 pence per day for charcoal. In Blantyre, more than half reported spending more than £10/month for fuel. In Zomba, Malawi, respondents reported paying between £5 and £10 per month for electricity, despite its unreliability. A commercial operation (Toror Factory, Kenya) burned large amounts of wood daily for tea leaf processing.

Complicating matters further, costs were likely to be irregularly paid, or avoided altogether by directly collecting wood.

*Q7 – What is the fuel you use for cooking?*

Answers were seldom distinguishable from Q1.

*Q8 – How many times a day do you burn the fuel, and for how long each time?*

Responses from both countries were similar. In Muranga, Kenya, for instance, all interviewees reported burning fuel two or three times a day, for preparing meals.

*Q9 – From where do you get the fuel?*

In both countries, the principal sources for fuel were direct collection (54% in Malawi, 42% in Kenya) and from markets (43% and 56%, respectively). Livestock manure and waste from farm produce and were reportedly insignificant as fuel sources.

For example, in Bvumbwe, Malawi, respondents reported collecting firewood from tea plantation estates. In Phalombe, some reported buying charcoal from Dzanje Market, and gathering firewood from the maize field and bushes around home, and from Bangala forest. In Kapseret, Kenya, two-thirds of the respondents reported purchasing their fuel from the local market.

*Q10, Q11, Q12 and Q13 – How much cooking fuel? Does it vary seasonally? Do you use the fuel as it arrives? How much does it cost?*

Similar answers to Q4-Q6.

***Part B: Heat and electricity***

*Q14 – Do you have electricity at home?*

Four-fifths of Malawi respondents, and slightly over one-third of Kenyan respondents, did not. Some (e.g. Phalombe, Malawi) reported electricity being available in neighbouring villages or public places.

In Kenyan regions such as Kapseret, all had electricity but none used it for cooking, owing to frequent power outages.

*Q15, Q16, Q17 and Q18 – How often do you get a power outage?How much do you pay for electricity? Do public places, or other places nearby, have electricity?*

Many respondents noted that electricity supplies may be available only intermittently or briefly (e.g. with power outages two to three times per week, for as long as 8 hours at a time, at Muranga, Kenya, three to four outages per week at Kesses, Kenya, and supply for as little as 30 minutes at Kiambu, Kenya).

*Q19 – People per household?*

The distribution in both countries was similar, with about 5 co-dependent persons being most common. Few lived alone or as a couple; around 15% of the sampled populations lived as a group of more than seven. See Appendix 6 for family sizes per county in Kenya and Malawi.

*Q20 – Do you have solar power? For what usage?*

Around 25% of Malawian and 41% of Kenyan respondents had access to solar power. 14% and 35%, respectively, identified lighting as a specific usage. For example, in the Thyolo district of Bvumbwe, Malawi, solar lighting was reported as a common usage by many of the respondents.

*Q21 – Do you process any agricultural/fishing products?*

Around one-third in Malawi, and one-fifth in Kenya, said yes.

In Blantyre, Malawi, several respondents noted using agricultural remains for manure, although subsistence farming appears to be lower here (fewer than half reporting growing produce); others gained income from selling charcoal at Kachere/Limbe markets.

*Q22 – What are the products that you process and how are the processes carried out (e.g. milling, drying, boiling, refrigeration, smoking)?*

In Zomba, respondents reported processing and smoking fish, and using electricity for refrigeration.

*Q23-Q30 – (processing agricultural/fishing products)*

Few responses.

*Q24, Q26 – How much of products (in any weight or volume unit) do you process per day or per week? Do you process the products continuously throughout the year or is it limited to certain seasons/months?*

At Phalombe, respondents stated that food was processed during the rainy seasons. One household produced 10 bags of maize, three bags of sunflowers, and 25 kg of peas.

*Q29 – How much and what type of fuel do you burn every day (week/month) to do the processing?*

In Bvambwe, Malawi, respondents noted that much fuel is left unused because it is too wet to burn, especially during the rainy seasons.

***Part C: Biomass resources***

*Q31, Q32 and Q33 – Biomass resources. What agricultural products are cultivated in your area? Is there harvest waste? What kind?*

Maize cultivation was most commonly reported in both countries, amounting to just under half of the survey responses in each, followed by beans (10% of responses). Wheat cultivation was reported in 10% of Kenyan surveys but no Malawi responses.

The availability of harvest waste was reported by most respondents in both countries, and principal varieties were identified with remarkable similarity: mainly maize stalks (71%) and bean leaves (around 11%).

***Part D: Social aspects***

*Q37, Q38, Q39, Q43 Collecting firewood: how many hours? How far? Other potential uses of this time?*

Firewood collection carries particular burdens. One Phalombe, Malawi, respondent noted spending two hours per day collecting firewood – an activity learned from parents, and practiced over her lifetime (most collectors are female). Traditional gender and family roles 'work well. Everybody knows what to do in their daily life'. Collection can be hampered by thorns, and by illegal collection from woods owned by estates.

Respondents occasionally commented on potential benefits of new fuel sources. At Kiambu one suggested that provision of biogas would mean the young girls of the village could get an education from not having to spend time collecting firewood. A Bvambwe respondent estimated spending up to 9 hours/day, travelling several kilometres, and that this time could be spent, instead, on earning extra income at the tea estates; farming; looking after children/elderly, and doing housework. A Phalombe responded suggested that, if solar powered lights were provided, students could do their studies at any time.

*Q40-Q42, Q44-Q45 (skills and traditions of fuel use)*

Few responses. The broad questions at this late stage of the survey may have fatigued or intimidated respondents, and answers would have demanded more transcribing by the surveyors.

*Q46 – Are there other ways people accomplish the same task?*

At Kiambu, some use power saws for chopping wood. Another suggested biogas cookers for those who had cows.

*Q47-Q50 (food products processed for sale)*

Few responses, possibly because most respondents used fuels for household usage rather than sales.

*Q51 – Who else gets involved (such as supplying fuel, buying products or affecting how you do it)?*

In Blantyre, Malawi, one respondent noted that cooperation between families is low because 'it is not their duty to be doing that' [helping us] for 'they have their own problems to handle'.

*Q52-Q53 – What do you like, or dislike, about this involvement of other persons? What aspects of this process work well? What is good about it?*

Few responses. Again, this reflection may have been impeded by the circumstances in which the surveys took place.

*Q54 – Would you like to continue processing food in this way in the future?*

In Bvumbwe, Malawi, those responding 'yes' were generally entrepreneurs.

*Q55– Would you like to change these food preparation practices, and in what way?*

Around one-third of respondents in both countries did not identify a desire to change, and some were undecided (18% Kenya responses; 5% Malawi). Various desired

changes were reported, but the largest number mentioned renewable sources (59% Kenyan, 36% Malawian answers). Better availability and consistency of electricity was desired by 40% of Malawian and 16% of Kenyan respondents.

In Phalombe, for example, various respondents wanted electricity and solar power, low-cost or free; a charcoal burner and electricity for cooking.

*Q56 – Are there difficulties with the products of the process (such as food quality)?*

One Kiambu respondent noted disliking the smoky taste in food from firewood burning, and another reported smoke from fires making eyes sensitive [Kiambu]. One Bvambwe respondent stated concern about smoke breathed in by burning fuelwood/charcoal and injuries of burning.

*Q57 and Q58 – What would you like to change about fuel provision in your community? What would you like to improve about food processing?*

A common answer from Bvumbwe, Malawi, was that there should be local, communally owned and freely available fuel from wood lots. Some suggested planting trees as one element of this. The Namingomba tea estate/forest is far from the village and collection is prohibited; collectors may be chased or abused, or required to pay for usage (women collecting, men paying). Others mentioned the wish for government to subsidize solar energy technologies.

*Q59 and Q60 – How do you think you, or others in your community, could be affected if the ways of using fuel and energy changed? How do you think others in your community might be affected by new methods?*

Could provide more time for education (Kiambu).

***Part E: Environmental aspects***

*Q61, Q62, Q63 and Q64 – What remains when burning fuel? Are you affected by breathing smoke?*

About two-thirds of Kenyan and Malawian surveys reported complete combustion of their fuels. Around three-quarters of Kenyans and nearly 90% of Malawian respondents reported being affected by inhaling the smoke and by the blackening of their environments.

**Discussion of socio-economic contexts**

***Kenya***

Numerous sources provide data on the Kenya economic context,[1] and some discuss fuels, particularly in urban environments:

- A 1987 study reports that the majority of urban households use woodfuel for cooking: '82% use charcoal and 19% use firewood. The very poor urban residents pay a much higher proportion of their incomes for fuel than do the other income groups. Income was found to be inversely related to the proportion spent on fuel. Very few households reported use of fuelwood alternatives'. An important factor in choice for poorer homes appears to be that charcoal is lighter to transport and cheaper to buy than firewood.[2]
- The US Energy Information Administration notes (2008) that 60% of Kenya's urban population and 7% of its rural population have access to electricity. 'The vast majority of the population, particularly in rural areas, relies on traditional biomass and waste (typically consisting of wood, charcoal, manure, and crop residues) for household heating and cooking'.[3]
- A 2006 study focusing on fuel supply in the Kisumu district of Kenya notes that lack of fuel in some areas (e.g. city slums and rural villages) makes development practically impossible. It observes that social norms discourage men from participating in fuel procurement and cooking. As a result, women's characteristics – e.g. age, education and occupation – may be decisive in affecting fuel choice. Independent of age or family size, those who do not own their home are more likely to use charcoal; those with higher-grade employment tend to choose firewood. The use of kerosene is not popular, particularly for meals that requires significant time to prepare. It concluded that, to satisfy the demand for firewood as

[1] Tabitha Atieno Olang, Miguel Estebana, and Alexandros Gasparatos, "Lighting and Cooking Fuel Choices of Households in Kisumu City, Kenya: A Multidimensional Energy Poverty Perspective," *Energy for Sustainable Development* 42 (2018); Ahmad Rahnema, "Alternative Cooking Fuels in Kenya: How Can Household Decision Making Be Influenced?," (IESE Business School, University of Navarra, 2017); Francesco Fuso Nerini, Charlotte Ray, and Youssef Boulkaid, "The Cost of Cooking a Meal. The Case of Nyeri County, Kenya," *Environmental Research Letters* 12, no. 6 (2017); M. Tiffen, M. Mortimor, and F. Gichuki, *More People, Less Erosion: Environmental Recovery in Kenya* (Chichester: John Wiley & Son, 1994).

[2] Diana Lee-Smith et al., "Urban Food Production and the Cooking Fuel Situation in Urban Kenya. National Report: Results of a 1985 National Survey," (1987). See also Diana Lee-Smith, "Cities Feeding People: An Update on Urban Agriculture in Equatorial Africa," *Environment & Urbanization* 22, no. 2 (2010) and D. B. Freeman, *A City of Farmers: Informal Urban Agriculture in the Open Spaces of Nairobi, Kenya* (Montreal: McGill-Queen's University Press, 1991).

[3] US Energy Information Administration, "Kenya Factsheet," (2018), https://www.eia.gov/beta/international/country.cfm?iso=KEN

the favoured fuel, community wood lots growing fast-maturing tree varieties should be encouraged. Coupled with more efficient stoves, this more sustainable fuel source could avoid ongoing deforestation, soil erosion and declining agricultural productivity.[4]

***Malawi***

A number of sources have also focused on the economic, environmental and policy context in Malawi.[5] Some, however, provide summary statistics more oriented towards the concerns of the present study, and illustrate more severe endemic problems in Malawi of food supply, poverty, child mortality, and environmental degradation:[6]

- Some 85% of the population lives in rural areas, although urban populations have been growing twice as fast since the 1950s.
- Malawi has relatively high population densities (0.23 hectares of land per person in rural areas). Crop productivity is limited by depleted fertility of soils and water shortages, and by flooding during the rainy season. Fertilisers are unaffordable. The most food sufficient area is the maize- and tobacco producing plain of the Central Region. Cotton and tobacco crops are typically more intensive and erosive than maize production, and the hotter low-lying areas along the Shire River in the South are more vulnerable to food insecurity.

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[4] M. O. Pundo and G. C. G. Fraser, "Multinomial Logit Analysis of Household Cooking Fuel Choice in Rural Kenya: The Case of Kisumu District," *Agrekon* 45, no. 1 (2006)

[5] Penny Allen, "First Steps Towards an Understanding of Rural Economy in Malawi," (SCF (UK), 1993); E Cromwell and J. Winpenny, "Does Economic Reform Harm the Environment? A Review of Structural Adjustment in Malawi," *Journal of International Development* 5, no. 6 (1993); Jane MacAskill, "Food Security in Malawi," (SCF (UK), 1993); Energy and Environment Ministry of Natural Resources, "Malawi State of Environment and Outlook Report: Environment for Sustainable Economic Growth," (Lilongwe, Malawi: Malawi Government, 2010); B. Halle and J. Burgess, "Country Environmental Profile for Malawi," (Commission of the European Communities, 2006); Environmental Affairs Department and Ministry of Environment and Climate Change Management, "National Climate Change Policy," (Lilongwe, Malawi: Government of Malawi, 2012).

[6] Anne C. Conroy, Maldom J. Blackie, and Jeffrey D. Sachs, *Poverty, Aids and Hunger: Breaking the Poverty Trap in Malawi* (Basingstoke: Palgrave Macmillan, 2006), pp.1-3; 14; 23-25; 105-106; Don Harrison, "Evaluating Living Standards in Rural Malawi: The Experience of a Non-Government Development Agency," in *People and Environment in Africa*, ed. Tony Binns (Chichester: John Wiley & Sons, 1995), pp. 130-132; 134; Hazel Barrett and Angela Browne, "Gender Environment and Development in Sub-Saharan Africa," in *People and Environment in Africa* ed. Tony Binns (Chichester: John Wiley & Sons, 1995); John Magrath and Elvis Sukali, "The Winds of Change: Climate Change, Poverty and the Environment in Malawi," (Oxfam International, 2009).

- The principal energy source is fuelwood (firewood), collected for typically two hours per day by female members of the household. About four-fifths of the fuel wood is used by households, and the remainder for industrial production such as curing tobacco and tea. Fuel wood consumption is contributing to severe deforestation, estimated at 40,000 hectares per year.
- Charcoal is 'lighter to transport and therefore cheaper than wood and also more compact to burn on the fire. But in terms of wood volume used, charcoal is 40% less efficient than fuelwood. Charcoal-consuming urban dwellers thereby exert a greater demand per head of population on forest resources than do fuelwood-consuming rural people'.[7]
- Particularly during times of drought, sources of rural household income include the sale of cash crops, leaving their land to work at tea estates or in South African mines, or temporary migration to towns for other forms of employment. By earning money during the unproductive dry season in urban areas, and thus easing the level of consumption of resources in rural areas, this mobility between rural and urban living has allowed home villages to continue to function. But, as noted by Hamish Main (p50), 'urban migration during the dry season is often done by 'the most productive people in a farming community, resulting in labour shortages disproportionate to the numbers involved' which may be a key factor in 'the eventual abandonment of some of their villages and farmlands'.[8]
- A related consequence is single-parent households, with 30% of rural homes headed by women. Collection of fuelwood and water, and ensuring daily provision of food, have a major impact on women's activities and options. Sexual bartering in exchange for fuel and food is increasingly common, and the incidence of HIV and AIDS orphans are rising.
- Half the population is below the age of 15. The average Malawian dies before the age of 40, with 73 per thousand infants dying in their first year, and 133 per thousand before their fifth year. Two-thirds of child deaths can be linked to nutritional factors. The average consumption by adults is some 1800 calories/day, well below norms for manual workers.
- On the national policy scale, agriculture and fishing account for 33% and 4% of the country's Gross Domestic Product (GDP), respectively. Manufacturing – principally agricultural processing, textiles, and production of building materials, clothing and footwear – is declining. Inadequate transport infrastructure (poor roads, limited air and rail links and poor access to ports) exacerbates problems. Most villages are accessible to only small trucks (1-3 tonne load capacity). Electricity, water and communications utilities are unreliable and expensive.

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[7] R. R. White, "The Influence of Environmental and Economic Factors on the Urban Crises," in *African Cities in Crisis: Managing Rapid Urban Growth*, ed. R. E. Stren and R. R. White (Boulder: Westview 1989), quotation p.8.

[8] Hamish Main, "The Effects of Urbanization on Rural Environments in Africa," ibid., quotation p.50.

As the present study and the cited sources suggest, fuel usage is distinctly different in the two countries. Kenya has a higher proportion of urban dwellers and electricity distribution; Malawi is considerably less provisioned with infrastructure. Fuels other than firewood and charcoal are dominant in both countries, although Kenyan contexts, in particular, have seen a wider spectrum of relatively uncommon alternatives such as kerosene, mains electricity and solar power for purposes other than cooking.

While there are similar trends in both countries – increasing reliance on firewood collection and charcoal burning and reduction of forest resources and environmental degradation – the Malawian context is more acute. Subsistence farming in rural districts occupies most available arable land. High reliance on human labour, rather than animals or machines, limits time available for other socially, culturally and economically beneficial activities. Women, in particular, are central to fuel choices and their implications. They are the predominant collectors of fuel wood, which typically occupies hours per day. Women are likely to be the point of contact with managers of private woods and sellers of charcoal, and so potentially victims of fuel bartering. Women are also the principal users of fuel in the household for cooking, and so most affected by the smoke created. The daily needs to gather firewood, seek household income and raise self-grown food supply may be too low to allow any variation from these routine practices.

## Appendix 1 Survey questionnaire

To be completed by the surveyor team:

a) Date and time:
b) Location: (District-T/A-GVH-Village)
c) A rough estimation of the area and population of the village
d) Pictures of domestic stove and any other burner used in the area (no human should be in the picture).
e) Roles of individual participants (e.g. in terms of usages, identified social role, identified job or responsibility relating to fuel/energy usage).
f) A separate questionnaire should be completed for each participant, *or* roles should be identified for participants in a focus group.

### Part A: Fuel Demands

General questions

1- What fuel(s) do you burn?
2- Do you burn fuel for anything other than cooking? If no go to question 7.
3- What are the other purposes for which you burn fuel?
4- How much fuel do you burn for this purpose per month/year (in weight, bundles or volume units)?
5- Do you use this fuel constantly throughout the year or does it vary with time?
6- How much does it cost per month/year?

Fuel for cooking

7- What is the fuel you use for cooking?
8- How many times a day do you burn the fuel and for how long each time?
9- From where do you get this fuel?
10- Approximately how much fuel (in any weight or volume unit) do you burn every day? Or how large is the fuel tank and how long does it last?
11- Do you use the same fuel all the time or does it vary seasonally?
12- Do you use the fuel as it arrives or do you prepare it beforehand (e.g. drying the wood)?
13- How much do you, or someone else, pay for it?

### Part B: Heat and Electricity

General questions

14- Do you have electricity at home? If not, go to question 17.
15- How often do you get a power outage (per week?) and how long does it last? (in hours)
16- How much do you pay for electricity? (estimate per month. If it is pre-paid or post-paid, how much is used or paid for per month?)

17- Is there any place nearby that has electricity? If so, where? (name and distance in km)
18- Do the public places (e.g. schools) in your area have electricity?
19- How many people live in your house?
20- Do you have solar power at home? Is it used for a) lighting b) cooking ?

Energy for processing of agricultural/fishing products

21- Do you process any agricultural/fishing products (e.g. tea leaves, coffee beans, peanut, fish preservation)? if yes, then please answer questions 22 to 29, otherwise go to question 32.
22- What are the products that you process and how are the processes carried out (e.g. milling, drying, boiling, refrigeration, smoking)?
23- Which parts of the process are done manually?
24- How much of products (in any weight or volume unit) do you process per day or per week?
25- What wild products do you process (e.g. wild green leafy vegetables, wild fruits, wild animals, dried mice, okra)
26- Do you process the products continuously throughout the year or is it limited to certain seasons/months?
27- Does it include sun drying or any other use of solar heating? If so, how do you use solar heat?
28- Does it include the use of electricity? Which parts of the process are done electrically?
29- How much and what type of fuel do you burn every day (week/month) to do the processing?
30- How much do you pay for the fuel?

**Part C: Biomass Resources**

31- Which agricultural products are cultivated in your area? and how much of it is produced every year?
32- Is there any waste from the harvest?
33- If yes, what are those (e.g. rice husk, barely straw)? and how much is it produced every year?
34- If no, what happens to the rest of the harvest?
35- Is there any forestry activity in your area that leaves tree waste (e.g. leaves, twigs or small branches)? (You can give multiple answers) a) agroforestry, b) woodlots, c) collect forest products such as mushrooms or medicinal, d) collect firewood from forests, e) making charcoal, f) planting trees.
36- If so, what happens to the waste?

**Part D: Social aspects**

37- How many hours a day do you take to collect fuel wood?
38- How many kilometres do you travel to collect fuel wood?
39- If you did not have to spend that time collecting wood, what would you use the time for?
40- How did you learn how to use the processes that use this fuel?
41- What skills are needed to do this well?

42- Who does it typically involve?
43- How much of your time is required for it each day or week?
44- Is this the way most people do it?
45- How long has it been done this way in the area?
46- Are there other ways people accomplish the same task?
47- What are the main products (such as cooking, drying, milled grain, or other products)?
48- Who uses the products?
49- Do you sell the products?
50- Who pays for the fuel?
51- Who else gets involved (such as supplying fuel, buying products or affecting how you do it)?
52- What do you like, or dislike, about this involvement of other persons?
53- What aspects of this process work well? What is good about it?
54- Would you like to continue processing food in this way in the future?
55- Are there any difficulties with the way that it is carried out, or managed?
56- Are there difficulties with the products of the process (such as food quality)?
57- What would you like to change about fuel provision in your community?
58- What would you like to improve about food processing?
59- How do you think you could you be affected if the ways of using fuel and energy changed?
60- How do you think others in your community might be affected by new methods?

**Part E: Environmental aspects**

61- When burning fuel, does it all get burned and turned into ashes or there is unburned fuel left?
62- Do you think that you breathe in a lot of smoke when you burn fuel?
63- Do you think that the smoke from burning fuel affects your breathing?
64- Does the smoke from burning the fuel turn things black (such as walls)?

University of Glasgow

**Appendix 2: Ethical approval**

University of Glasgow | College of Science & Engineering

ETHICS APPLICATION FORM
Important Notes:

**1.** Please also upload an information sheet and a consent form as supporting documentation.
**2.** If you intend to conduct a study with UNDERAGED (under 16 years of age) participants you MUST fill in the Children Research Ethical Plan form and ensure that you obtain all the necessary permissions described in that form. Please fill in the form and submit it as PDF together with your ethics proposal.

PI:
Dr Nader Karimi (UG School of Engineering)

Co-Investigators:

Prof Simiyu Sitati (HoS. Eng), Dr Augustino Makokha and Dr Zachary Siagi, School of Engineering, Moi University, P.O. Box 3900-30100, Eldoret, Kenya.

Dr Deepa Pullanikkatil, Mbaula Network, PO Box 31219, Blantyre, Malawi (a network of renewable energy NGOs in Malawi).

Dr Manosh Paul, Dr Zhibin Yu and Dr Neil Burnside (UG School of Engineering)

Prof Sean Johnston (UG School of Interdisciplinary Studies)

1. DESCRIBE THE BASIC PURPOSES OF THE PROPOSED RESEARCH.

Agricultural activities are major contributors to many African economies. These activities require efficient downstream processes such as drying, roasting, boiling and refrigeration, which are all energy intensive and demand heat, electricity or both. Yet, severe energy issues in sub-Saharan Africa continue to hamper modernisation of these processes, stressing the economy, environment and public health of many African nations.

As a remedy, advanced technologies for thermochemical conversion of biomass are proposed to be combined with the state-of-the-art power-generation techniques. This results in a cost-effective integrated energy system, which takes biomass in the form of agricultural waste and converts it to heat and electricity with high efficiency

and low emissions. Nonetheless, knowledge of the local capacities, demands and challenges related to food processing industries in ODA countries remains as an imperative unknown. This calls for gathering information from the regional partners and evaluating the technical, social, cultural and economic factors of the technology accordingly.

Hence, the objective of field research is to assess the following:

Technical

1. The existing energy-intensive food processing industries in the partner countries.
2. Energy requirements of the current and modernised processes, regional energy resources, demands and infrastructure, local manufacturing and maintenance capabilities.
3. Performance estimation of the integrated energy system based on the collected data.

Social

4. Current social resources: e.g. the designers, operators and beneficiaries of the existing processes.
5. Locally available skills for designing and operating alternative energy solutions.

End-user

6. Current regional usages of the agricultural products.
7. Local views on existing problems and their desired goals.

Economic

8. Funders and beneficiaries.
9. National policies on energy and agriculture.

To achieve these, we will work closely with our partners in Kenya and Malawi to collect data in these two different countries. Question topics have been designed and the partners will supervise local student researchers to gather data in different regions.

2. INDICATE WHO IS FUNDING THE RESEARCH (IF COMMERCIALLY FUNDED, ENSURE THAT PARTICIPANTS ARE INFORMED).

This project is funded by the Scottish Funding Council Global challenges Research Fund.

3. DESCRIBE THE DESIGN OF YOUR EXPERIMENT (E.G. CONDITIONS, NUMBER OF

PARTICIPANTS, PROCEDURE AND EQUIPMENT WHERE APPROPRIATE).

Five to ten groups of undergraduate students or academics/graduate students will be formed in each partner country to collect data from farms, food processing units, local communities, governmental and other relevant organisations. The large number of these groups ensures collection of a sizeable amount of data even in the case of failure of one or two groups.

Participants will be sought from relevant social groups and stakeholders, including persons involved in food processing/energy production such as equipment designers, operators, managers, farmers, personal producers, funders and relevant government officials.

Depending on the particular social group, site and individual cases, some interactions may occur in focus groups or as one-to-one short answer questions.

In issues of literacy/language proficiency, or where lengthy comments are obtained from participants, survey responses may be audio recorded and then summarised by the survey team member. In all cases, translated or summarised responses will seek to be as complete and representative as possible.

4. DESCRIBE HOW THE PROCEDURES AFFECT THE PARTICIPANTS.

The described research procedures are low risk and should not pose any risk or harm to participants. Participants will be informed that they can opt out of participating in the research project at any time, and that their names will not be included in any report. Social or organisation role, however, may be recorded.

5. STATE WHAT IN YOUR OPINION ARE THE ETHICAL ISSUES INVOLVED IN THE PROPOSAL.

Responsibility for research criteria, data acquisition and analysis
All academic partners will contribute to research design and ethical conduct. Academic partners in Kenya and Malawi will be responsible for managing the survey teams. Data will be analysed largely by researchers in the School of Engineering and School of Interdisciplinary Studies at Glasgow University, but shared and discussed by all academic partners.

Surveys
Survey data collection will be of low risk and not include any major ethical issues. The survey will not ask for names or data which may easily identify an individual participant. Participation in focus groups, in which views will be shared amongst participants, will be an option. Participation in surveys will, wherever possible, allow for privacy and ensure confidentiality by avoiding public or semi-public locales.

6. SPECIFY THE NATURE OF THE PARTICIPANTS. INDICATE IF THE RESEARCH INVOLVES CHILDREN OR THOSE WITH MENTAL DISABILITIES OR HANDICAP. IF SO, EXPLAIN THE STEPS TAKEN TO OBTAIN PERMISSION FROM L.E.A.s, HEADTEACHERS, PARENTS, ETC. GIVE A BRIEF DESCRIPTION HERE AND FILL IN THE CHILDREN RESEARCH ETHICAL PLAN. THE FORM MUST BE UPLOADED TOGETHER WITH THE CONSENT AND INFORMATION FORMS.

Diverse individuals can be expected to participate in the evaluation project. However, children under 16 or individuals with vulnerable status (e.g. having intellectual disabilities or not having recognised legal competence) will be excluded from the project.

7. STATE IF PAYMENT WILL BE MADE TO SUBJECT.

Payment will not be offered to participants.

8. DESCRIBE THE PROCEDURES FOR ADVERTISING, FOR RECRUITING PARTICIPANTS, AND FOR OBTAINING CONSENT FROM PARTICIPANTS.

Advertisement and Recruitment
Academic partners will approach potential participants via organisational networking and via enrolling participants during site visits. Intermediaries will not be involved in selecting participants. However, in some instances, a person of authority at an interview site may be required to give permission for surveys to be conducted on site.

Consent

Participants will receive an information sheet or equivalent verbal description of the project and an explanation of why their views are requested. All participants will confirm their understanding and give their consent to participate by signing a consent form or having their verbal agreement audio-recorded.

9. STATE WHETHER THE PROPOSAL IS IN ACCORD WITH THE BPS CODE OF CONDUCT OR THE ESRC FRAMEWORK OF RESEARCH ETHICS.

This proposal adheres to the six key principles of the ESRC framework of research ethics. Risk and harm during the research project are kept at a minimum. Participants' rights and dignity will be respected at all times. Participation is absolutely voluntary, and no one will be forced or pressured into participating in either a group or individual context. At all times the purpose and activities of the project will be transparent to participants. Their questions will be invited and will receive understandable and relevant responses. The participant information will clearly state key contacts for the research project for the participants to contact at any time. There are no conflicts of interest in this project.

10. DESCRIBE HOW THE PARTICIPANTS' ANONYMITY AND CONFIDENTIALITY WILL BE MAINTAINED.

As described in Section (4), names will not be revealed in any published report, but may be recorded for the researchers (ie. anonymised, with code numbers or pseudonyms for tracing). Surveys will normally be conducted in a non-public space if participants request it or if potential vulnerabilities are identified by the survey team members. Social or organisational roles will be recorded to aid data analysis, unless not agreed by participants.
Data collected will be kept for 10 years according to University of Glasgow's rules. The project co-investigators will keep them in electronic form on password-protected university computers.

11. DATE ON WHICH PROJECT WILL BEGIN AND END.

The data collection fieldwork portion of the project will begin on 1 Dec 2017 and finish on 15 Jan 2018.
Data analysis and writing up of the evaluation results will take place during January-March 2018.

12. LOCATION AT WHICH THE PROJECT WILL BE CARRIED OUT.

Survey sites in Kenya and Malawi will be identified by the research partners:

- School of Engineering, Moi University, P.O. Box 3900-30100, Eldoret, Kenya.
- Mbaula Network, PO Box 31219, Blantyre, Malawi. (Mbaula is a network of renewable energy NGOs in Malawi)
- Abundance, Mbando Village, Machinga District, Malawi, (a non-profit organisation focusing on improving the quality of life and environmental protection in developing countries: www.abundanceworldwide.org).

Specific sites will be determined by their current role in energy production and food drying, and will include stakeholders in distinctive social roles (workers, process managers, operators, maintainers of equipment, funders and relevant officials.

13. DESCRIBE HOW PARTICIPANTS WILL BE DEBRIEFED AT THE END OF THE EXPERIMENT (THIS MUST INCLUDE THE OPPORTUNITY TO CONTACT THE EXPERIMENTER - OR SUPERVISOR - FOR FEEDBACK ON THE GENERAL OUTCOME OF THE EXPERIMENT).

The participants of the project will receive contact information for the evaluation lead and the evaluation supervisor via the information sheet. Once the evaluation report has been written, it will be publicly available via the project leads.

**Appendix 3 Summaries of surveys**

| Moi University (Kenya) | County | No. of surveys |
|---|---|---|
| 1 | Baringo County | 5 |
| 2 | Bungoma County (found in Trans-Nzoia onedrive folder) | 3 |
| 3 | Busia County (found in Trans-Nzoia onedrive folder) | 3 |
| 4 | Elgeyo Marakwet County | 5 |
| 5 | Embu County | 12 |
| 6 | Homabay County | 5 |
| 7 | Kericho County | 3 |
| 8 | Kiambu County | 8 |
| 9 | Kisii County | 6 |
| 10 | Kisumu County | 5 |
| 11 | Kitui County | 7 |
| 12 | Machakos County | 7 |
| 13 | Makueni County | 8 |
| 14 | Muranga County | 5 |
| 15 | Nakuru County | 5 |
| 16 | Nyeri County | 2 |
| 17 | Trans-Nzoia County | 4 |
| 18 | Uasin Gishu County | 40 |
| | | |
| Abundance (Malawi) | | |
| | Malawi / Dowa | 9 |
| | Malawi / Dedza | 7 |
| | Malawi / Machinga | 10 |
| | Malawi / Zomba | 11 |
| | Malawi / Lilongwe | 4 |
| | | |
| RenewNAble (Malawi) | | |

| | | |
|---|---|---|
| Batch 1 | Malawi / Blantyre | 40 |
| Batch 2 | Malawi / Phalombe | 100 |
| Batch 3 | Malawi / Phalombe | 100 |
| Batch 4 | Phalombe (22) / Bvumbwe (78) | 100 |
| Batch 5 | Malawi / Bvumbwe | 100 |
| Batch 6 | Malawi / Blantyre | 36 |
| Total | | 650 |

Table A-1: Distribution of survey forms and counties

| Spreadsheets generated | Counties/Villages | Country | No. of questionnaires per village |
|---|---|---|---|
| 1 | Baringo County | Kenya | 5 |
| 2 | Bungoma County (found in Trans-Nzoia onedrive folder) | | 3 |
| 3 | Busia County (found in Trans-Nzoia onedrive folder) | | 3 |
| 4 | Elgeyo Marakwet County | | 5 |
| 5 | Embu County | | 12 |
| 6 | Homabay County | | 5 |
| 7 | Kericho County | | 3 |
| 8 | Kiambu County | | 8 |
| 9 | Kisii County | | 6 |
| 10 | Kisumu County | | 5 |
| 11 | Kitui County | | 7 |
| 12 | Machakos County | | 7 |
| 13 | Makueni County | | 8 |
| 14 | Muranga County | | 5 |
| 15 | Nakuru County | | 5 |
| 16 | Nyeri County | | 2 |
| 17 | Trans-Nzoia County | | 4 |
| 18 | Uasin Gishu County | | 40 |
| | | | |

| | | | |
|---|---|---|---|
| 19 | Dowa | | 9 |
| 20 | Machinga | | 13 |
| 21 | Zomba | | 11 |
| 22 | Dedza | | 7 |
| 23 | Bvumbwe | Malawi | 178 |
| 24 | Blantyre | | 76 |
| 25 | Phalombe | | 222 |
| 26 | Lilongwe | | 4 |
| 27 | Balaka | | 4 |

Table A-2: Distribution of spreadsheets, villages and questionnaires. Individual spreadsheets, and the raw surveys on which they are based, are available from S. F. Johnston.

## Appendix 4 Maps of surveyed regions

Map of Kenya (Source- http://www.nationsonline.org/oneworld/map/kenya_map2.htm and https://www.google.co.uk/maps/@-0.0562665,35.971943,8.75z

With reference to the supplied questionnaires and the 'Surveys No' spreadsheet, identified belowis a rough indication of the area and where the villages are where the data was collected (dark blue circle / RED dots). The following map is a close-up of this selected area. The Towns / villages are identified with RED dots.


**Figure A-1: Kenya overview, with sampled regions indicated**

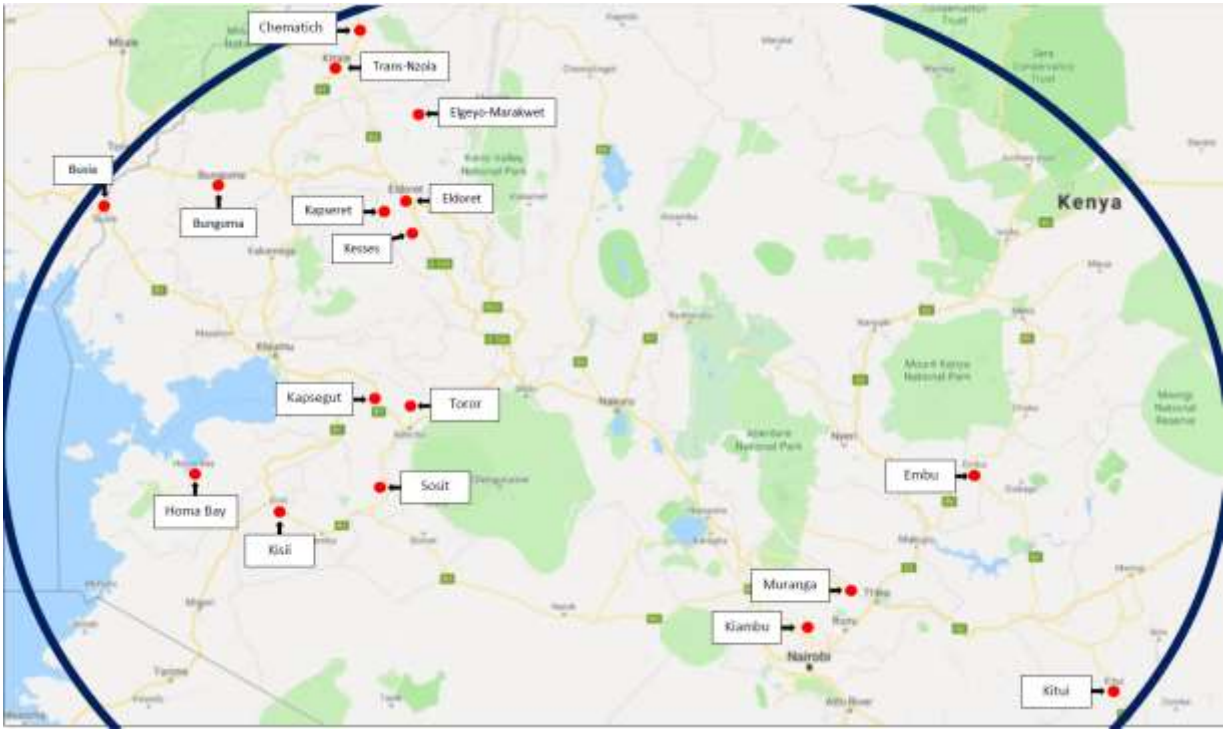



**Figure A-2: sampled villages in Kenya**

Map of Malawi (Source- http://www.nationsonline.org/oneworld/map/malawi_map.htm)

With reference to the supplied questionnaires and the 'Surveys No' spreadsheet, identified below are the regions / towns where the data was collected. I have identified these regions with GREEN Dots and boxed them with their names. Please see below.

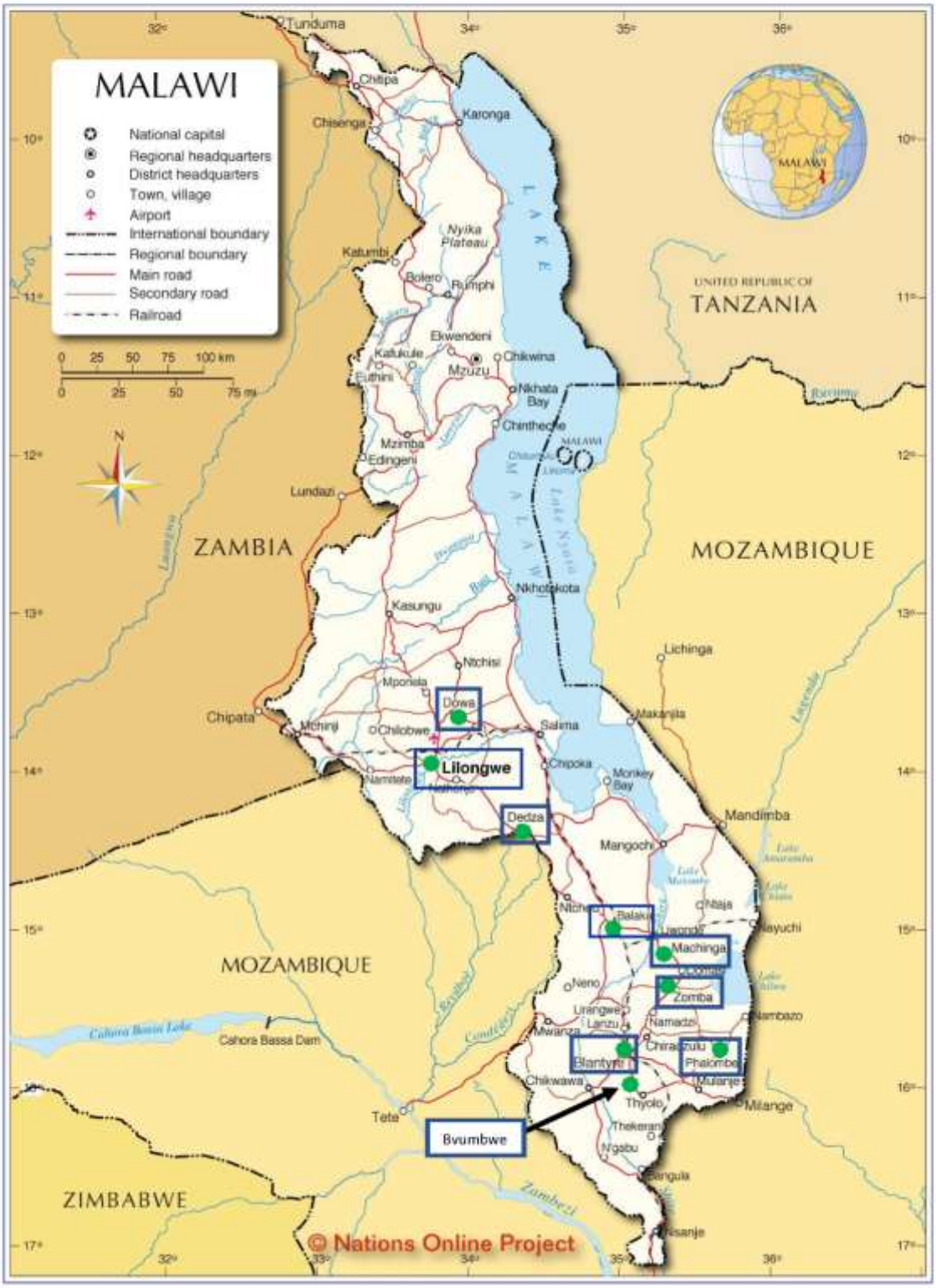
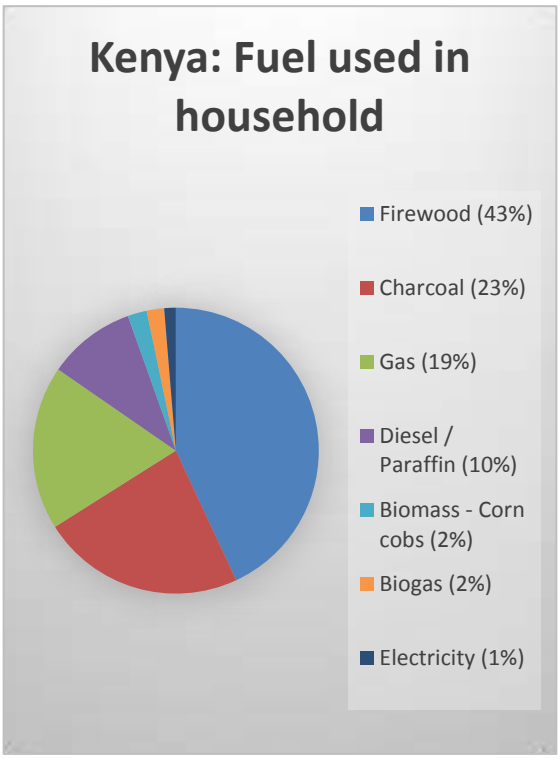
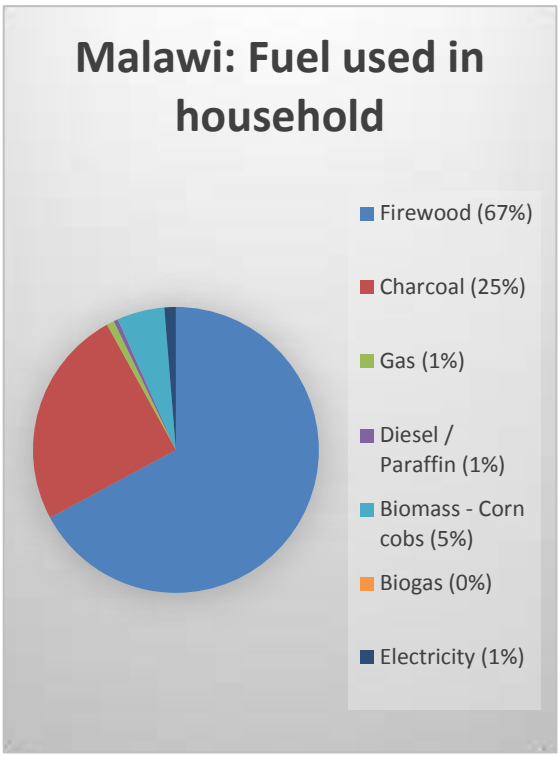


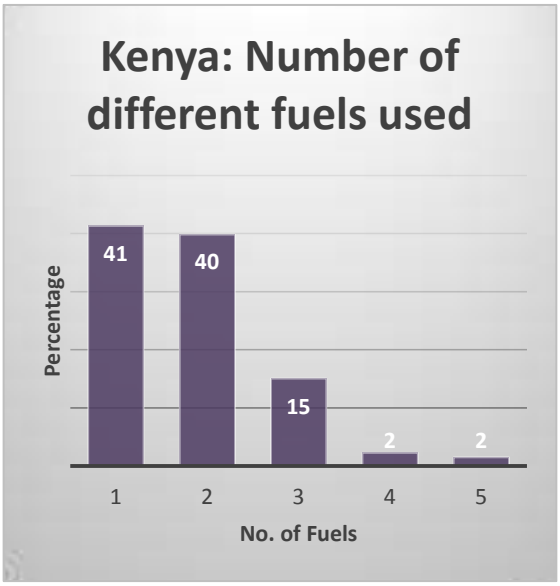

**Figure A-3: Malawi overview, with sampled areas indicated**

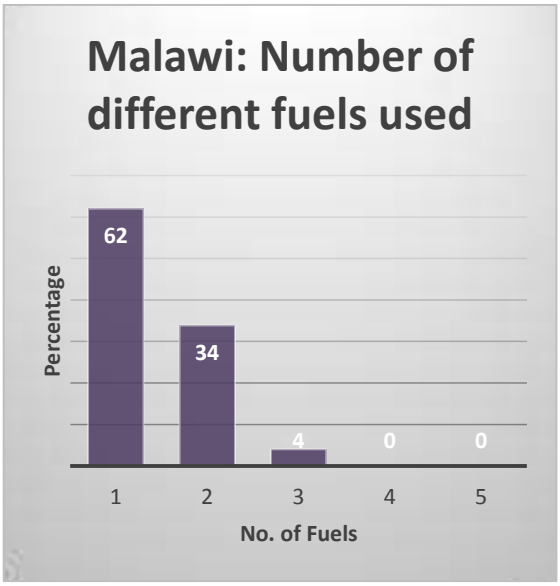
## Appendix 5 National summaries

***Q1: What fuel(s) do you burn?***

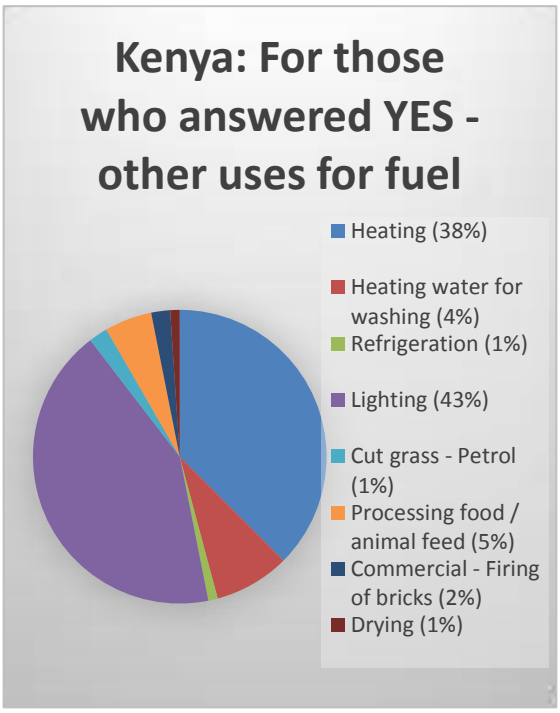


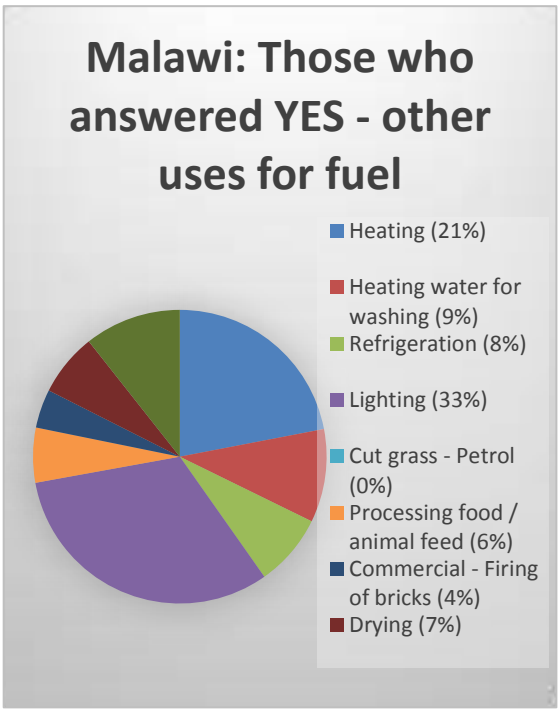



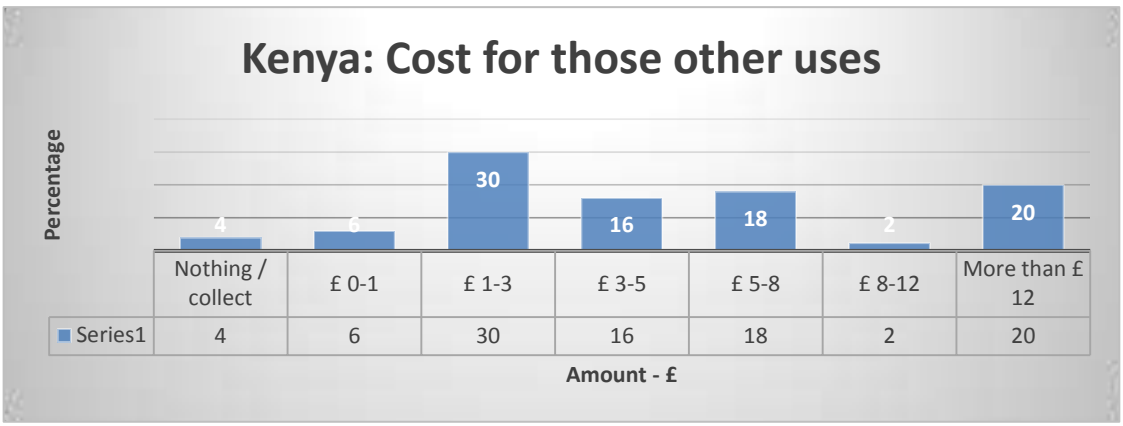



***Q3: What are the other purposes for which you burn fuel?***

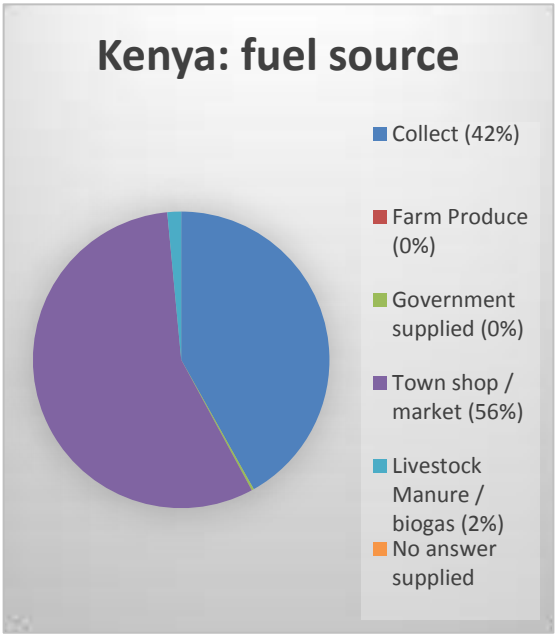


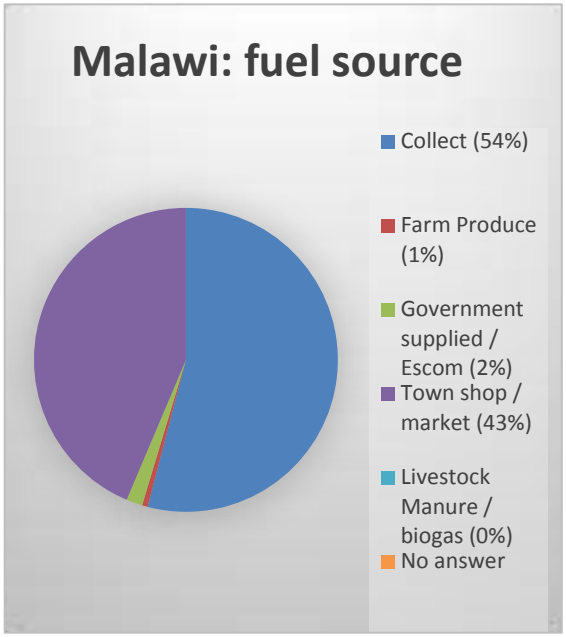




***Q6: What does it cost per month?***

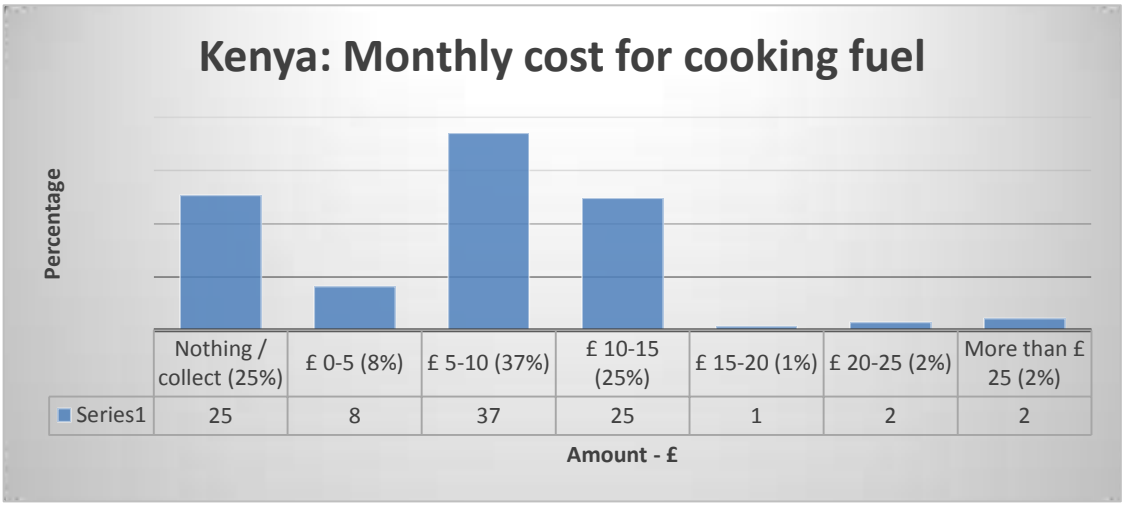


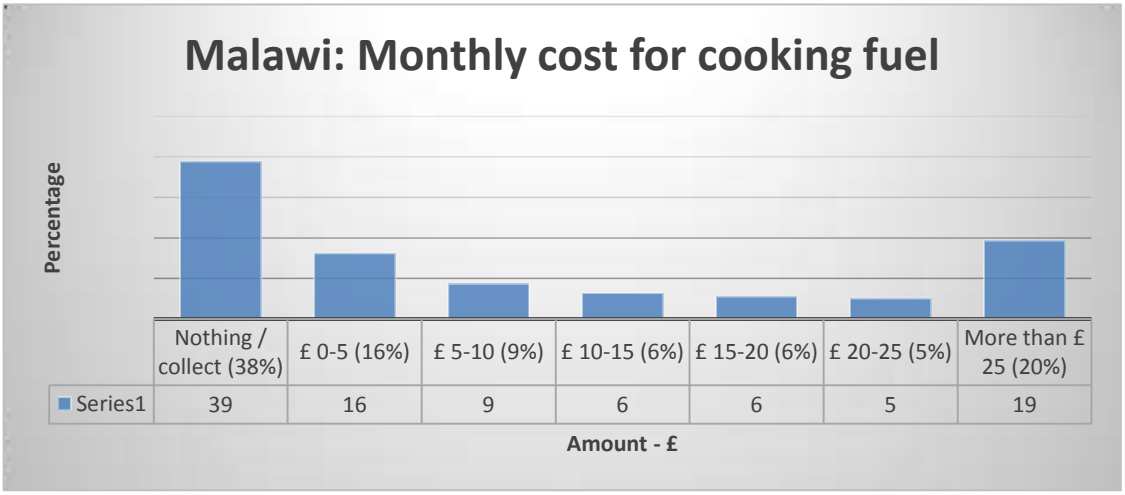

***Q9: From where do you get this fuel?***



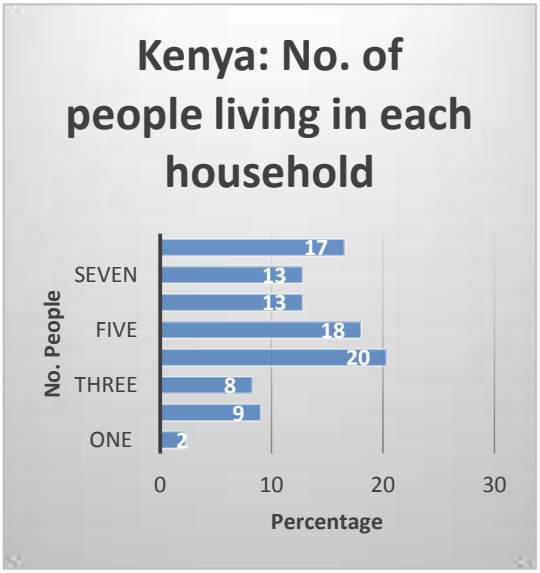



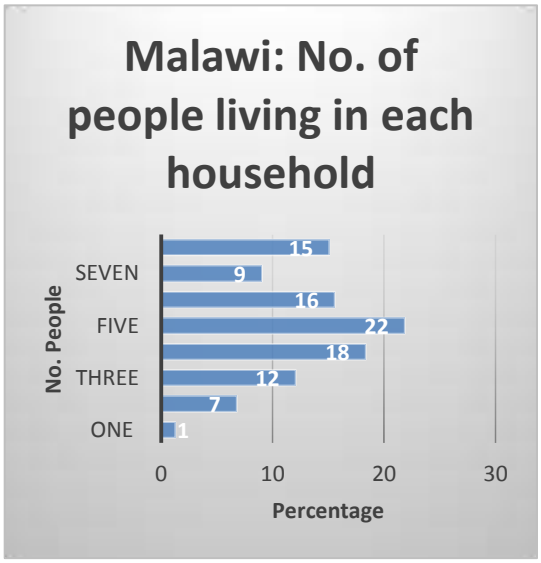

***Q13: How much do you pay per month?***



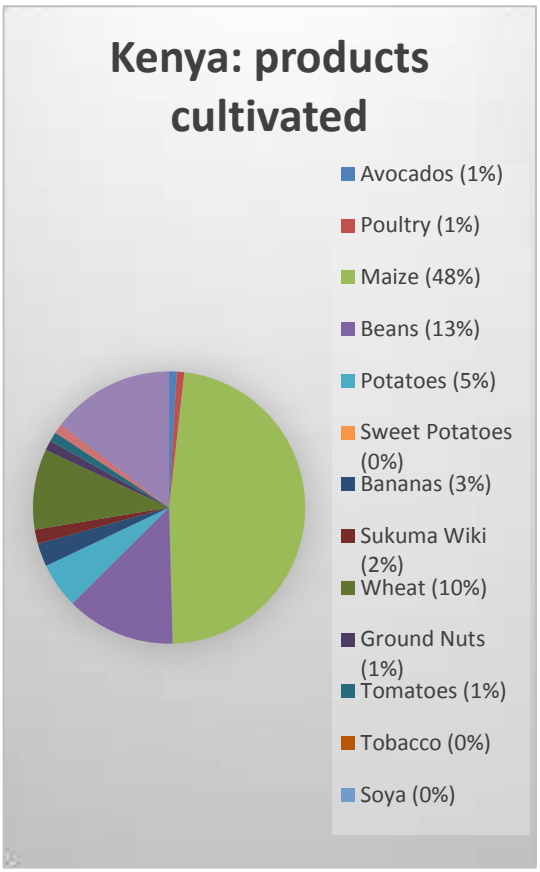



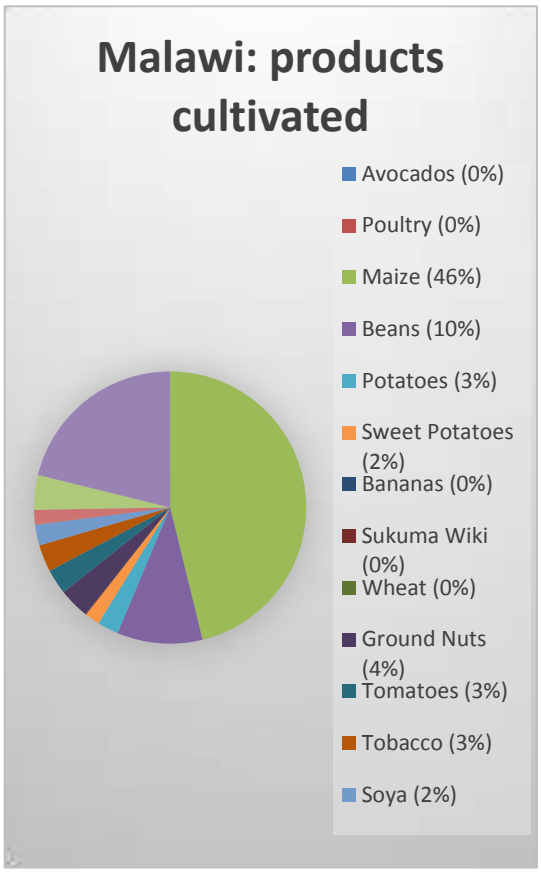
***Q19: How many people live in your house?***



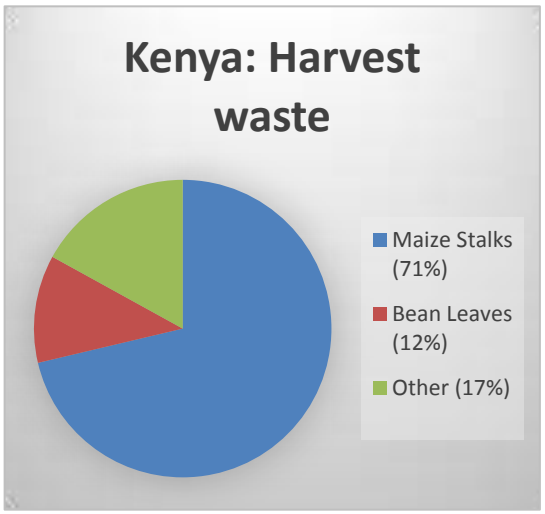



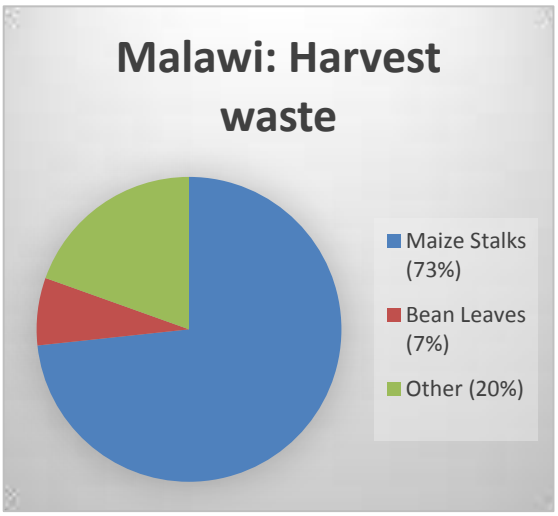

***Q31: Which agricultural products are cultivated in your area?***



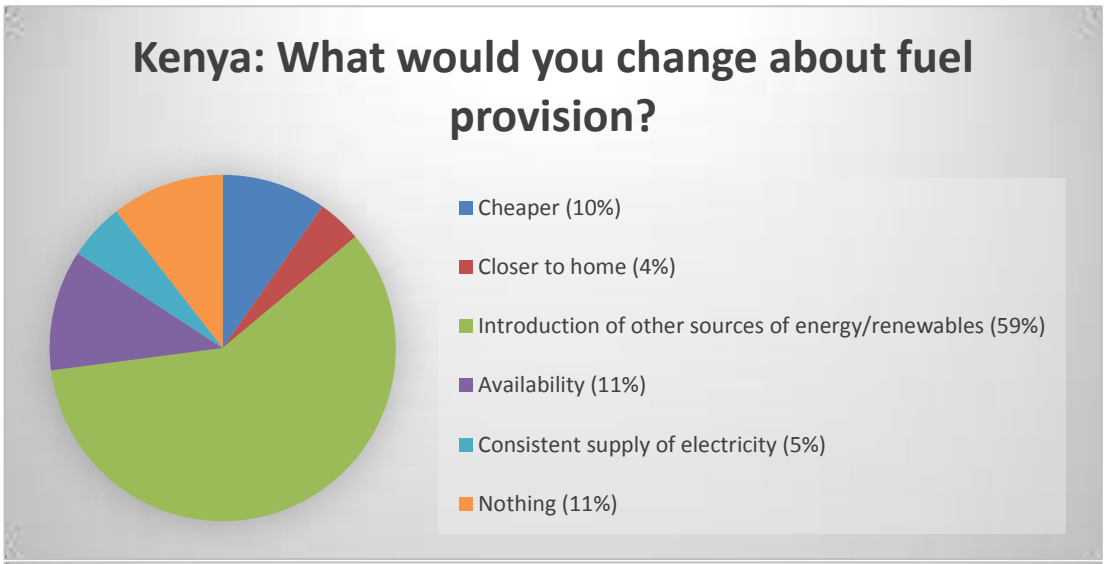



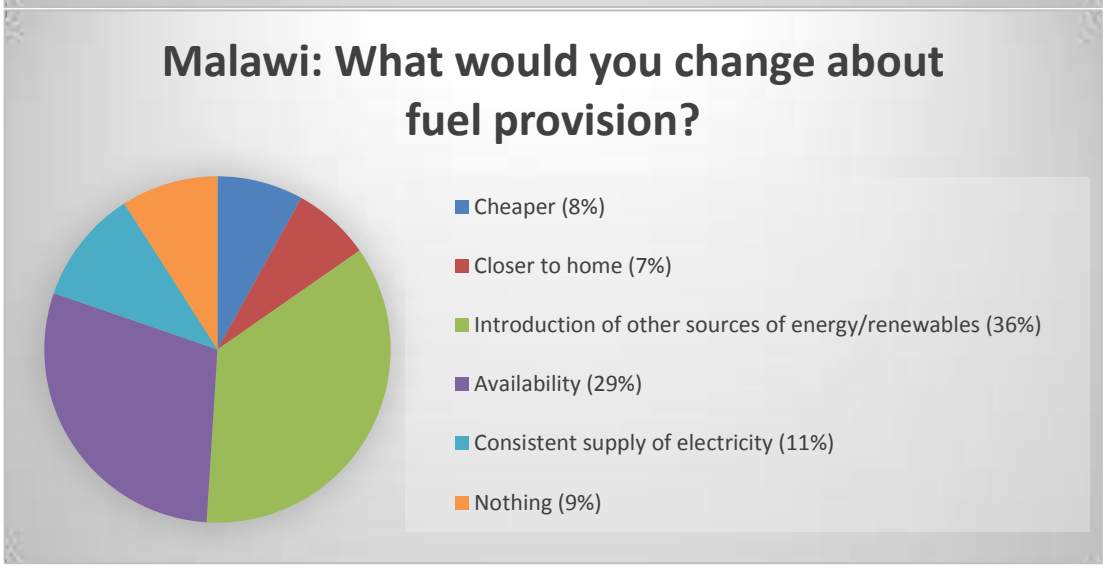
*Q33: What waste is produced after harvest?*



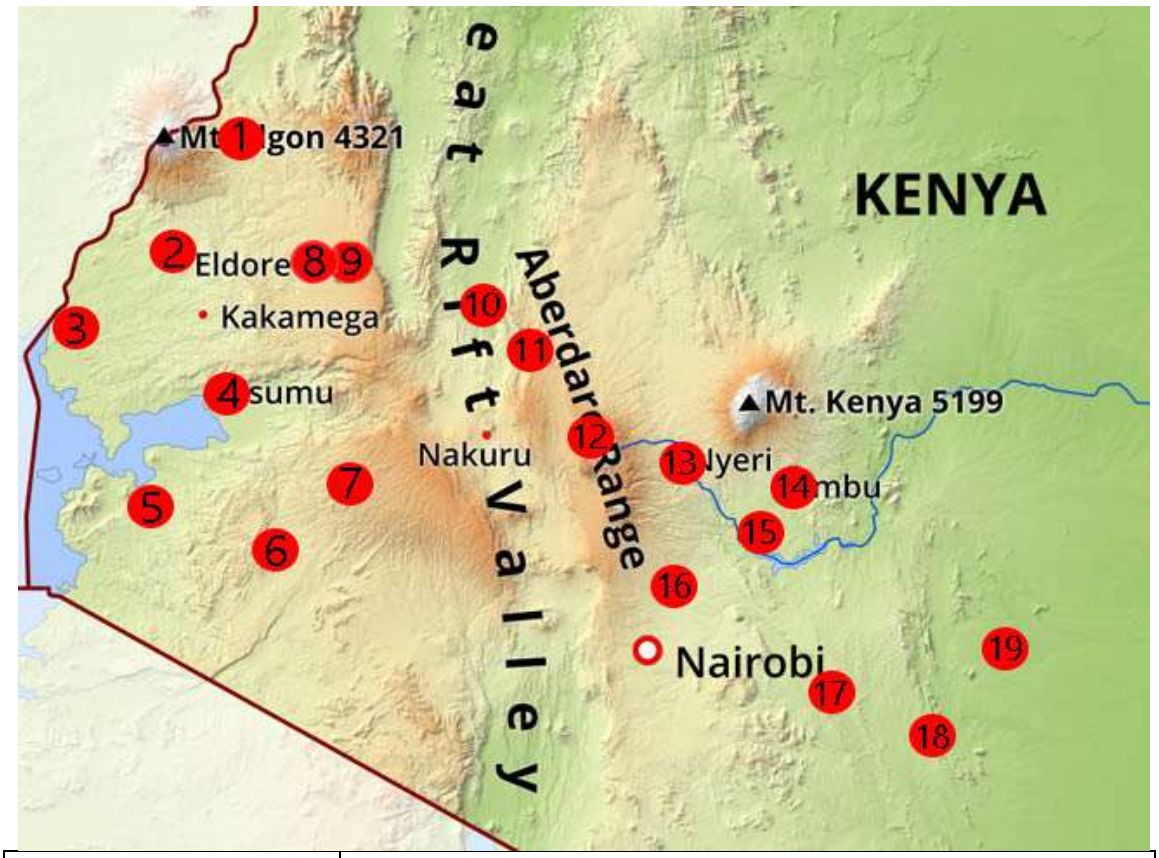

*Q57 What would you like to change about fuel provision in your community?*

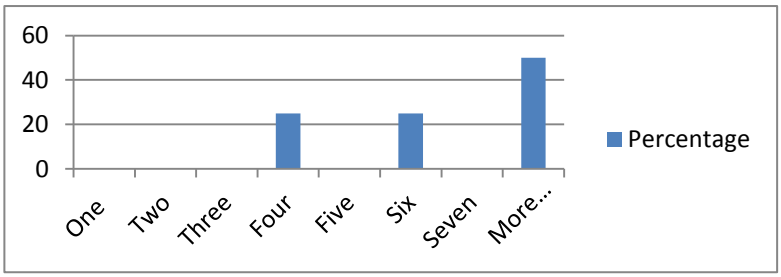
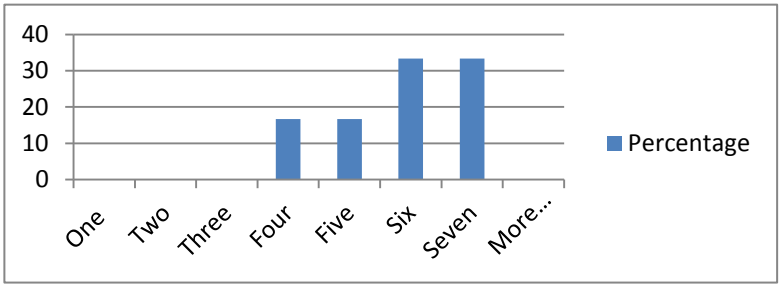


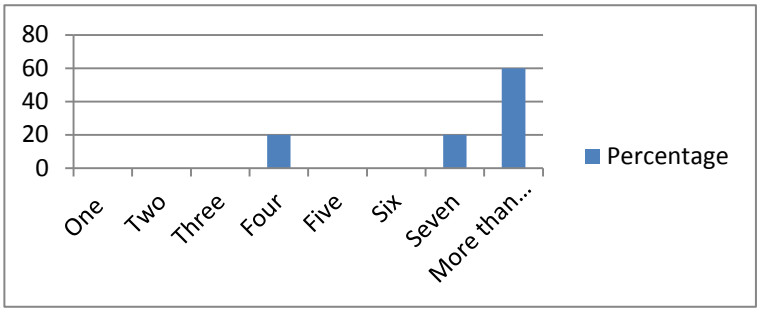
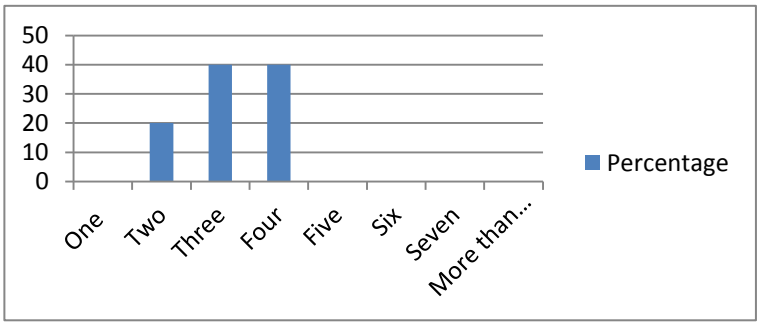
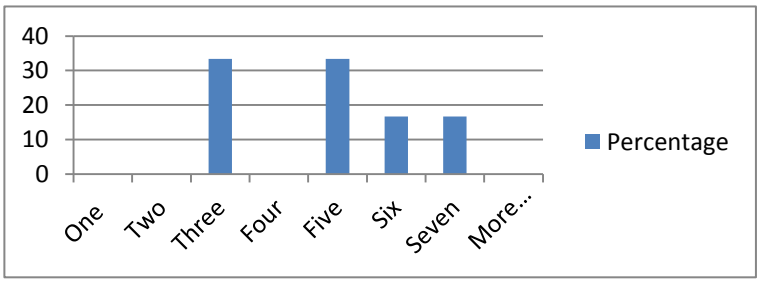



## Appendix 6 Regional variations

### *6A Kenya primary fuel sources and household size by county*




| Region | Dominant fuels |
|---|---|
| 1. Trans-Nzoia (*n*=4) | Firewood (43%), charcoal (38%)   |
| 2. Bungoma (*n*=6) | Charcoal (47%), firewood (30%)   |

| | |
|---|---|
| 3. Busia<br>[little data] | Firewood (50%), charcoal (33%) |
| 4. Kisumu (*n*=5) | Firewood (40%), charcoal (30%)<br>  |
| 5. Homabay (*n*=5) | Gas (40%), charcoal (30%), firewood (20%)<br>  |
| 6. Kisii (*n*=6) | Firewood (92%)<br>  |
| 7. Kericho<br>[little data] | Firewood (50%) |

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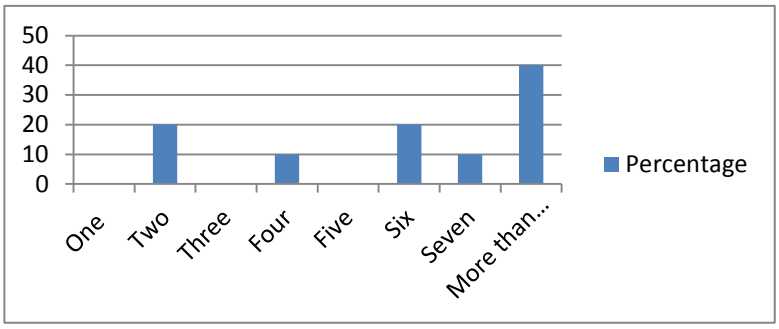
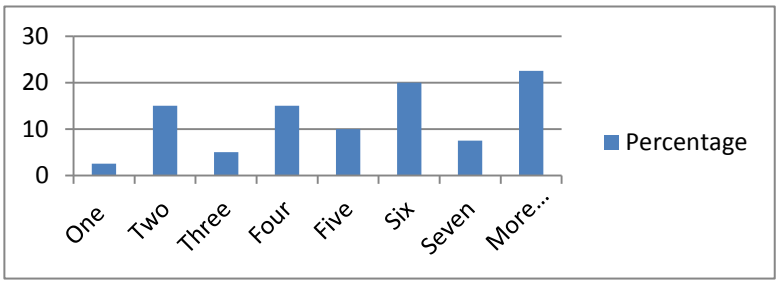
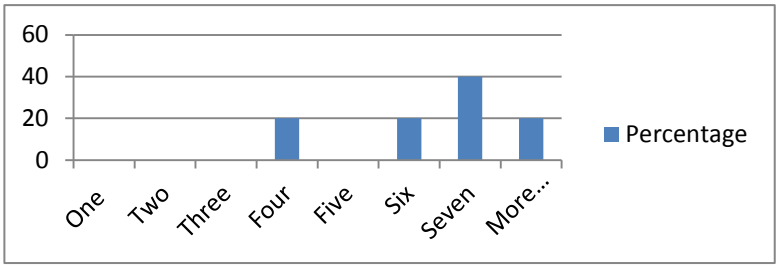
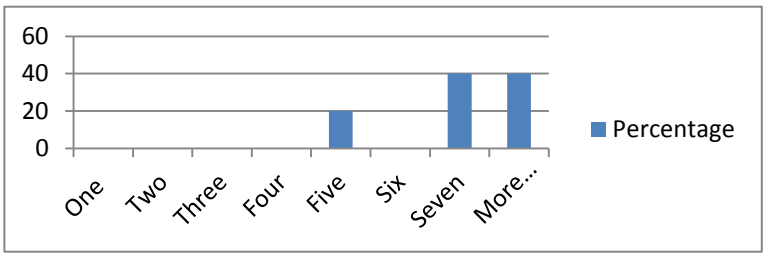
|---|---|
| 8. Eldoret (*n*=10) | Firewood (40%), biomass (28%)<br>  |
| 9. Uasin Gishu (*n*=40) | Firewood (38%), gas (28%), charcoal (26%)<br>  |
| 10. Elgeyo Marakwet (*n*=5) | Firewood (57%), gas (10%)<br>  |
| 11. Baringo (*n*=5) | Firewood (80%)<br>  |

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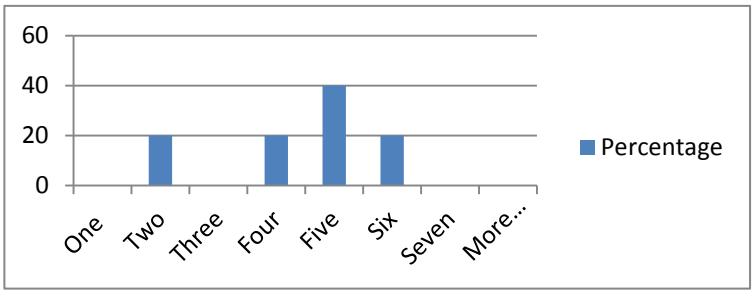
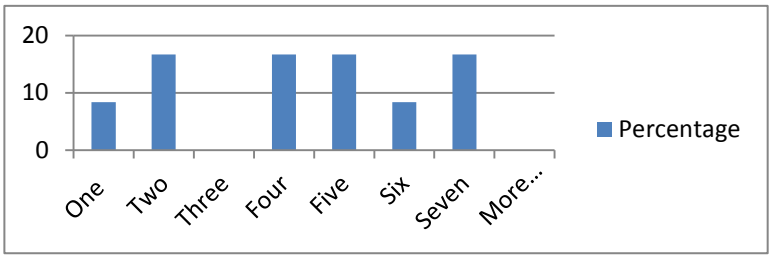
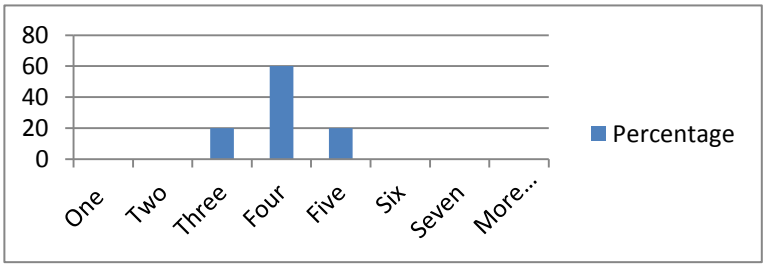
|---|---|
| 12. Nakuru (*n*=5) | Gas (40%), charcoal (30%), firewood (23%)<br>  |
| 13. Nyeri<br>[little data] | Charcoal (50%), firewood (50%) |
| 14. Embu (*n*=12) | Charcoal (35%), firewood (32%)<br>  |
| 15. Muranga (*n*=5) | Firewood (60%)<br>  |

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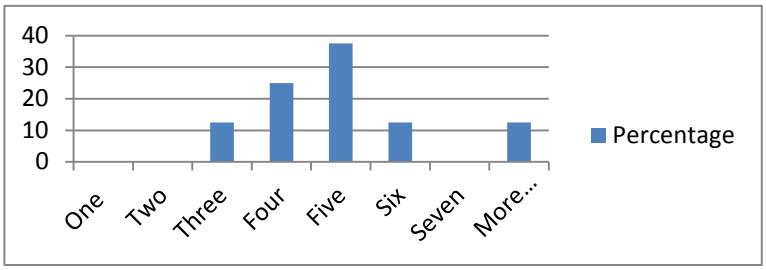
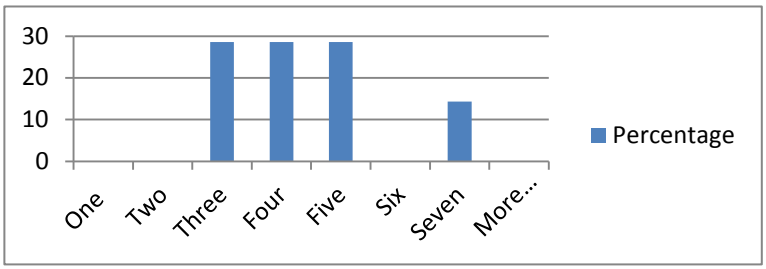
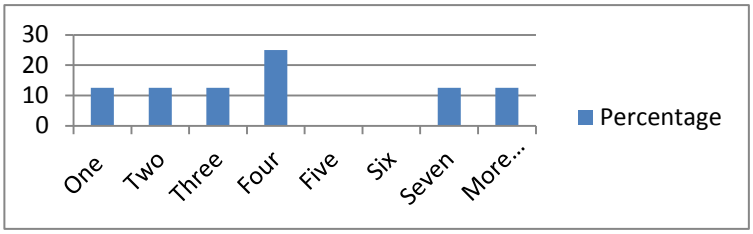
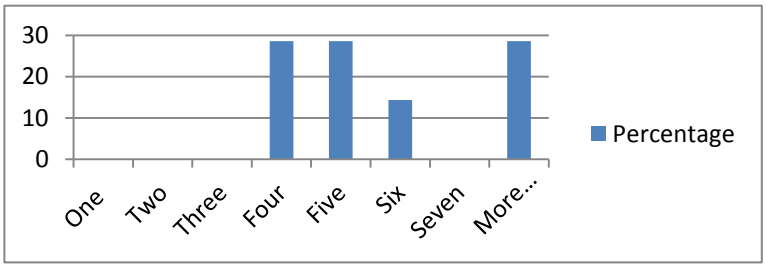
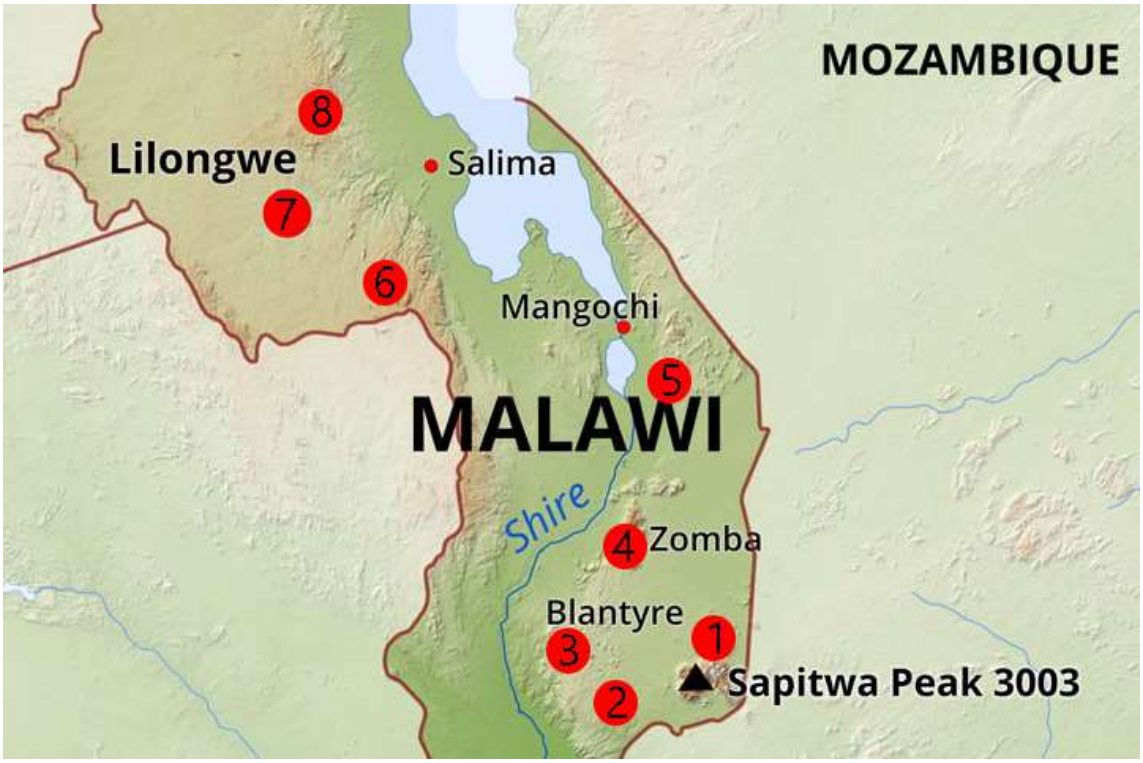
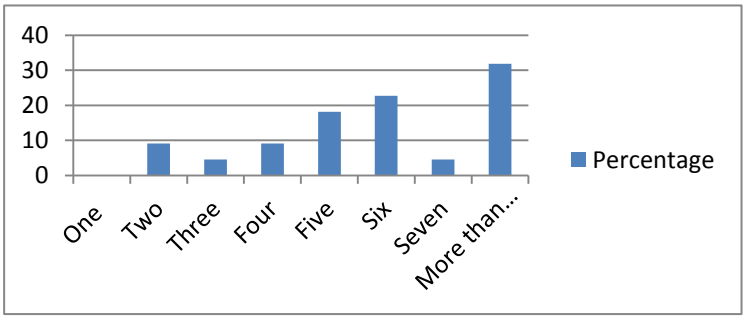
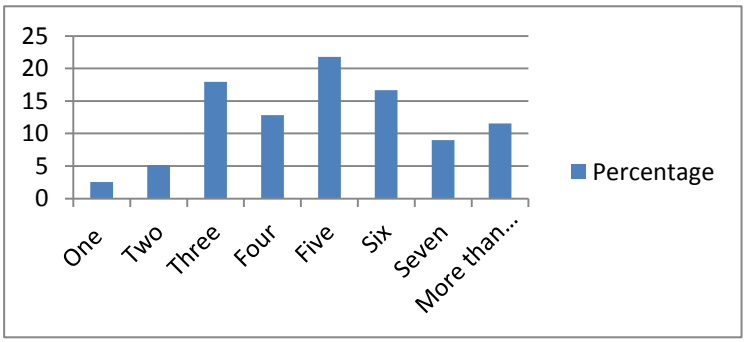
|---|---|
| 16. Kiambu (*n*=8) | Firewood (43%), gas (23%, biogas (18%)<br>  |
| 17. Machakos (*n*=7) | Firewood (77%), gas (15%)<br>  |
| 18. Makueni (*n*=8) | Firewood (32%) and charcoal (32%)<br>  |
| 19. Kitui (*n*=7) | Charcoal (36%) and diesel/paraffin (36%)<br>  |

***6B Malawi primary fuel sources and household size by county***




| | |
|---|---|
| 1. Phalombe (batch 4, *n*=22) | Firewood (79%), charcoal (11%), biomass (9%)<br>  |
| 2. Bvumbwe (*n*=78) | Firewood (80%), charcoal (17%)<br>  |
| 3. Blantyre (*n*=40) | Charcoal (66.33%) and firewood (26.5%) |

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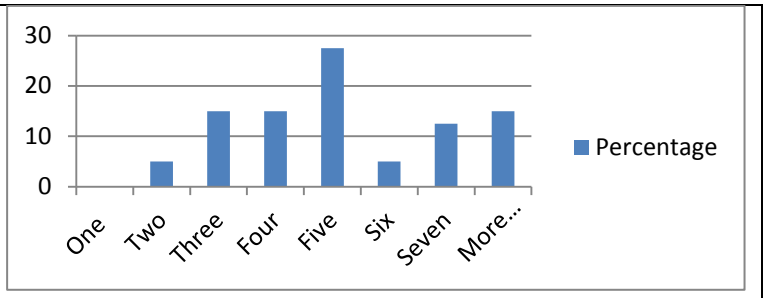
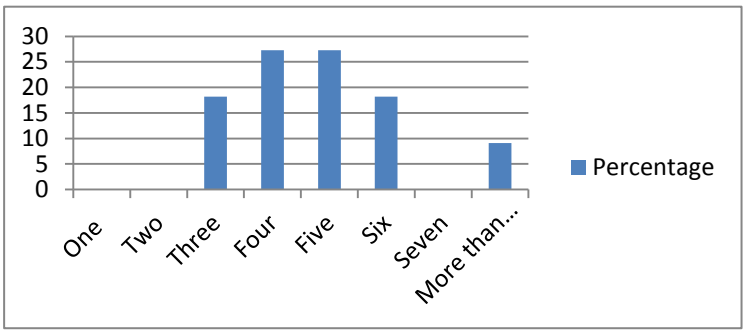
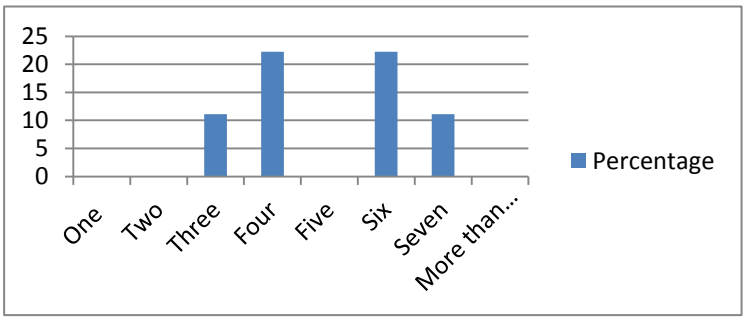
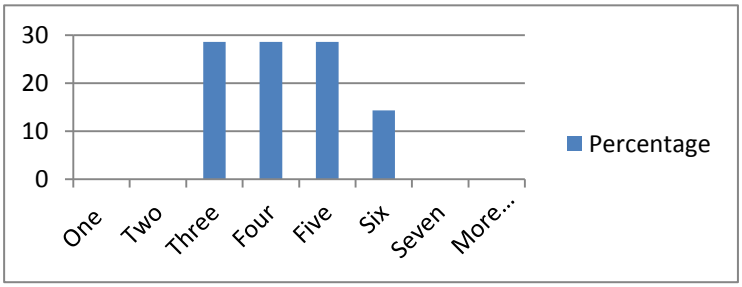
| |  |
| 4. Zomba (*n*=11) | Firewood (55%), charcoal (23%)<br>  |
| 5. Machinga (*n*=10) | Firewood (74%), charcoal (20%)<br>  |
| 6. Dedza (*n*=7) | Firewood (59%), charcoal (16%)<br>  |
| 7. Lilongwe (*n*=4) | Firewood (88%) |

| | |
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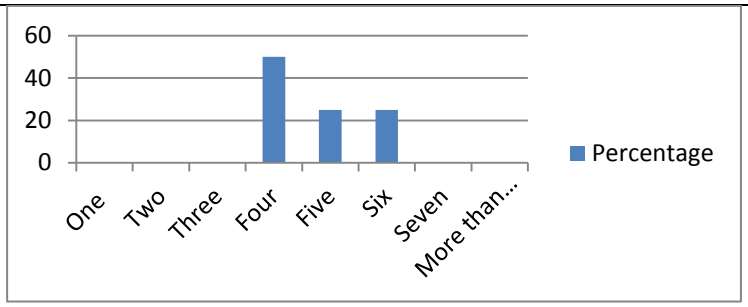
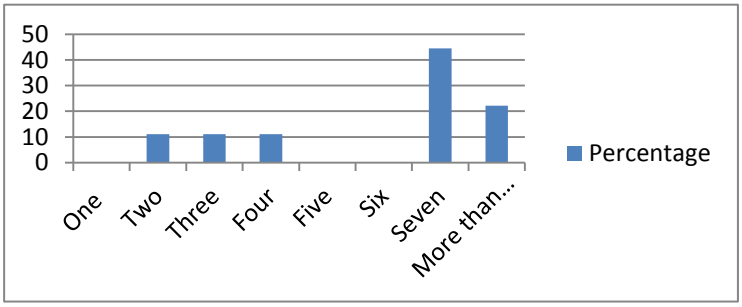
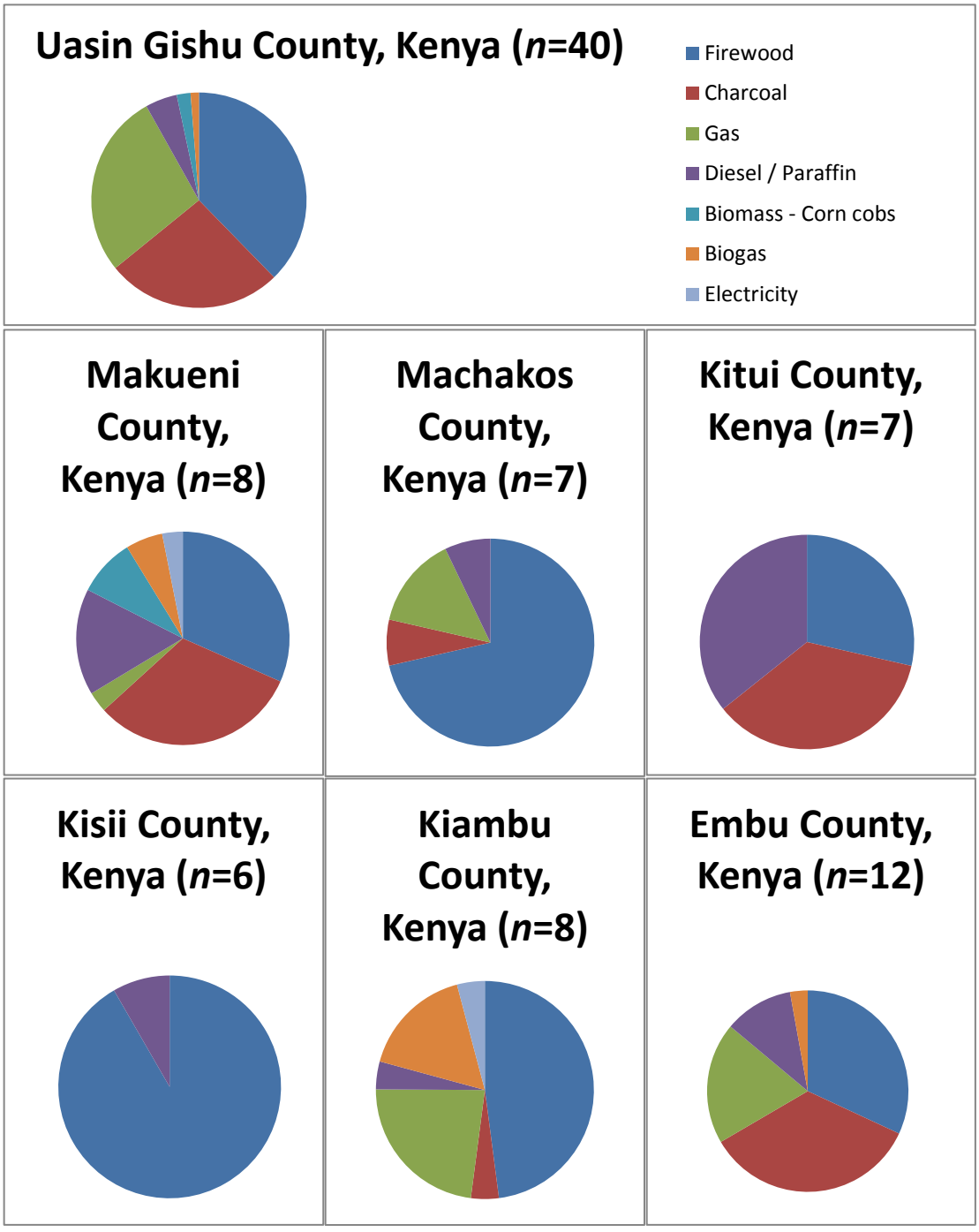
| |  |
| 8. Dowa (*n*=9) | Firewood (52%) and charcoal (35%)<br>  |

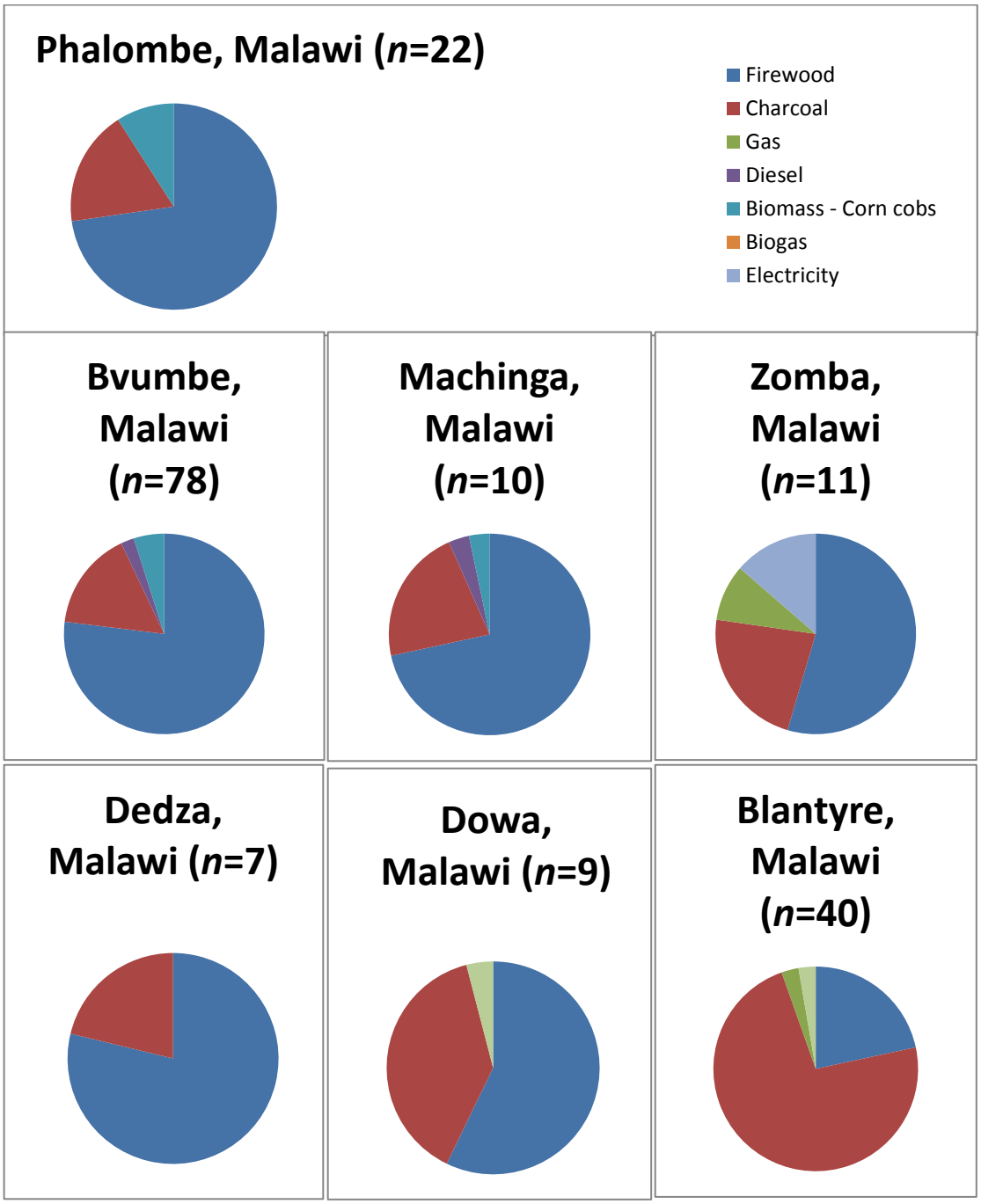
**Appendix 7 Graphical summaries for particular regions**

The graphics selected below illustrate the large variations between the responses of different regions. Each pie chart displays data from selected single counties where there are 6 or more survey responses recorded. Note that responses from different areas within the same county may differ considerably.

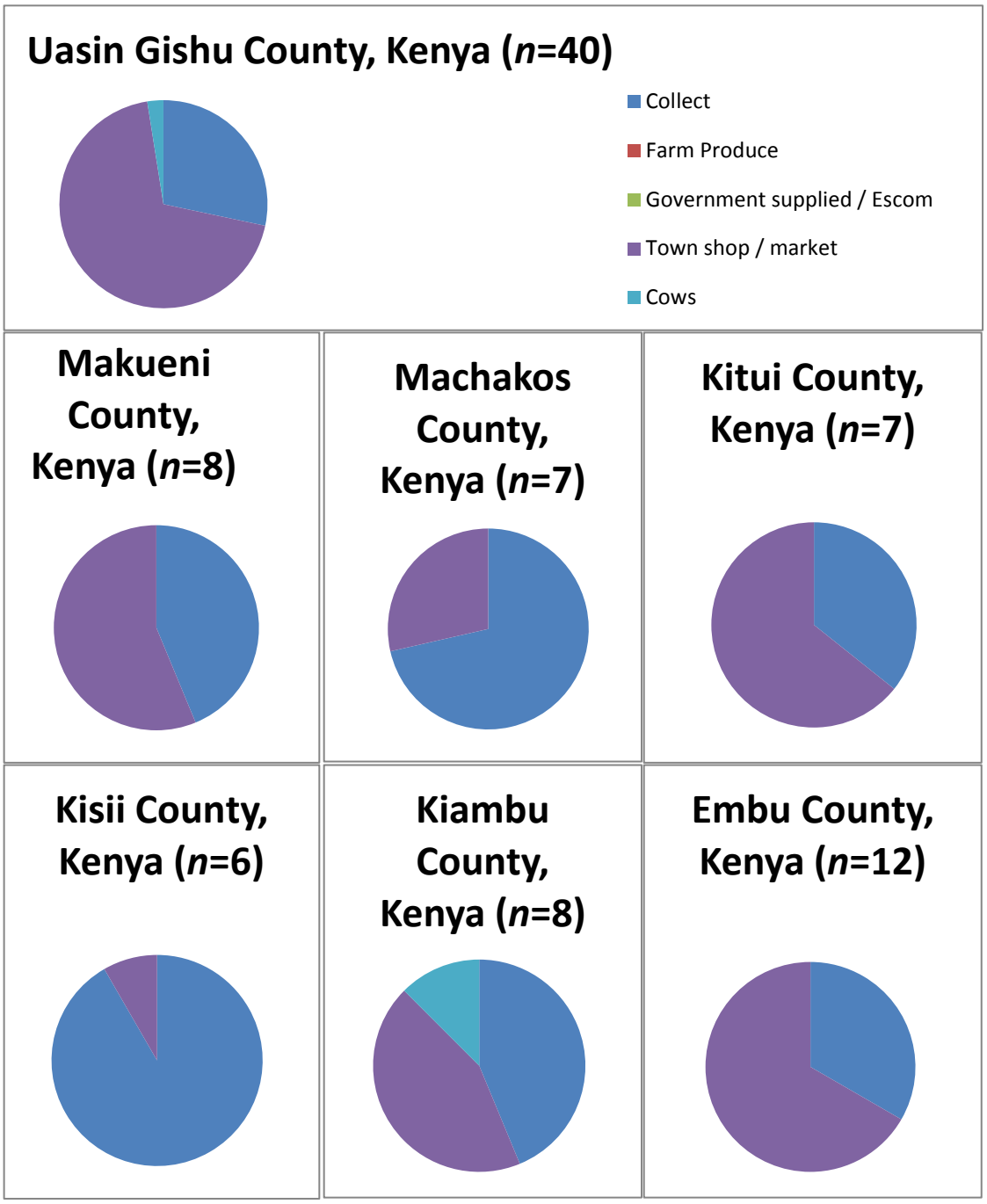
***Q1: KENYA: What fuel is used in the household?***



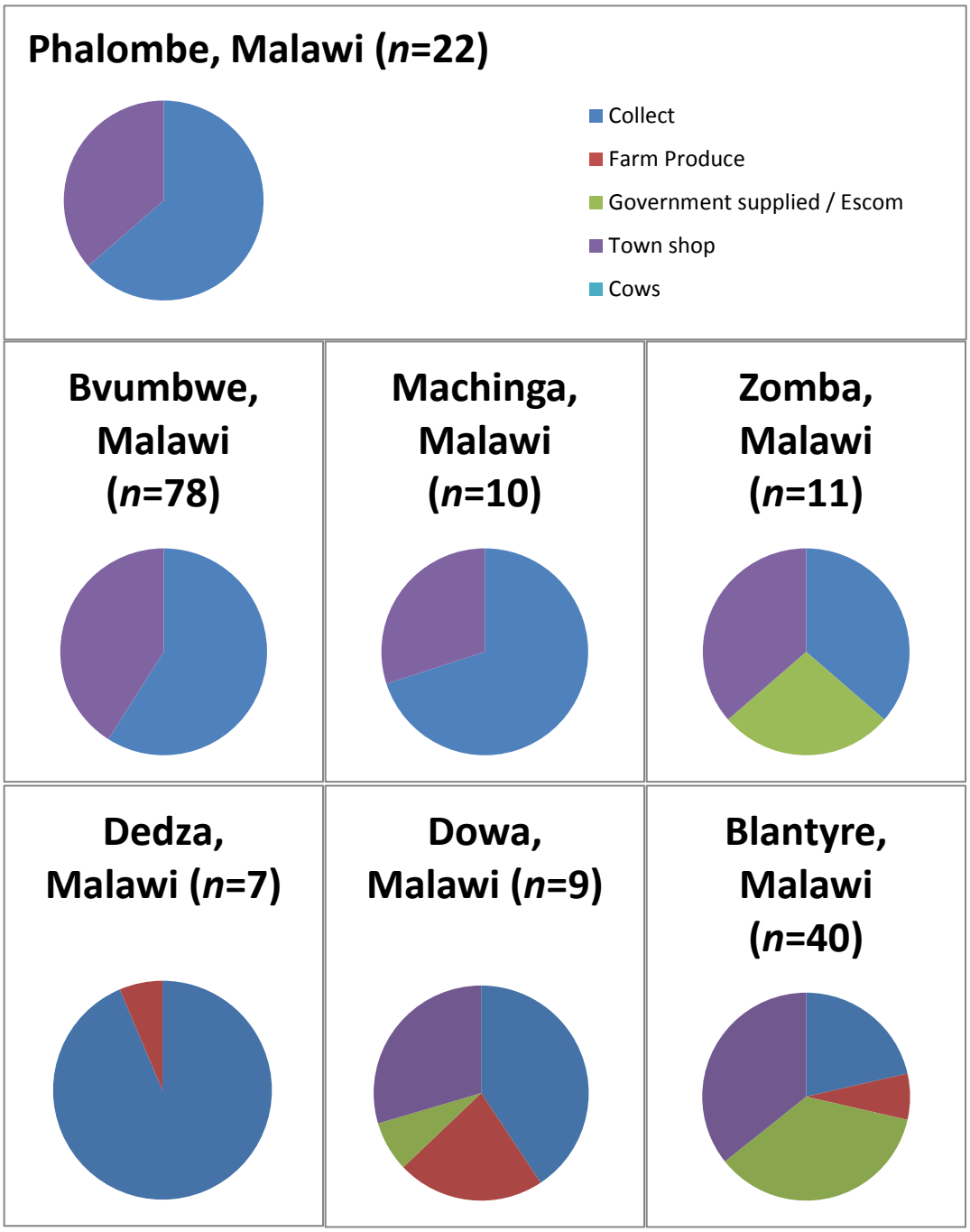

***Q1: MALAWI: What fuel is used in the household?***


Phalombe, Malawi (n=22)
Firewood
Charcoal
Gas
Diesel
Biomass - Corn cobs
Biogas
Electricity
Bvumbe, Malawi (n=78)
Machinga, Malawi (n=10)
Zomba, Malawi (n=11)
Dedza, Malawi (n=7)
Dowa, Malawi (n=9)
Blantyre, Malawi (n=40)

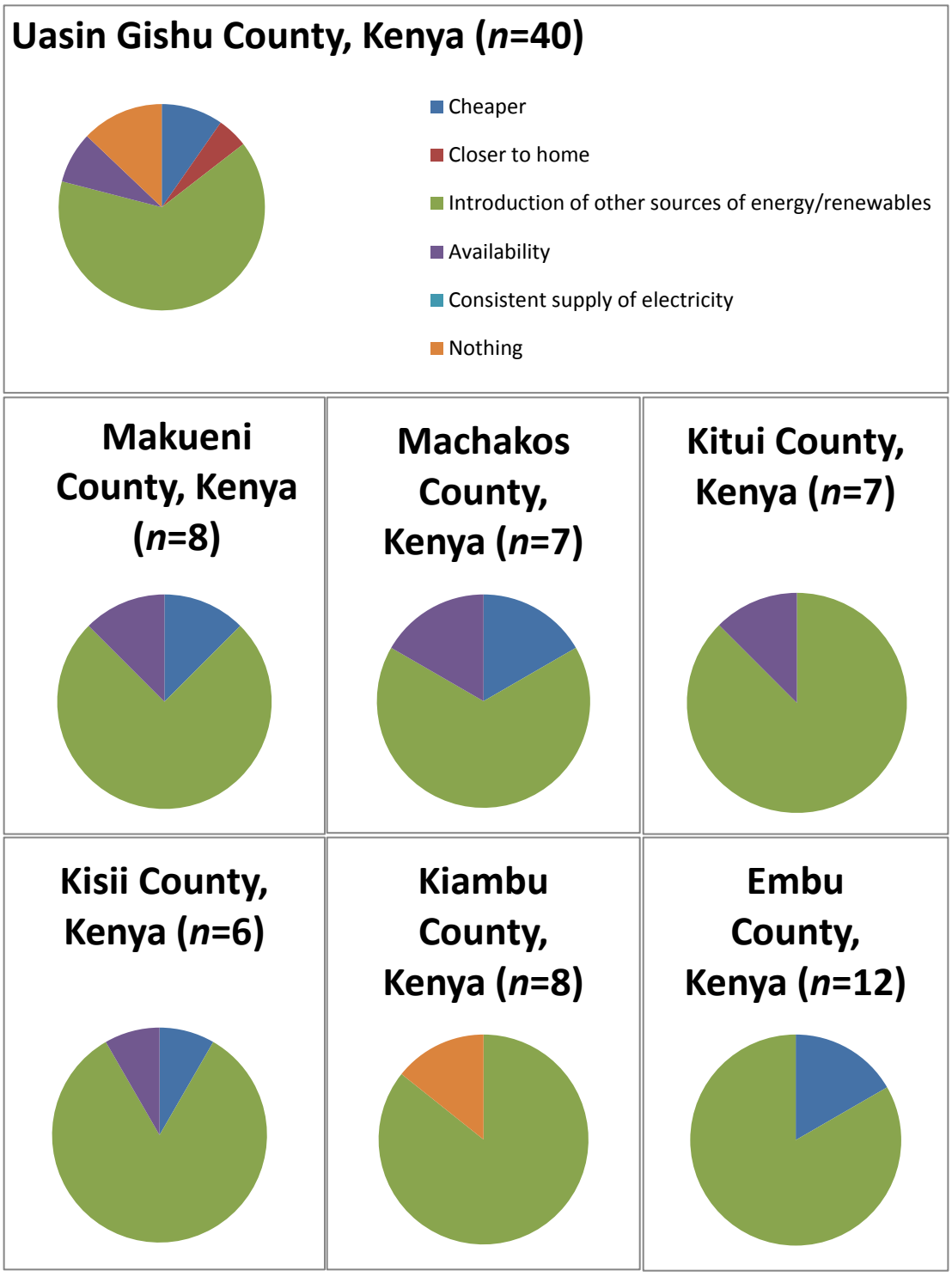
*Q9: KENYA: From where do you get this fuel?*



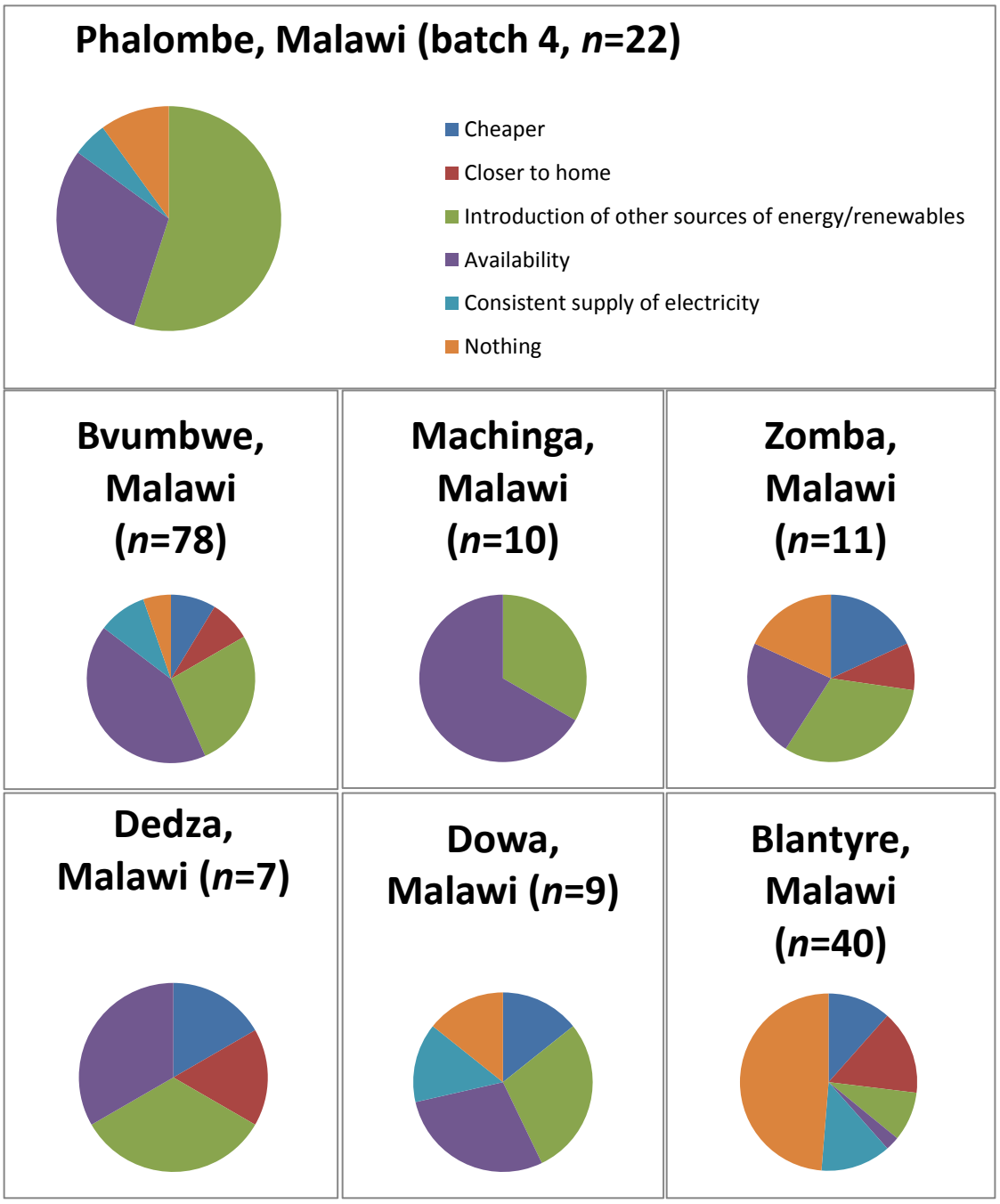
*Q9: MALAWI: From where do you get this fuel?*



*Q57: KENYA: What would you change about fuel provision?*



*Q57: MALAWI: What would you change about fuel provision?*



University of Glasgow

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