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Cooking and Lighting Habits in Rural Nepal and Uganda

SCORE Project

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Abstract

Nearly a quarter of the world's population has no access to electricity and nearly half cook with biomass or coal. Over the past 30 years there have been several initiatives to design and introduce appropriate, renewable energy technologies for household energy supply. However, few of these have been successful in terms of significant penetration and long term sustainability. A new initiative, the SCORE project, was launched in 2007 with the objective of producing a clean biomass cook stove which also incorporates a thermo-acoustic engine which converts some of the heat into electricity. It was vital to determine the technical requirements of this new device as a pre-requisite to engineering development particularly in the two candidate countries where this new technology was to be trialled: Nepal and Uganda. Accurate data could not be sourced in the open literature and therefore studies were commissioned in order to obtain the relevant data. The data obtained is of significant value for any development projects involving the provision of small-scale off-grid electrical power and heat for cooking.

1 Introduction

Energy access for the poor is a vital precondition to achieving the Millennium Development Goals (MDGs) and sustainable development. Out of the 6.5 billion people in the world, around 1.44 billion have no access to electricity, around 2.5 billion cook with solid biomass (wood, sawdust, charcoal, dung, etc) and around half a billion cook with mineral coal. The great majority of these people are poor and living in remote areas of developing countries. Countries with lower levels of investment in energy access are also off-track with the MDGs, especially the poorest countries in Sub-Saharan Africa and South East Asia [5].

The challenges regarding energy access for the poor and especially for those living in remote areas are huge, not only because of their lack of purchasing capacity to access commercial technologies or fuels and/or the lack of appropriate local technologies, but because a range of barriers exist related to social, cultural and organizational issues, which have not been fully addressed [1].

During the past 30 years or so there have been several initiatives to design appropriate technologies to lower costs and to ease operation and maintenance, especially in the area of renewable energy technologies. There have also been several initiatives designed to address the social and cultural issues associated with energy technologies and energy sources, the aim of which is to contribute to long term sustainability and replication. There are currently several examples of relatively low cost, appropriate and locally made

technologies which have been proven to work well under specific conditions and contexts. However, the attempts to replicate them in different contexts have mostly failed, and in many cases long term sustainability has also not been achieved.

The SCORE project [2] [3] is a recent initiative in appropriate energy technologies, the aim of which is to combine the two main needs of cooking and electricity generation into a single stove unit, using the traditional source of biomass fuel (generally wood) but in a way that is more efficient and environmentally friendly. An important initial component of this project has been to carry out household surveys to formulate detailed specifications on the needs for cooking and electricity. Two countries have been chosen to cover the expected range of needs across different regions of the world.

This document summarises the findings of two surveys; one in Nepal and one in Uganda, which looked at people's current practices and the challenges that they face in meeting two basic energy needs, cooking and lighting. The survey places particular attention on cooking and lighting habits in order to find out patterns which could be useful when designing and/or promoting new technologies.

2 Methodology

Stratified sampling methods were used for both cases in order to gather data from the varying climatic conditions of the different geographical regions for both countries. In Nepal the sample was made up of 360 households, divided into three equal groups of 120 households from each of the main geographical regions (mountainous, hilly and *tera*). In Uganda the sample was made of 471 households, divided into five groups, each covering one of the five main geographical regions; Central-Southern, Central, Northern, Western, and Eastern. 112 were from the Central-Southern area (Mukono and Masaka), 106 Central (Kampala and Wakiso), 85 Northern (Arua), 85 Western (Bushenyi) and 83 Eastern (Sironko). A questionnaire with the same set of questions was prepared for both countries and then translated into the local language.

The questions were designed to gather information about cooking and lighting needs and habits, and also to find out about the energy resources used for cooking and lighting. In addition to surveying the existing situation, the questionnaire is also designed to assess the potential demand for improved technologies through questions related to purchasing capacity; people's ideas on what makes a good cook stove; awareness of the respondents and their views regarding smoke emission and its impact. The questionnaire also asked about people's interest in electricity for lighting (replacing kerosene and candles) and for powering devices like radios and small television sets.

The focus of the surveys was the family unit, where this is considered to be those family members living in the same house and sharing the same budget.

3 Country backgrounds

While Nepal and Uganda are two countries with very different cultural backgrounds, they are also similar in many respects. Each country has distinctive geographical features. Both are landlocked and have a wide range of terrain from mountainous/hilly regions to tropical areas and both are relatively small and densely populated. According to the World Bank (2007 estimate), out of 207 countries in the world ranked by their purchasing power, Nepal stands in 189th position with an annual GDP of US\$1040 and Uganda in 192nd position with an annual GDP of US\$920[6]. Both countries have low human development indicators (HDI); out of 177 countries listed and ordered by their HDI[7], Nepal stands in 142nd position and Uganda in 154th. Furthermore, both countries have a high proportion of the population living in rural areas, in Uganda the figure is 87 per cent and in Nepal, 86 per cent[7].

Regarding energy access, both Uganda and Nepal have a very low level of energy consumption and much of the population relies heavily on biomass fuels. The annual per-capita energy consumption in 2005 in Nepal was 338 kilograms of oil equivalent (kgoe). For Uganda there is no equivalent data available, but it is estimated to be similar to that of Nepal. This value is far below the average consumption in developing countries and also below the average consumption of the low income countries (see table below).

Table 3.1 Energy consumption by region [8]

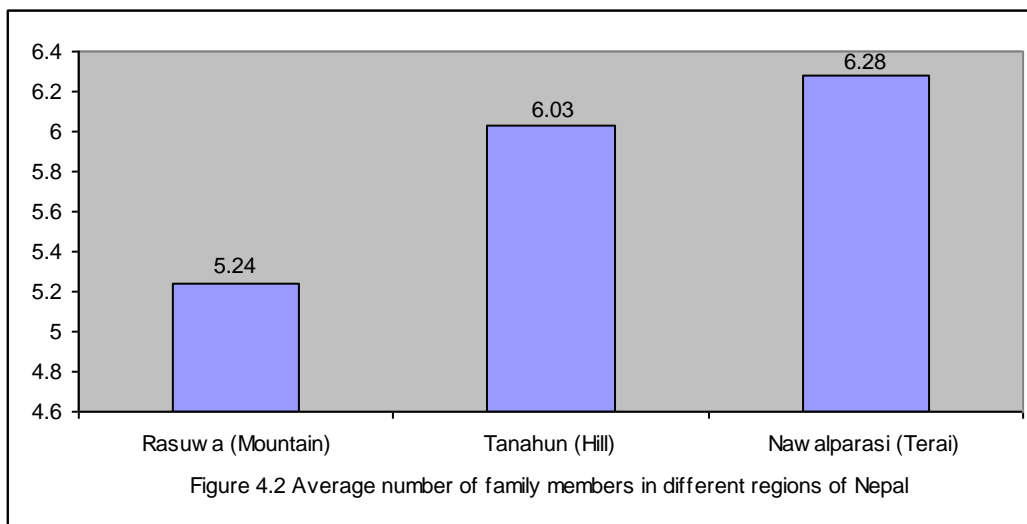
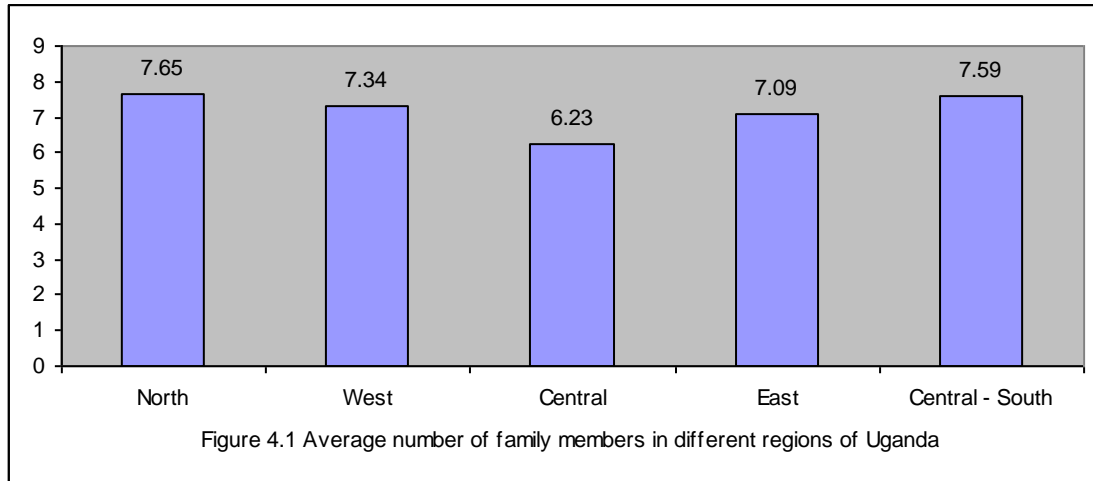
Region/Classification	Annual energy consumption kgoe (2005)
Asia (excluding Middle East)	1,051.50
Central America & Caribbean	1,365.90
Europe	3,773.40
Middle East & North Africa	1,765.50
North America	7,942.90
South America	1,151.20
Developed Countries	4,720.00
Developing Countries	975.9
High Income Countries	5,523.60
Low Income Countries	491.8
Middle Income Countries	1,509.30

4 Research findings

4.1 Family and housing

The average family size among respondents in Nepal was 5.85 members, but with clear differences between regions; 5.24 in the mountainous areas, 6.03 in the hilly areas and 6.28 in the *terai*¹ (see figure 4.1). In Uganda the average number of family members among the respondents was 7.16, with the lowest regional average being 6.23 in the Central region and the highest regional average 7.65 in the North (see figure 4.2). The average household size of the survey groups was similar to the national average in Nepal (5.8) but significantly higher in Uganda (5.2).. It is interesting to note that in both countries in the warmest regions the average family size is higher than in the other regions. However, there appears to have been no research on this and it was not considered part of this study.

¹ Terai refers to land south of the Siwalik Hills, the lowest outer foothills of the Himalaya that once was marshy grasslands, savannas, and forests. In Nepal it refers to plains from the edge of the Siwaliks south to India plus some seven low valleys in the Siwaliks or immediately north of them. In two places the international border closely follows the Siwaliks and "Terai" includes northern districts in Uttar Pradesh and Bihar.



In Nepal the number of rooms in a house ranged from one to nine, with around 72 per cent of houses having two or three rooms. In the mountain region families tended to have smaller house with fewer rooms; 27 per cent of the interviewees had a single room and 39 per cent had two rooms in their houses, while in the other two regions only about 5 per cent of the families have houses with only one room and a large proportion have either three or four rooms. In Uganda the highest regional average was found in the West, with above seven rooms, and the lowest regional average was in the Central region with 2.8 rooms. The national average is 4.4 rooms per house.

While in Uganda it has been difficult to grasp any clear reason for the difference in family houses, in Nepal it appears that the altitude and consequently temperature may influence in the number of rooms; those in the high mountains have a smaller number of rooms to facilitate heating. This finding could be interesting to explore further in future studies since outside temperature is related to the amount of energy needed for heating; the lower the temperature the more energy is needed to keep the house warm.

4.2 Income and poverty

In terms of income sources, farming is the main occupation for about 80 per cent of the respondents in Nepal, however, some of the respondents were also found to be engaged in

foreign employment and government services. The main income source in Uganda is also agriculture; in the North 68 per cent of respondents made their living from agriculture, in the West 81 per cent in the East 83 per cent, only in the Central region does agriculture contribute much less to the economy where only 17 per cent of the people depend on it for a living. The main reason for the low contribution of agriculture in the Central region is the presence of the capital city, Kampala; many people of this region are engaged in some sort of work or services for the city.

With regards to income for the survey group in Nepal, about 28 per cent of households had an annual income of less than US\$ 450 (about US\$1.2 per day), slightly more than 3 per cent had an annual income of greater than US\$ 3000 (US\$ 8.2 per day), while the rest lie between these figures. In Uganda 22 per cent of the families live on less than \$US 600 (US\$ 1.6 per day) and about 9 per cent had more than US\$ 1000 annually (US\$ 2.7 per day).



Figure 4.3 Typical houses in rural Uganda



Figure 4.4 Photo of Tamang community, Rasuwa District, Nepal

4.3 Water supply

Information on the access to water for the survey groups is given in Table 4.1 below.

Table 4.1 Access to water

	Nepal	Uganda	
		Dry season	Wet season
Percentage using rainwater	None	11.3	52.9
Percentage using natural spring	7.3	41	13.9
Percentage using well	29.1	35	23.7
Percentage using standpipe	63.7	10.8	9.5
Volume used per day (l)	150	120	
Volume per person per day (l)	29	17	
Average trips per day	7	6	
Average time per trip (minutes)	10	18	
Average collection time per day (hours)	1.17	1.8	

The most noticeable feature regarding access to water is the much greater reliance on natural sources within the survey group in Uganda. In Nepal over 90 per cent of the survey group have access to an improved water supply, either a well or a standpipe. Since these are located in the community collection times are lower, leading to a greater volume of water being used. Although in Uganda collection times are almost double that for Nepal, they are relatively low compared to many sub Saharan Africa countries. Nine minutes each way suggests an average distance of about 0.6km to the water source whereas 1km or more is quite common in other locations. Collection times can also be significantly increased by waiting time at the source, particularly in the case of wells and standpipes.

No seasonal variation in supply was reported in Nepal but significant seasonal variation in the choice of water source was reported in Uganda, with significant use of rainwater in the

wet season. This would be expected to reduce collection times in the wet season, but no difference was reported.

4.4 Cooking fuels and utensils

The study showed that in both cases respondents were highly dependent on biomass energy sources. In Nepal 72 per cent were dependent on firewood about 47 per cent of the respondents using firewood for all their cooking needs, while another 25 per cent reported using firewood for two-thirds of the total time spent cooking. The remainder used a combination of fuels, consisting of wood, agricultural residues, twigs and dung. In Uganda, firewood was the main fuel for cooking for 68 per cent of the respondents, charcoal for 19 per cent, and twigs for about 8 per cent. The rest of the respondents used one or more sources including agricultural residues, sawdust, and dung.

The surveys showed that in Nepal, the average quantity of biomass fuel used for cooking was 15 kg per person per week, while in Uganda it was 8.1 kg per person per week. In Nepal people generally cook more often (three to four times per day) than they do in Uganda (two to three times). Significant amounts of fuel are also used for space heating and preparation of animal food. The average figure for developing countries is around 8.4kg of fuel per person per week [12]

The average time for collecting firewood per household in Nepal was reported as 41 hours per month, ranging from 50 hours per month in the mountainous region to 31 in the terai region, and in Uganda the average around 10 hours per week. Although this is partly due to the higher consumption of fuel in Nepal it also reflects the fact that access to firewood is much easier in Uganda.

The number of cooking pots was found to be slightly different for Nepal and Uganda. In Nepal about 80 per cent of the respondents used one pot for cooking breakfast, 18 per cent used two pots and only 2 per cent used two or three pots. For lunch and for dinner about 50 per cent use two pots while the other 50 per cent use three pots. In Uganda most people used two or three pots for lunch and for dinner, while for breakfast most use one or two pots.

Firewood is generally cut into sticks of different dimensions depending on the cooking method or stove type. In Nepal about 58 per cent of the respondents reported using 3-6cm thick firewood while about 31 per cent of them used firewood which was larger than 6cm thick. In Uganda about 24 per cent of the respondents used wood less than 3cm thick, 29 per cent used wood 3 to 6 cm thick and 35 per cent used wood thicker than 6cm.

Regarding starting the fire, in Nepal it was found that 31 per cent of the respondents never experienced problems and about 64 per cent of them had problems for about a quarter of the time. In Uganda about 30 per cent said that have some sort of problem when starting the fire. Problems in starting the fire are generally caused by the use of damp wood; this creates a lot of smoke pollution inside the room as the wood doesn't combust efficiently. The issue of damp wood arises when wood fuel is not stored properly, and so is not protected from rain and snow. This is a particular problem in Uganda where many rural houses have grass thatched roofs which leak in the wet season.

4.5 Cooking habits

In Nepal, it was reported that the people in the study areas use a stove three or four times a day for cooking food; breakfast, lunch, *khaja*² and dinner, the total average time for cooking

² Khaja is typical dish made of rice, roasted soybeans, potatoes mixed with carrots, cucumbers, ginger and garlic, served with ginger, garlic, salt and touch of lemon

was reported as around three hours. Households with animals also spent 45 minutes to one hour, once or twice per day, cooking animal food (*kundo*). People from certain areas and certain ethnic groups (castes) also prepare home brewed alcohol (*rakshi*) one to three times per month, which takes two to three hours per session. In Uganda most of the respondents cooked three times a day; breakfast, lunch and dinner, with an average total cooking time of around 2 hours and 45 minutes. No other significant cooking activities were reported.

In Uganda it was found that the 53 per cent of the respondents cooked in the kitchen, 13 per cent cooked in other places inside the house, 19 per cent cooked in a temporary shelter and 15 per cent cooked outside the main house. Although this was not specifically reported for Nepal it is expected that cooking is always done within the house, and often in a family room, particularly in the mountainous region where the stove is important for space heating.

In Nepal 62 per cent of respondents reported using a traditional mud stove, 32 per cent a 3-stone stove and 6 per cent an improved stove. In Uganda 76 per cent of respondents reported using a 3-stone stove, 12 per cent (mainly in the more urban areas) a charcoal stove and 12 per cent an improved stove.

Only about 5 per cent of the survey households in each country have a chimney fitted to their stove. In Nepal 87 per cent of respondents reported that smoke was a major problem causing discomfort and illness, while in Uganda this figure was 60 per cent. This difference is probably due to more open housing structures in Uganda and also the fact that a significant proportion of cooking is done in the open air.

4.6 Cooking pot shape and size

Figure 4.6 shows a traditional Nepalese cooking pot made by local craftsmen from brass. Around 65 per cent of the respondents had non-cylindrical pots of this or other types. The remainder had mainly aluminium cylindrical pots that are sold in the markets.



Figure 4.6 Traditional Nepalese cooking pot

In Uganda around 97 per cent of respondents reported using cylindrical pots. The range of reported sizes is summarised in Table 4.2. In the case of the illustrated pot the diameter is measured at the base.

Table 4.2 Cooking pot sizes

Height of pot (cm)	Percentage in Nepal	Percentage in Uganda	Diameter of pot (cm)	Percentage in Nepal	Percentage in Uganda
4 to 9	21	14	10 to 19	30	35
10 to 15	60	64	20 to 30	56	30

16 to 20	16	20	31 to 40	10	27
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4.7 Features of a good stove

The features contributing to a good stove in order of priority for respondents in the two countries are summarised in Table 4.3.

Table 4.3 Priorities for a good stove

Features of stove	Priority in Nepal	Priority in Uganda
Saves fuel	1	3
Cooks quickly	3	1
Smokeless	2	4
Many pots	N/A	2
Low cost	5	5
Warms house	4	8
Portable	N/A	6
Small	N/A	7

The top priorities are similar for both Nepal and Uganda – users want a stove that saves fuel, cooks food quickly and is smokeless. That the stove should be low cost is a lower priority in both countries. (Although ‘low cost’ was not specifically defined, experience with improved stoves such as the *ANAGI* in Sri Lanka and *Jiko* in Kenya suggests this may be below US\$15). The differences in priorities seem to reflect different conditions in the two countries:

- Having a stove which can accommodate many pots is considered an attractive feature in Uganda where most households currently use a 3-stone fire which takes only one pot. In Nepal many households use the traditional mud stove which already takes more than one pot so this feature is expected of a stove.
- Warming the house is important in Nepal mainly because of the high priority given to this by respondents from the (colder) mountainous regions. In Uganda, some areas get quite cool in the evening at certain times of the year and the desire to have a stove which also provides space heating was mentioned by 23 per cent of respondents.
- Rural huts in Uganda have limited space so the size of the stove is considered important and also, because a significant proportion of households cook outside, portability is considered an important feature.

4.8 Lighting

The other main use of energy by the majority of households in developing countries is for lighting. Since access to electricity is limited in many countries, particularly in Africa, other options are used, primarily kerosene and also to a lesser extent candles and batteries. Table 4.4 compares the types of lighting used by the survey groups.

Table 4.4: Lighting used by survey households

Source of energy lighting	Nepal	Uganda
Electricity	62.8 per cent	8 per cent

Kerosene	30 per cent (Where 67 per cent of these report using 0.25 to 0.5 litre/week of fuel at US\$1/litre i.e. a cost of US\$0.25 to 0.5 per week)	58 per cent (The main use is in a lantern with a reported consumption of 3 litres per week)
Other – candles and batteries	7.2 per cent	12 per cent (10 per cent report using candles with an average consumption of 6.8 candles per week at a cost of US\$1.80.)
Non response	0	22 per cent (It is assumed that these households use their fire for lighting.)
Hours of lighting	2 to 3 per day	Average 2.75 per day

The main difference that can be seen from the table is the much higher proportion of households in Nepal which have access to electricity. In the absence of electricity the primary fuel used for lighting is kerosene in simple wick lanterns. These lanterns typically have an energy efficiency (lumens/Watt) of about 1 per cent of an electric light bulb. From an internet search the typical kerosene consumption for providing lighting for 3 to 4 hours per day is 1 litre per week at a cost of US\$1 suggesting the reported cost in Nepal is below average and that in Uganda is considerably above average.

4.9 Use of electricity

Table 4.5 Use of electricity

Access to electricity	Nepal		Uganda	
Percentage of population with access to electricity	40 per cent		5 per cent (2 per cent in rural areas)	
Percentage of survey group with access to electricity	62.8 per cent		8 per cent	
Uses of electricity	Percentage of households	Hours use per day	Percentage of households	Hours use per day
Lighting	100 per cent	3 - 5	100 per cent	N/A ³
Radio	71 per cent	3 - 5	86 per cent	4 - 6
TV	62 per cent	1 - 3	71 per cent	3 - 4
Cassette players and other devices	44 per cent	2 - 4	50 per cent	2 - 4

Table 4.5 shows the use of electricity in the sample groups. In both countries the access to electricity in the sample groups is significantly higher than the national average. All households who have access to electricity use it for lighting, with the other main use being for radio and TV sets. Other uses such as ironing, cooking and refrigeration are limited. The main time of day that electricity is used is in the evenings. In both countries electric lighting is generally provided by incandescent bulbs, with 40-60W bulbs being the most popular size in Nepal, compared to 75W in Uganda.

³ N/A- not available

The Electricity consumption for the survey group is shown in Figure 4.7. No comparative data is available from Uganda. Although sort of uses and the hours of lighting are fairly similar in both countries, in Uganda the cost penalty for high consumption is much higher and therefore consumption will probably be less. In Nepal the reported cost for less than 20kWh is US\$0.06/kWh and for greater than this US\$0.12/kWh. In Uganda the reported cost for less than 15kWh is US\$0.046/kWh and for greater than this US\$0.32/kWh

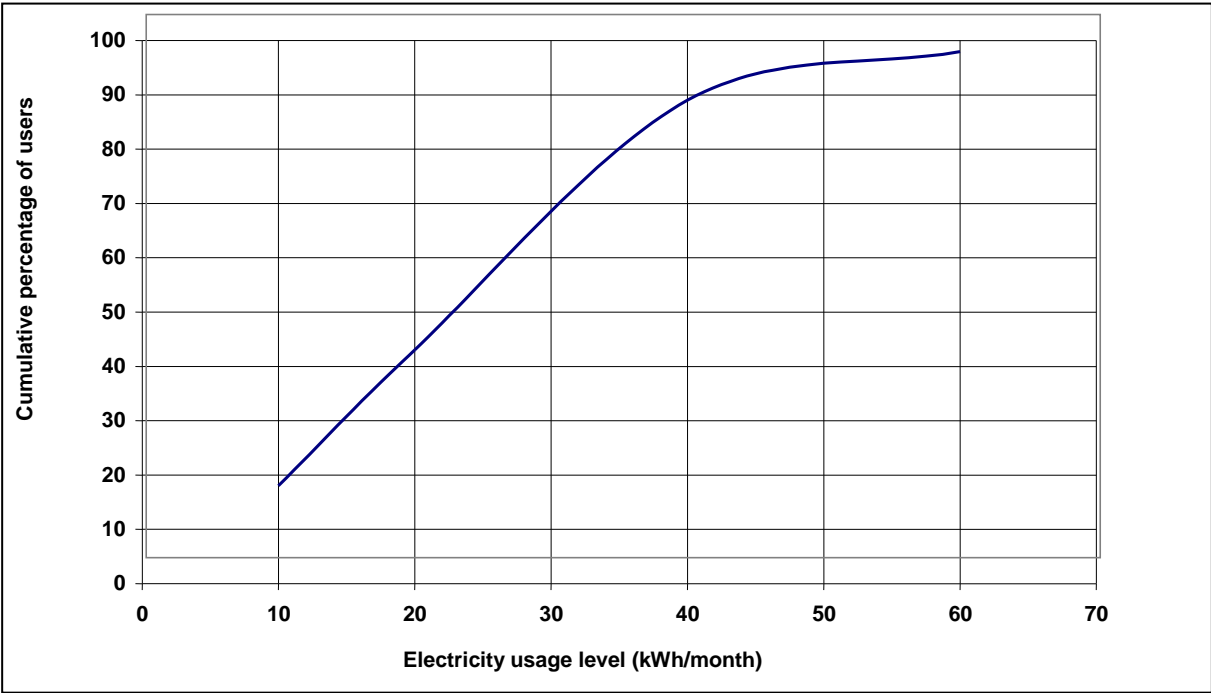


Figure 4.7: Electricity consumption in rural Nepal

From Figure 4.7 the average usage in Nepal is about 24kWh per month or 0.8kWh per day. With an average usage of four hours per day this represents a typical load of 200W which agrees with Table 4.3, suggesting two or three light bulbs, plus radio and TV part of the time.

4.10 Demand for electricity

In general there was a high demand for electricity from respondents who did not already have access to it. This was more marked in Nepal where 100 per cent rated it as important, (including 83 per cent as extremely important), whereas only 60 per cent rated it as important in Uganda. The higher figure in the Nepalese group could be due to the much higher use of electricity in the survey communities, and therefore the greater awareness of its benefits and confidence in its use. The lower figure in Uganda could be influenced by recent rises in tariffs and the unreliable supply.

Benefits from an electricity supply were rated out of 100 and are compared for the two survey groups in Figure 4.8. The three main benefits – improved lighting, help with education and better access to news through radio and TV – are similar for both groups. The major difference is that in Uganda there is a much greater expectation that access to electricity will help with setting up businesses. It could be that the lower expectation in Nepal is due to the

fact that the much wider introduction of electricity in the survey group has not led to any significant increase in the number of small businesses.

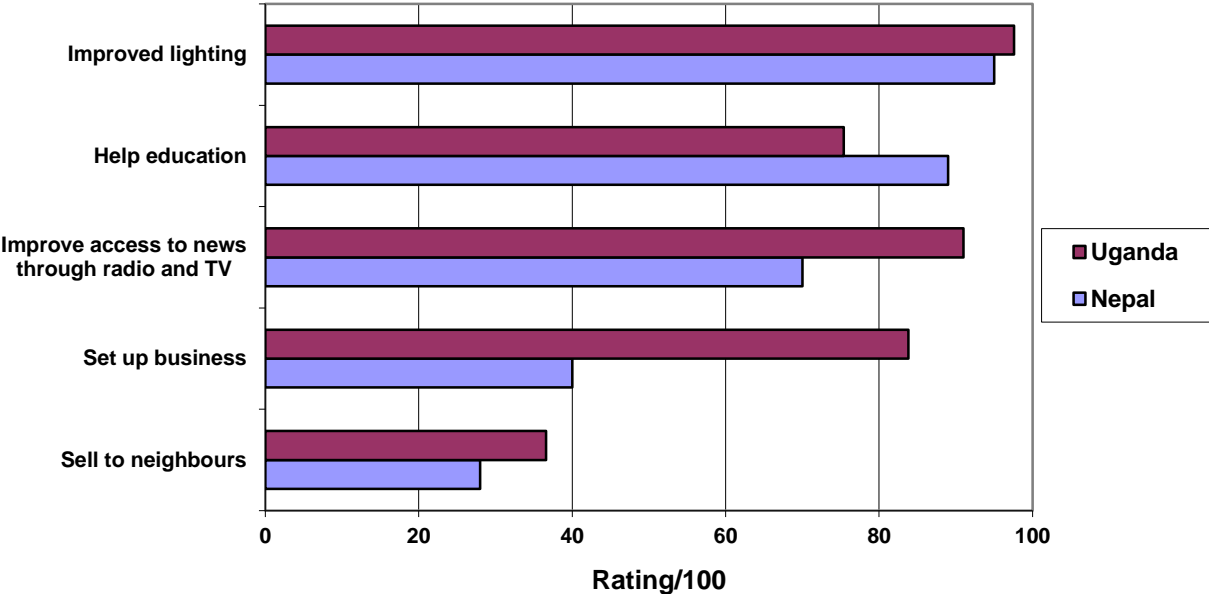


Figure 4.8 Expected benefits of electricity

5 Implications of survey findings for the SCORE project

5.1 Fuel

The main fuel used by both survey groups was wood, which was used by around 75 per cent of respondents, with the remainder using mainly twigs and in one (more urban) area of Uganda, charcoal. The level of use of waste agricultural materials was low. These latter materials can be readily burnt on an open fire but need to be compacted into briquettes for a stove to reduce bulk and increase energy content. Access to wood is a growing problem, especially in Nepal, and women have to collect whatever is available at hand. The wide variations in species and condition could be a problem in reliably achieving the high combustion efficiencies sought for the SCORE project.

In both surveys around 80 per cent of wood used was greater than 25mm in diameter and over 30 per cent greater than 60mm. This indicates the firebox needs to accommodate a larger size range than is currently specified with an opening size above the grate of at least 150mm wide by 70mm high.

Damp wood was found to be a problem for about a quarter of the time, particularly in Uganda where keeping wood dry in the wet season was a common problem because of leaking roofs. This confirms the desirability of having a drying space within the stove.

The average fuel consumption in Nepal was 2.1kg/day per person, and in Uganda it was 1.15kg/day per person. Consumption in Nepal is high because of several factors; people tend to cook three to four times per day, a considerable amount of fuel is used for space

heating in the winter, and fuel is also used to cook animal food. The Uganda figure is just below the generally accepted world average of 1.2kg/day per person. To achieve the SCORE target to reduce consumption by one third the SCORE stove needs to aim at a level of fuel usage of around 0.8kg/day per person on average, rising to 1.4kg/day per person in mountainous areas of Nepal. 0.8kg/day per person, with an average family size of 4.5 and cooking 3 hours per day is equivalent to a consumption of 1.2kg/hour.

5.2 Pot sizes

The surveys showed a wide range of pot sizes, with smaller pots tending to be used for breakfast cooking and larger pots for the main meals. In Nepal 30 per cent were less than 200mm in diameter, 56 per cent between 200 and 300mm and 10 per cent greater than 300mm. In Uganda the equivalent proportions were 35 per cent, 30 per cent and 27 per cent. The higher proportion of large pots used in Uganda was probably due to the above average family size of the survey group.

The need to cater for a range of pot sizes raises a number of issues for the design of the SCORE stove. These could be addressed in one of the following ways:

1. Sitting the pot in a recess with the hot gas channelled around it gives the best heat transfer to the pot but the recess has to be matched to the pot size. To allow for swapping the pot between recesses for boiling and simmering the stove will only cater for one pot size although it could be possible to have a third smaller pot in parallel with main pot. Stove tops could be produced for three common sizes of pots, 200, 250 and 300mm. In the Nepal survey over 60 per cent of pots were non-cylindrical and to cater for pots of the shape shown in Figure 4.6 the recess would have to have a removable split ring that fits around the top of the pot to seal the opening and prevent the escape of smoke.
2. A common arrangement for improved stoves in developing countries is to sit the pot in a conical opening in the stove top with a baffle in the channel below to force the hot gas into contact with the base of the pot. This reduces the area of contact between the gas and pot and therefore the heat transfer but allows for various pot shapes and a good range of sizes.
3. Individual or common metal hot plates could be incorporated into the stove top although this will increase cost. The heat transfer to the pot will not be as efficient as direct contact with the hot gas but heat transfer from the gas to the plates could be improved by having ribs on the underside of the plates that protrude into the gas flow. Individual plates are probably best to reduce heating of the kitchen space.

The surveys in both countries showed a strong preference for at least a 2-pot stove.

5.3 Cooking practices

The ability to cook food quickly was given as a top priority for stoves in both surveys. This is particularly important for the preparation of breakfast. In Uganda it was reported that the average time for bringing the pot to boil at breakfast was 18 minutes, and for the main meals it was just under 30 minutes. No equivalent results were reported from Nepal but they are likely to be similar as the main item cooked at breakfast is tea, as in Uganda, and cooking times for the main meals are roughly the same. The Nepal survey reported the pot was typically half full when boiled for breakfast, containing 2 to 2.5 litres. The SCORE target of boiling 4 litres of water in 15 minutes therefore seems high and reducing this to 3 litres in 15 minutes seems more realistic.

Space heating during winter months was considered a high priority requirement of the stove in the mountainous region of Nepal and to a lesser extent in the hilly region and in certain

locations in Uganda. However, in hotter months and in hotter countries heat dissipated by the stove in the house will be an inconvenience. In Uganda almost 20 per cent of the survey families cook outside in the dry season and portability was given as a priority for a good stove. This is probably primarily due to the problem of smoke but removing the source of heat from the house is probably also a consideration. The SCORE stove will not be portable for use outside and therefore consideration needs to be given to minimising the heat dissipated from the stove inside the house in conditions where this could be a problem.

5.4 Electricity supply

In Nepal a substantial proportion (63 per cent) of the survey group had access to electricity which means that usage figures are likely to be accurate. The average household consumption was 0.8kWh per day, which for an average usage time of 4h per day gives an average power use of 200W. This is twice the SCORE target of 100W but since the primary use was for lighting and the common means used in the survey group was 40 to 60W incandescent bulbs the difference will be easily accounted for by the use of more efficient CFL and LED bulbs. These should give a saving of 30 to 40W per room so 100W seems appropriate for a longer term target for the SCORE stove. Earlier work [3] has shown that 10 – 20 Watts of electricity can make a significant improvement to the life of the rural poor so a lower target of 12 to 50W to provide lighting will satisfy a majority of households, especially those with lower incomes, and careful consideration will need to be given to the trade-off between output, cost and reliability in achieving optimum demand.

5.5 Overlap between cooking and electricity use

In both surveys it was reported that people generally cooked three times per day. There were two main cooking times with each session lasting 1 to 1.5 hours, one around lunchtime and one in the early evening around 5 to 7pm. The main demand for electricity was in the evening after 6 or 7pm. This indicates that some form of electricity storage will probably be essential and that the charging period (cooking time of 2.5 to 3 hours) will be less than 75 per cent of the discharge period (electricity usage 4 to 5 hours) meaning the input power may need to be at least 33 per cent more than the output power.

5.6 Affordability

Good statistical data on household income and electricity installation costs was obtained from the Nepal survey and by making the reasonable assumption that demand is linked to income it is possible to derive an estimate of affordability to households for an electricity supply system such as SCORE. Figure 5.1 shows the installation cost data from the survey group in Nepal. Also plotted are lines for 4% and 5% of household income reported by the survey group. The comparison suggests that households pay around 4% of annual income for installation of a grid electricity supply. A similar conclusion has been found in an evaluation of demand for solar PV electricity installations.(11).The target cost for a SCORE unit is to be significantly cheaper than the best alternative for decentralised household electricity supply, solar PV units . Figure 5.2 shows the trend in installed PV unit costs obtained from data on the internet. A realistic SCORE target at the lower end of the range is \$80 for an installed unit. However, even at this cost Figure 5.3 suggests that the units would only be affordable to a few households based on a limit of 4% of annual income. This confirms the SCORE plan that marketing will need to be accompanied by a strong programme of microfinance.

Figure 5.1 Relationship between income and electricity installation cost in Nepal

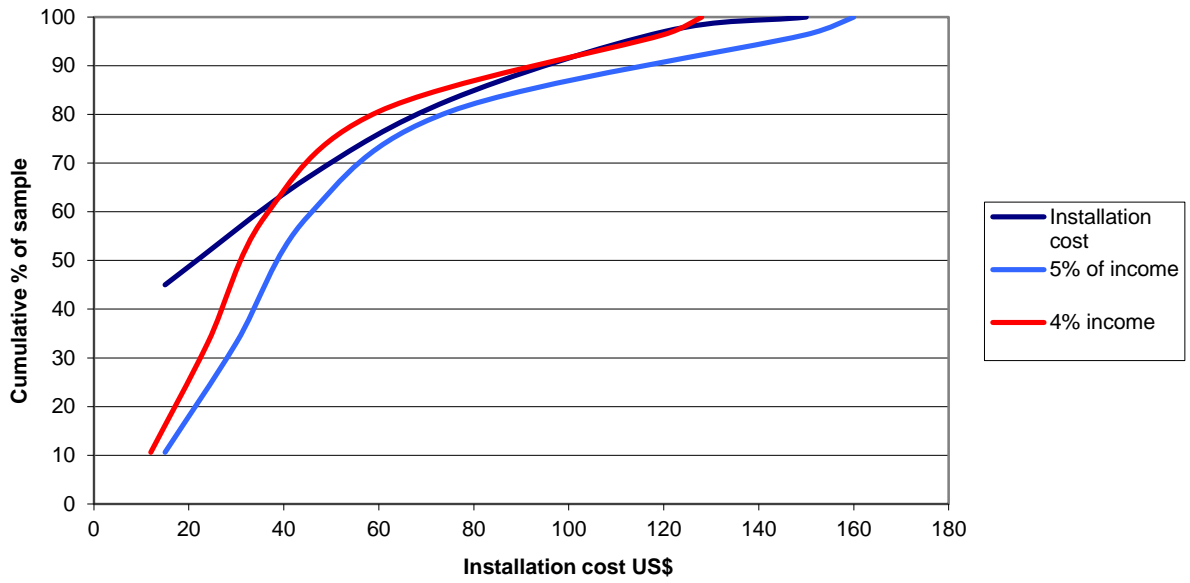


Figure 5.1 Relationship between income and electricity installation cost in Nepal

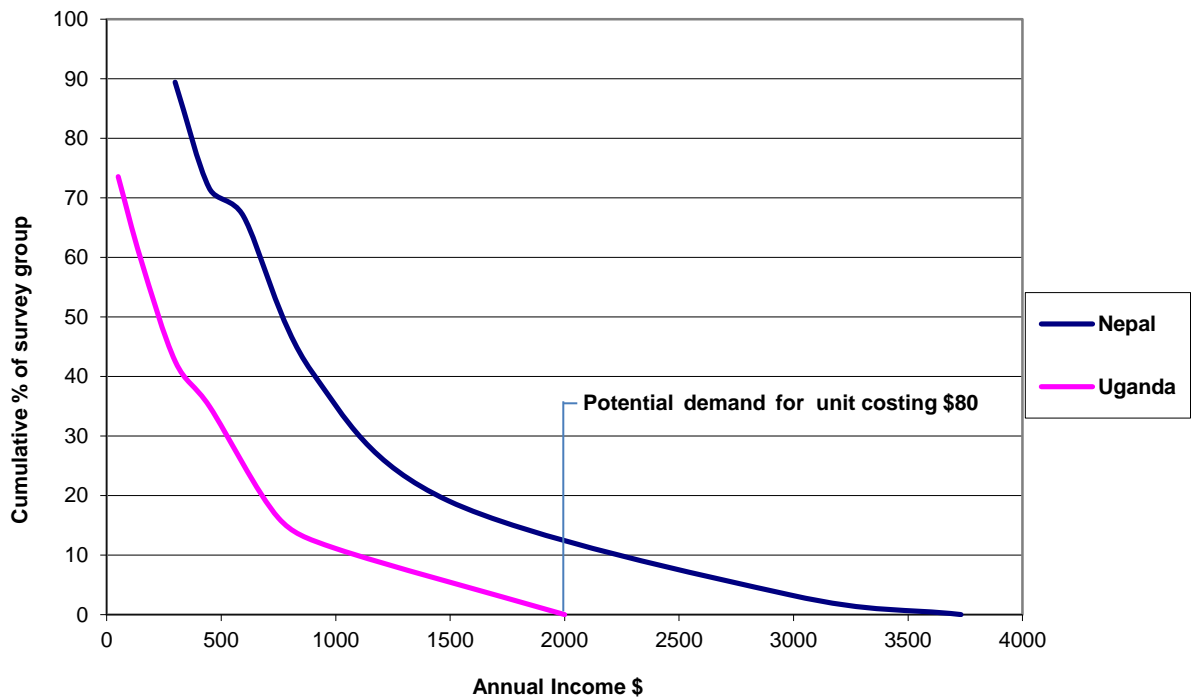


Figure 5.3 Family Income levels in Nepal and Uganda

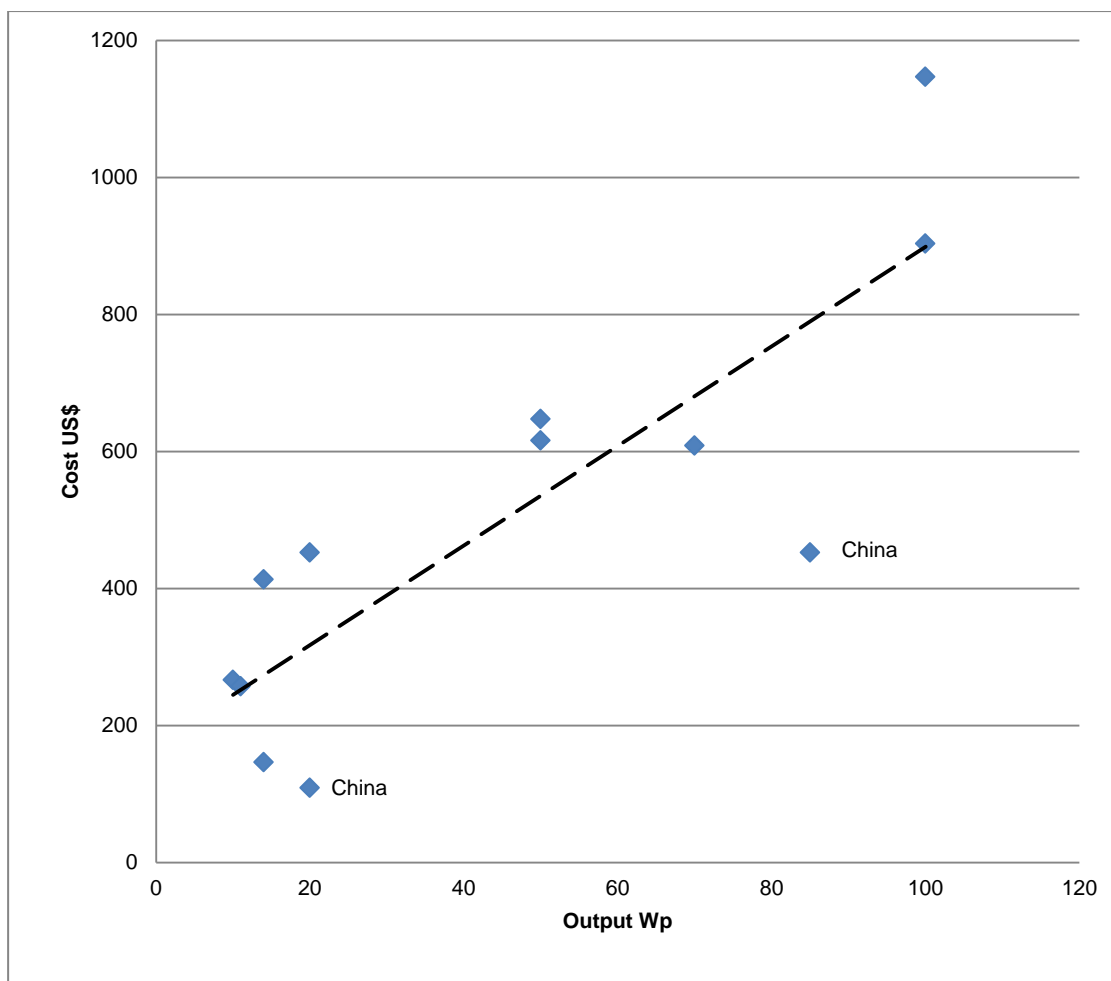


Figure 5.2: Trend of Cost of Solar PV Systems

5.7 Summary of requirements for SCORE stove

The main conclusions from the surveys in Nepal and Uganda in regards to the requirements for the SCORE unit are summarised in Table 5.1 below.

Table 5.1: Summary of requirements for SCORE unit

Attribute	Requirements
Efficiency	High efficiency
Smoke reduction	Use of chimney
Number of pots	Three
Size of wood	To accommodate a range wood sizes, up to 8cm in diameter
Cooking position	Preferably seated
Cost	Not determined
Size of the stove	As small as possible
Provision of hot water	Convenient in some case but not very important
Provision of space heating	It is important for cold places such as the case of the

	Nepali Mountains, but not for warm places
Electricity production	Main use, lighting, radio, TV, and charging mobile phones. Three hours 3 bulbs, small radio and couple of hours of TV. Approximately 300Wh per day.
	Minimum acceptable electricity generation 20W. This will cope with basic lighting and other very small but important electricity needs such as mobile charging.
	Energy storage
Simplicity and safety	Simple to use, simple to adjust or repair and safety is required. Safety is important because babies or toddlers generally share the space while women are cooking.
Design	Robust design, stable on their position, (NB the systems may need to be anchored on cement platform)
Spare parts	Availability of spare parts and ease of maintenance
Information	Operating instructions available in local languages

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APPENDIX 1

A. Images from Rural Uganda



Figure A2 Large family kitchen in Uganda –
Note 3-stone stove with pot at rear



Figure A3 One third of a week's wood supply
for a large family in Uganda

B. Images from rural Nepal



B.2 Preparation of breakfast by a rural
family of Nepal



B.3 Bundles of wood for sale in Nepal