Volume I - Main Report: Test “Pro-Poor” Self Approach to Improve Local Mud Stoves in the Terai

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ABBREVIATIONS

AEPC	Alternative Energy Promotion Centre
BESP	Biomass Energy Support Programme
CCT	Control Cooking Test
CDR	Central Development Region
CRT	Centre for Rural Technology
CT	Consultant Team
DDC	District Development Committee
DEEU	District Energy and Environment Unit
DFID	Department for International Development
EDR	Eastern Development Region
ESAP	Energy Sector Assistance Programme
FECOFUN	Federation of Community Forest Users Nepal
FWDR	Far Western Development Region
GHG	Green House Gas
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
GJ	Giga Joule
HHs	Households
I/NGO	International/Non-Governmental Organizations
IAP	Indoor Air Pollution
ICS	Improved Cooking Stove
LGCDP	Local Governance and Community Development Programme
LPG	Liquefied Petroleum Gas
MDGs	Millennium Development Goals
MoLD	Ministry of Local Development
MWDR	Mid Western Development Region
NEEP	Nepal Energy Efficiency Programme
RECAST	Research Centre for Applied Science and Technology
ToR	Terms of References
VDC	Village Development Committee
WBT	Water boiling test
WDR	Western Development Region
WTC	Women's Training Centre

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

This study is carried out to contribute to a more detailed understanding of the practices, performance and the areas of improvement in the widely used mud stoves in Terai region of Nepal and identify approaches for effective dissemination of improved cooking technologies for the poor and disadvantaged communities in the region. With support from GIZ Nepal, Scott Wilson Nepal has carried out this study from July 2011 to October 2011.

2.0 METHODOLOGY

The study covered 10 poorest districts (with 2 districts in each of the Development Regions) out of 20 districts in the Terai with the districts selected based on the poverty index number. Altogether, 736 sample households were randomly selected for this survey. To carry out the study, 6 enumerators were engaged by Scott Wilson Nepal. The selected enumerators were then given rigorous training including pre-testing of the questionnaire before mobilizing the survey team to the field. The survey team was mobilized in 2 of the poorest VDCs in each of the 10 districts. Efficiency tests (two water boiling and two control cooking tests in each of the ten districts) were carried out in 40 households.

The data collected from household survey was analyzed using SPSS software package and analyzed accordingly prior to preparation of survey report. The categorization of poor into 3 categories (i.e. hardcore poor, medium poor and the poor) as used by this study was made based on the approach used by Poverty Alleviation Fund (PAF). This is based on the food sufficiency levels. The key findings of the study are summarized below:

3.0 FINDINGS

a. Poverty profile of the surveyed households

Poverty was widespread among the surveyed households. Majority of the “hardcore poor” were the Dalits (73.4%) and Madhesis (60.7%) followed by Muslims (44.4%). This figure was 38.0% for Indigenous Terai people. The hill tribe settlers in the “hardcore poor” category were fewer at 20.0% and a greater proportion of them were in the “poor” (68.1%) category.

b. Socio cultural assessment of users

Most of the households had 7-8 members in their family with male and female ratios almost equal in number. The largest number of males and females were found in Kanchanpur and Kailali. The main occupation of the respondents was found to be agriculture (60.7%) followed by wage/labor (28.5%) and business (7.4%).

There was no notable difference among the different categories of the poor in cash income levels. In all categories, 60-70% of the households were earning more than Rs 5000 per month mainly due to remittance incomes.

c. House and kitchen conditions

A higher percentage of houses in Nawalparasi (37.5%) are made from thatch whereas 83.9% of the houses in Kanchanpur have a tile roof. Similarly, 51.6% of the houses in Kanchanpur have wooden walls whereas a majority of the houses in Saptari (71.4%), Siraha (81.0%), Rautahat (96.6%), Nawalparasi (63.1%), Dang (90.8% and Bardiya (58.3%) have a mud wall.

A higher percentage of poor households (58.1%) when compared to the medium poor (9.9%) and hardcore poor (32.0%) have a separate kitchen outside the main house. Majority of the hardcore poor households (73.9%) have a kitchen inside their house without any kind of partition.

d. Cooking practices

In central and western Terai such as Nawalparasi, Kapilbastu, Dang and Bardia, rice was added in water and cooked whereas in Eastern Terai such as Siraha and Saptari water was boiled and rice was added after boiling water and the water was removed after the rice was cooked.

With respect to cooking time the study showed that 84% of the respondents spent 1-3 hours a day in the kitchen followed by 12.6% spend 3-5 hours and 3.4% spent more than 5 hours in the kitchen.

e. Cooking fuel used in Terai

The type of cooking fuel predominant in all of the surveyed districts is firewood followed by cow dung, agricultural residue (rice husks, maize cobs and wheat straw) and other (grass and thatch). Cow dung was common in the Madheshi ethnic group (56%) and among Muslims (34%). Similarly, Muslim communities were the highest users of agricultural residue (20%) as their primary cooking fuel. In Bardia, Kailali and Kanchanpur, thatch was used for lighting firewood whereas in Nawalparasi, Kapilbastu and Dang plastic pieces were used.

Study showed some variation in use of firewood among the poverty groups. The levels for hardcore poor (177.9kg/month) and poor (176.1kg/month) were similar and higher when compared to medium poor (145.9kg/month) households. The consumption of crop residue is greater within medium poor (100.7kg/month) and poor (201.4kg/month) households.

f. Mud stoves practices

In eastern districts such as Siraha and Saptari, single pot mud stove were mostly found to have 10-25 cm deep combustion chamber for collecting charcoal and ash inside the chamber. Madhesi (67.9%) and Dalit (81.0%) use single pot stoves. Majority of the stoves in the surveyed households have been built by the owners themselves, avoiding instances to pay for external labour.

In Saptari bigger stoves were kept outside especially for cooking food for animals and boiling paddy and the other for cooking their food. In Rautahat, two stoves were used, one for cooking

vegetarian food and the other for non-vegetarian food whereas in Sarlahi one stove was made just for making local alcohol.

A majority of the households in Nawalparasi (83.9%), Sarlahi (72.8%), Dang (63.5%), Rautahat (59.1%), Bardiya (41.7%) and Kanchanpur (41.9%) have said they are not happy with the performance of their existing stoves.

g. Users' willingness to change and pay

Among the users that were willing to change their stoves, the hardcore poor were more willing (at 75%) to pay for the services, almost at par with the less poor group (72%) of people. The medium poor are relatively less prepared to pay with 65% willing to pay.

There are relatively equal amount of households in the "medium poor" category that have said they are willing to pay a certain amount of money (i.e., 24.5% willing to pay less than Rs. 200, 22.4% willing to pay Rs. 200-Rs.300, 28.6% willing to pay Rs. 300 – Rs. 500 and 24.5% willing to pay more than Rs. 500). In the same way, more (38.9%) of the Hill tribe settlers amongst the ethnic groups are willing to pay more than Rs. 500 for an ICS.

h. Efficiency of mud stoves in use

For the open type stove, the test results for the specific fuel consumption (average of set 1, set 2 and set 3) for the high power test (cold start) was 171.3 g/lit with 13% efficiency, high power test (hot start) was 161.9 g/lit with 15% efficiency and low power test (simmer) was 252.8 g/lit with 20% efficiency.

For the closed type stoves, the specific fuel consumption (average for set 4 and set 5) for high power test (cold start) was 232.65g/liter with 11% efficiency, high power test (hot start) was 157.05g/liter with 15% efficiency and low power test (simmer) was 181.55g/liter with 21% efficiency.

For the CCT, since the T-test value (0.37 for specific fuel consumption and 0.78 for total cooking time) is greater than P value (0.05); there is no significant difference between the open type stoves. Similarly, the T-test value for the closed type stoves (0.23 for specific fuel consumption and 0.12 for total cooking time) is greater than the P value (0.05), which shows that there is no significant difference between the tested stoves.

i. Indoor air pollution

All of the households in the surveyed districts have either 1 or 2 doors. The number of windows were maximum of two whereas the holes ranged from 5 -10. The windows were mostly of small dimensions (average around {0.8 m X 0.8 m}) and holes in average 20 - 30 cm diameter.

Equal proportions of Hill tribe settlers and Indigenous Terai households (77.0% each) have a well ventilated kitchen whereas majority of the Madhesi households (57.1%), Dalit households (58.0%) and Muslim households (83.3%) have poorly ventilated kitchen.

More than 85% of the Madhesi, Dalit and Muslim kitchens are very smoky which points out that the numbers of ventilations in those kitchens are minimal. However, 36.3% of the kitchens of Hill tribe settlers and 30.3% of the kitchens of Indigenous Terai people are not very smoky. There was a common trend in the occurrence of cough problems, chest problems and fire injury, with an average 10% of the surveyed 736 households experiencing fire related incidences.

j. Organizational mapping and assessment

There is still low level of awareness among our survey groups about the ICS or programmes working to support ICS. BESP/ESAP is the major programme with focus in Terai as well as other regions, for dissemination of improved mud stoves. RRESC supported by BESP are increasing their presence and support services in Terai. At district and village levels, the DEEUs/DEESs have been established to provide support for planning and coordination for distribution of ICS but their impact is still not effective.

4.0 OVERALL CONCLUSIONS

The survey findings show that the mud stove users, who are from poor households, are generally dissatisfied with the performance of their stoves and majority of the households are willing to install an ICS at a low cost.

Most of the surveyed households complained that increased smoke in the kitchen caused them to spend more time in the kitchen because they couldn't cook their food efficiently. It was recorded that most of the households also experienced cough problems, chest problems and fire injury which was mainly due to increased smoke and lack of ventilation.

Although the efficiency of the stoves tested are close to the efficiency values of an ICS, necessary improvement to achieve multi and mixed fuel designs, alterations in ventilation systems and additions of chimney could be made. These improvements would not only help in decreasing the amount of predominantly used firewood but also help to distribute fuel pressure towards cow dung, agricultural residue (rice husks, maize cobs and wheat straw) and other fuels (e.g. grass and thatch).

There is no major presence of actors (institutions and programmes) that are active in the Terai working to improve cooking practices. However organizations such as BESP/ESAP, FECOFUN, and DEEUs/DEESs are involved in developing and promoting appropriate and rural and renewable energy technologies.

5.0 RECOMMENDATIONS

The present scenario of traditional cooking stoves in the poorest districts of Terai emphasizes the need for AEPC to develop rigorous quality control plans, with proper orientation and training, which can be used by all the stakeholders involved. The study suggests that the organizations involved in dissemination of ICS should also address IAP by organizing awareness programs for simple changes in the kitchen and ventilation conditions to reduce pollutants.

A reasonable approach, by locally based institutions such as DDC, DEEU and FECOFUN could be stressing education for girls and men to make them aware about tools for higher energy efficiency in cooking. It is also strongly recommended that the after sales services be strengthened and people urged to pay for services in adopting ICS to decrease abuse and increase self reliance among the users to adopt improvements in their cooking practices.

CHAPTER 1: INTRODUCTION

1.1 Historical perspective

Planned development started in Nepal in 1956. ICS was one of the first development initiatives after the planned development started. The first ICS, which were multi-pot stoves, were developed in India. Those stoves were of high mass and shielded fire type and had a chimney to remove smoke from the kitchen. They also had adjustable metal dampers to regulate the fire. ICS was first introduced in Bharatpur of Chitwan as Hyderabad smokeless *chulo* (stove) at Bikas Pradarshani (exhibition) in 1956. Wider dissemination of ICS started in early 70s, when main emphasis was on improving fuel efficiency in order to reduce deforestation. At that time, Lorena stove, which was a large mud stove with a number of rings, was promoted by the Women's Training Centre (WTC). It provided training to women on construction of Lorena stoves. In late 70s, Research Centre for Applied Science and technology (RECAST) was involved in improving these stoves and renamed them as Nepali *chulo.*

Nepal, challenged by the growing population, is heavily dependent on traditional biomass fuels which contribute about 87% of total energy consumption. Nepal is among one of the lowest per capita energy consumption (about 15 GJ in 2005) countries and most of the energy consumed was for cooking (65%) followed by space heating and other activities. Smoke in the home is one of the major contributing factors of many diseases to large segment population of the country as well as contributing, though very minimally, to green house effect.

Mud-brick ICS, metal stoves, briquette making and burning technology, chimney and smoke hood are some technologies that have been disseminated by ICS programmes to those households which use firewood and agricultural residues as a source of energy for cooking and heating. At present, and in the foreseeable future, alternation of biomass fuel is not feasible for the vast majority of the people. However, with the help of other renewable technologies, such as biogas and solar cooking that are being researched, developed and distributed in the country, there is potential that usage of these technologies can be taken to the poorest segment of the societies to improve the efficiency of cooking processes.

1.2 Background to the study

In rural areas of Nepal, biomass fuel is burnt in either the traditional mud stoves or three stone stoves or tripods with poor combustion. As a result, there is inefficient use of fuel as well as heightened exposure to indoor air pollution (IAP) that causes serious health risks especially to women and children.

Combustion is a complex sequence of chemical reactions of fuel with an oxidant, accompanied by the production of heat or both heat and light in the form of either glow or flames. Smoke, the result of incomplete combustion, depends on the type of wood and vegetation being burnt; the temperature of the fire; wind conditions; and more importantly, to the moisture content in fuel *(Ballard-Tremeer, 1997, cited by Bates et al., 2005)*. When

biomass is burnt, it emits harmful chemicals such as particulates, carbon monoxide, formaldehyde and nitrogen dioxide along with carbon dioxide and water vapor *(Ban et al., Inventory of Innovative Indoor Smoke Alleviating Technologies in Nepal, 2004)*. High concentration of these pollutants is detrimental to the general health of those exposed to IAP. The indoor concentration of a given pollutant is established by the rates of its production and removal from the environment (Saldiva and Miraglia, 2004).

While there is long history of extensive and intensive research on cooking practices and dissemination of improved cooking stoves (ICS) in the hills of Nepal, little is known and short is the history of similar focus on the Terai population of Nepal. Nonetheless, some works have been carried out to undertake some preliminary research and a number of agencies have begun to reach out to the people of Terai. This study will further contribute to reducing the knowledge gap in these areas and help in better understanding the cooking practices with respect to the mud stoves and how a meaningful and effective intervention can be designed to forward improved cooking technologies for the poor and disadvantaged communities in Terai.

1.3 Objectives of the study

With support from GIZ Nepal, Scott Wilson Nepal has carried out this study in ten districts of Terai covering all five development regions from July 2011 till October 2011.

The objectives of the Study are as follows:

- *Develop better understanding of the performance and convenience of the presently used mud stoves, and*

- *Determine if there are simple ways to gradually improve the performance of mud stoves based on an improved "do-it-yourself" approach.*

1.4 Scope and limitation of the study

This study primarily includes those households which use firewood, agricultural residues and cow-dung cakes as a source of energy for cooking purposes. The priority has been to reach out to poor households and those who have limited access to improved or commercial energy (e.g. LPG, kerosene etc). The interview, questionnaire, checklists and informal discussions are designed to derive information on the aspirations, the performance and convenience of the currently used traditional mud stoves and find out how these poor segments of the society.

The study covers 736 households (HHs) across Terai on a sample basis. It is understandable that not all the poor communities or ethnic groups are covered due to limits of the survey. At the same time, Terai is diverse in its cultural (and resulting linguistic and cooking practices) diversity and the study has not covered all these ethnic groups due to limitations in access and scope of the survey work. At the same time, the current research was carried out in peak farming season where families, particularly the women who use the mud stoves, were in their fields and accessing them and their time was challenging. Efforts were made to meet the families in their convenient period as the research process at each household was rigorous and time consuming.

The study team also encountered cultural resistance to visits by members of the research groups from other cultural groups. This was more evident among Muslim households where our team members were discouraged to visit or when allowed, the households were reserved in their exchange of views.

Similarly, the testing of the stoves proved to be too demanding for the households. Some households were too cautious to the testing process, and their behavior to cooking changed, thereby affecting to a minor extent the normal mode of cooking. Some families wished to be paid for such tests even when the extra costs such as firewood was covered by the research team. It was not possible to repeat such tests in most households.

1.5 Study approach and methodology

1.5.1 Study activities

a. Desk Study

- The study team reviewed available literature and findings from other studies and projects/programmes.
- The team explored with organizations the stove technologies, dissemination approaches, target groups and current annual sales of ICS currently available in the Terai.
- It assessed the current status of these programs with respect to technology development, pilot testing, small implementation, large scaling up.

b. Consultative meeting with key stakeholders

- Contacted key stakeholders and agencies/programmes working in the related area to access documentation and to receive permission for field/household visit.
- These key stakeholders consist of but are not limited to: AEPC/Energy Sector Assistance Programme, Centre for Rural Technology, Practical Action, PAF etc.

1.5.2 Selection of study areas

a. Criteria for selecting study areas

Based on the TOR and suggested approach for study, it required multi-stage sampling. Sampling strategy in three tiers with associated priorities was adopted: (a) Selection of poor Terai districts (based on poverty index number) (b) Selection of poor VDCs based on DAG mapping, and (c) selection of households representing poor and ethnically diverse communities.

When selecting the study sites, the following considerations were made with poverty level of the district, VDC and household level receiving the highest priority:

- Poverty levels
- Ethnicity of the Terai people/Cultural zones with different practices;

- Types of stoves used and cooking diversity;
- Types of fuel used;
- Origin of households

b. Selection of districts, VDCs and the households

The study area covered five Development Regions with two districts representing each Region. Within the district, two VDCs were selected giving a total of 10 districts for the Study. Within those 10 districts, VDCs with the poorest and most disadvantaged communities were identified. For this purpose, DAG mapping data (LGCDP/MoLD) for all the VDCs were analyzed and two VDCs from each district with highest DAG presence were identified.

Out of those 20 VDCs, 736 sample households were surveyed. These households were identified, in the absence of detailed household level data on poverty, through consultations at the VDC (e.g. VDC Secretary) or at the community level.

1.5.3 Approach to stove efficiency test

It is estimated that stove efficiency test (two water boiling and control cooking test in each of the ten districts) was carried out in 40 HHs (see list of households in Supplementary Document 2).

1.5.4 Survey districts and sample sizes

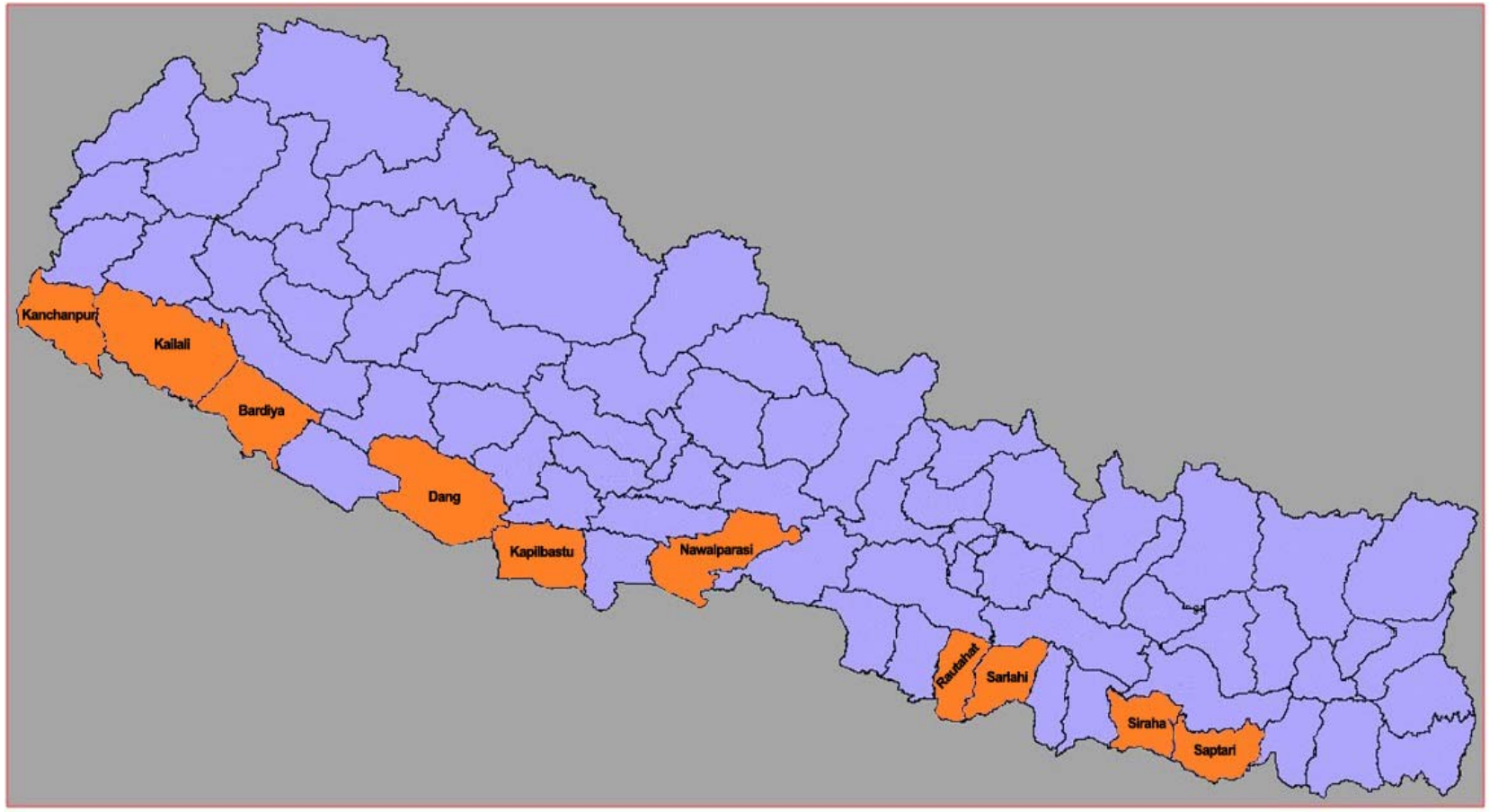
The 20 districts of Terai have been ranked according to their poverty level. Poorest two districts are selected from each development region.

Table 1: Sample districts with number of surveyed households

Development region	Districts covered	Areas/VDC	Sample of households proposed	Actual HHs surveyed	Efficiency testing HHs
FWDR	Kailali	Shreepur	28	46	2
		Geta	28	45	2
	Kanchanpur	Jhalari	28	32	2
		Krishnapur	28	30	2
MWDR	Bardia	Jamuni	28	37	2
		Sorahawa	28	35	2
	Dang	Shreegaun	28	30	2
		Dikpur	28	35	2
WDR	Nawalparasi	Mukundapur	28	30	2
		Dibyapuri	28	35	2
	Kapilbastu	Pakadi	28	33	2
		Banganga	28	33	2

Development region	Districts covered	Areas/VDC	Sample of households proposed	Actual HHs surveyed	Efficiency testing HHs
CDR	Sarlahi	Haripur	28	44	2
		Hariun	28	48	2
	Rautahat	Dumariha	28	33	2
		Chandranigahapur	28	57	2
EDR	Siraha	Bhadaiya	28	32	2
		Padariya	28	31	2
	Saptari	Bakdhawa	28	29	2
		Jandole	28	41	2
Total			**560**	**736**	**40**

Figure 1: Map of surveyed districts



Selected districts of the Terai region

1.5.5 Selection of researchers and their orientation

The field research work was carried out by a group of 6 researchers which visited 736 households and studied cooking practices and environment during the course of the research study.

Six female researchers who originated from the Terai region were recruited for field survey. The researchers were as follows:

1. Puja Chaudhary
2. Rama Basnet
3. Mamta Chaudhary
4. Roma Khatiwada
5. Sarita Chaudhary
6. Manju Chaudhary

The researchers were provided with two-day orientation training prior to field mobilization. The purpose of orientation was to develop a common understanding among the survey team about the objective, technology and outcomes of the proposed survey.

Orientation of the researchers also involved a pre-testing of the questionnaire at an agreed site in Kathmandu in families using mud stoves. The result of the pre-testing exercise was further discussed and the questionnaire was finalized after making appropriate adjustments.

CHAPTER 2: POVERTY PROFILE AND SOCIO CULTURAL ASSESSMENT OF USERS

2.1 Poverty in Terai

Terai has different level of poverty across 20 districts included in the Terai region

Table 2: Poverty level of the ethnic majority in the Terai

. ***Source: Final Report on Identifying Cooking Requirements according to Geographic Location, Fuel, Cooking Systems in Nepal, AEPC.***

Ethnic Group	Poverty level and Caloric Intake		
	% Below Poverty	Food Poverty %	Caloric Intake (kcal)
Terai Janjati	38.6	39.2	2260
Madhesi	17.6	25.5	2583
Muslim	41.3	44.6	2213

Annex 4 gives the list of Terai districts based on their poverty levels. Mahottari, in the Central Region, is the poorest district while Bara, also in the Central Region, is the least poor district in Terai. This is based on the "Estimates of per capita income by region, 2001," in the "Nepal Human Development Report 2001: Empowerment and Poverty Reduction" by UNDP.

There is also poverty information available at the VDC level for each district (with some exceptions). Annex 5 provides the first five VDCs with highest number of Disadvantaged Groups (DAG) among the population. This is based on the DAG mapping carried out by LGCDP within the Ministry of Local Development.

Table 3: Poverty level of the ethnic majority in the Terai

Regions of Terai	Major Ethnic Groups	Population and Poverty level	
		Total Population	% Below poverty
Western Terai	Terai Janjati	799863	38.60
	Madhesi	88220	17.60
	Muslim	101348	41.30
Central Terai	Terai Janjati	2216878	26.60
	Madhesi	1847194	17.60
	Muslim	588164	41.30
Eastern Terai	Terai Janjati	782822	38.60

	Madhesi	1847194	17.60
	Muslim	588164	41.30

Source: Final Report on Identifying Cooking Requirements according to Geographic Location, Fuel, Cooking Systems in Nepal, AEPC (date not provided)

Nepal Living Standard Survey (NLSS II survey, 2003/04) provides poverty information for Western Terai, Central Terai and Eastern Terai. Terai Janajati, Madheshi and Muslims are majority of the ethnic groups that are represented in these regions. NLSS II (Central Bureau of Statistics 2003/04) shows that among these three ethnic groups, the one with the highest percent of people below poverty are the Muslims (41.3%) and the lowest percent below poverty are the Madhesis (17.6%). The percentage of food poverty is also highest among the Muslims (44.6%) followed by the Terai Janjatis (39.2%) which is shown in Tables 1 and 2.

2.2 Levels of poverty and its assessment at national level

In order to reach out to poorer communities within Terai, it was important for the study to assess different levels of poverty prevalent among the potential users and their response to the ICS services through ICS programmes. This is particularly necessary in order to understand the people's willingness to pay for the services, and this likely depends on the level of poverty of the households.

In order to acquire information on different levels of poverty, the study explored available information used by the Government agencies or programmes. The study noted that sought after categorization of the poor was used by the Poverty Alleviation Fund (PAF) in its 59 programme districts (see Annex 3 for a map of PAF programme districts).

To identify the different poverty levels, PAF has categorized the poor into 3 groups according to sufficiency of food that is produced by each household. PAF also uses group discussion for "participatory social assessment" of and the "well-being ranking process" to identify the poor households. The poverty level groups according to PAF's classifications are: *(ref: "PAF Program Implementation Status", page 15)*

1. Hardcore poor (with food availability for 3 months)
2. Medium poor (with food availability for 3-6 months) and
3. Poor (with food availability for 6-12 months)

This categorization of poor has been adopted for the purpose of this study.

Accordingly, the surveyed households have been categorized with reference to this indicator in which households that produce food sufficient for 0-3 months are in the "hardcore poor" group, households that produce food sufficient for 3-6 months are in the "medium poor" group and households that produce food that is enough for 6-9 months and 9-12 months (according to the questionnaire) are in the "poor" group.

2.3 Poverty status of the surveyed households

Figure 2: Poverty level of the surveyed households by Development Regions

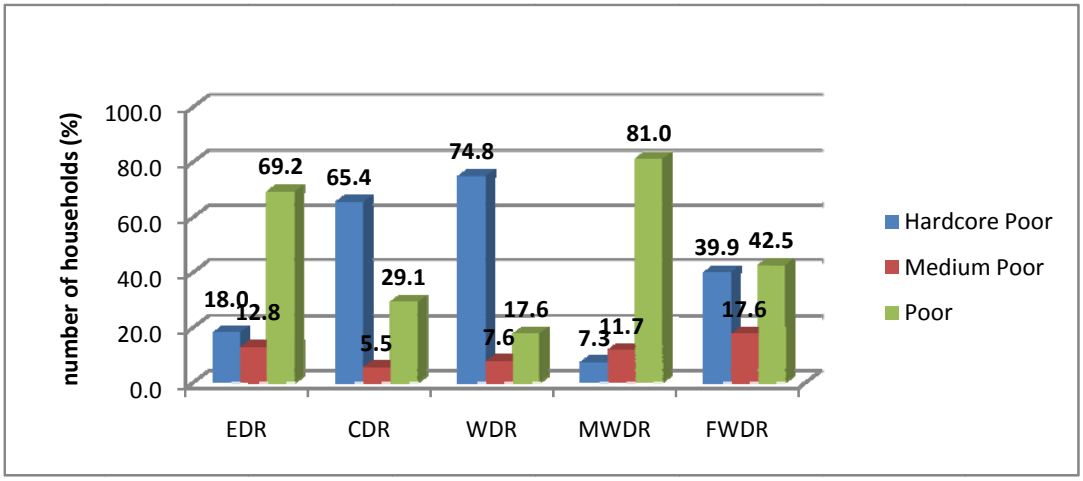


Figure 2 shows that the percentages of households in the "poor" category are highest in the, MWDR (81.0%), EDR (69.2%) and FWDR (42.5%) whereas in the WDR (74.8%), and CDR (65.4%) there are a large percentage of households in the "hardcore poor" category. The households in the "medium poor" category seem to be notably lower when compared to poor and hardcore poor households.

Figure 3: Poverty level of the different ethnic groups

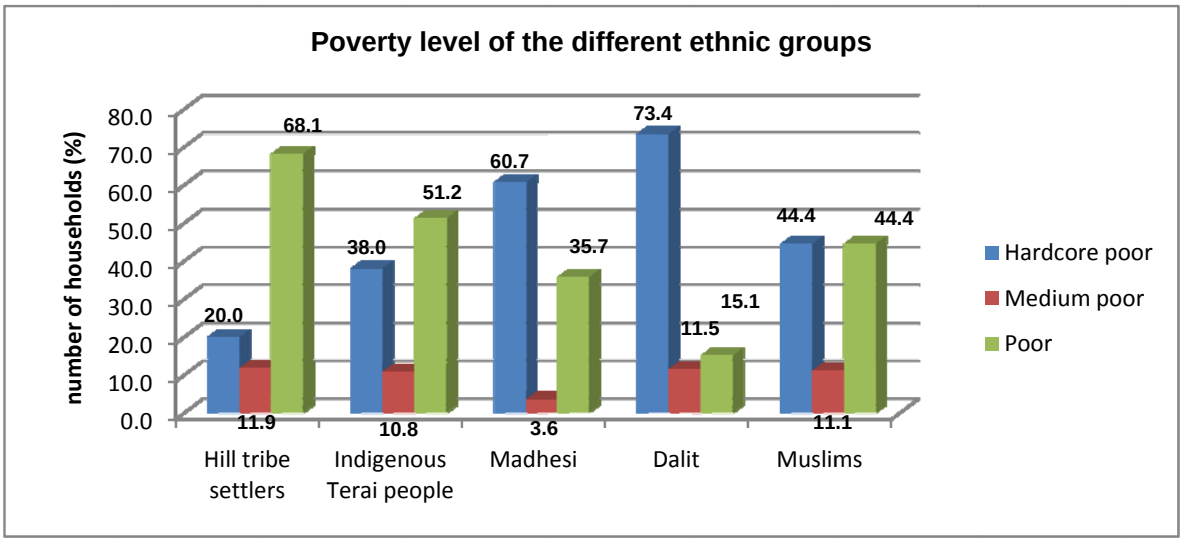


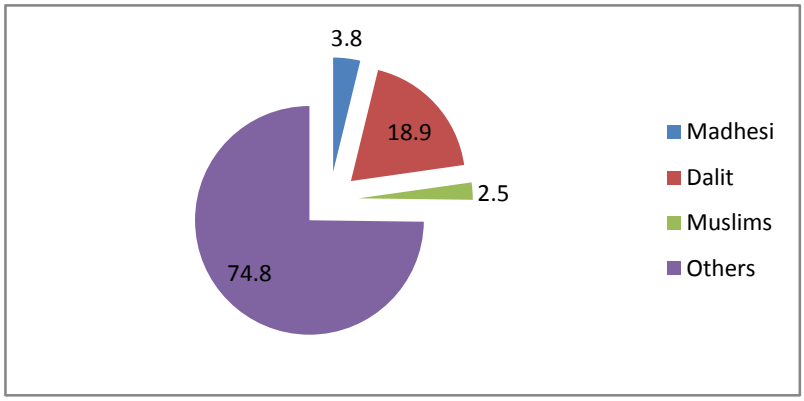
Figure 3 shows that the majority of the Dalits (73.4%) and Madhesis (60.7%) followed by Muslims (44.4%) and Indigenous Terai people (38.0%) are in the "hardcore poor" category. The hill tribe settlers that are in the "hardcore poor" are only 20.0% and a greater proportion of them are in the "poor" (68.1%) category.

2.4 Ethnicity of the surveyed households

Out of 736 households surveyed, 3.8 % were Madeshi, 18.9 % Dalits, 2.5 % Muslims and others (which included Madhesi Janjatis such as Tharu, Chaudhary) and Hill migrants etc were 74.8% as shown in table 4 below.

Despite efforts to include equal proportion of different ethnic groups, the survey could not reach a greater number of Muslim households as very few of the Muslim households were welcoming to share information with the enumerators.

Figure 4: Ethnicity of the surveyed households.



2.5 Family composition and size

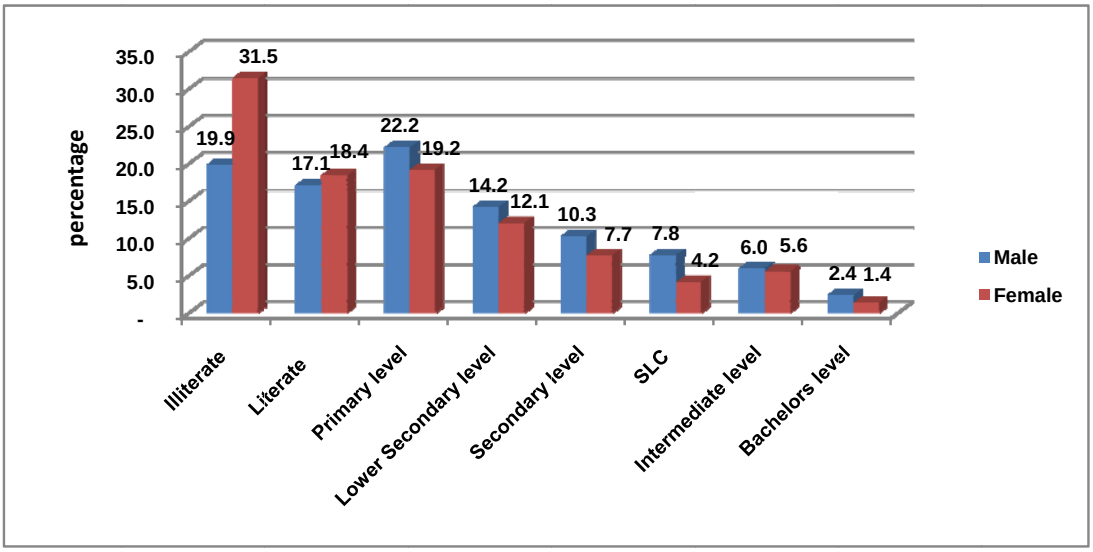
Most of the households had 7-8 members in their households with male and female ratios almost equal in number. The largest number of males and females were found in Kanchanpur (average 3.1 males) and Kailali (average 3.2 females) respectively.

Table 4: Number of male and female in the surveyed districts

	Saptari	Siraha	Sarlahi	Rautahat	Nawalparasi	Kapilbastu	Dang	Bardiya	Kailali	Kanchanpur
No. of males in family	2.7	2.6	2.5	2.5	2.1	2.6	2.3	3.0	3.0	3.1
No. of females in family	2.7	2.7	2.4	2.3	2.0	2.4	2.7	2.9	3.2	2.7
No. of children male	1.3	1.4	1.3	1.5	1.4	1.6	1.3	1.2	1.3	1.2
No. of children female	1.2	1.6	1.2	1.5	1.7	1.7	1.3	1.4	1.4	1.1

2.6 Literacy status

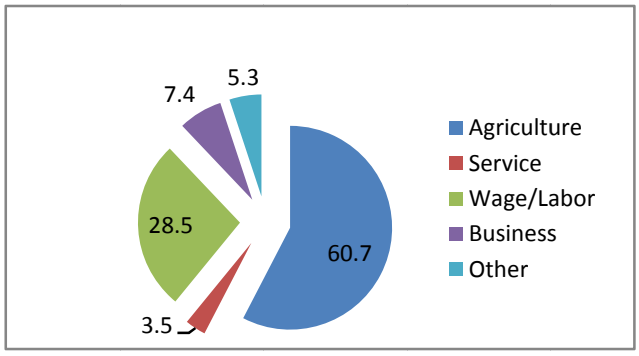
Figure 5: Education level of the male and female in the surveyed households



Among the 736 surveyed households, a significant number of females (31.5%) were seen to be illiterate as compared to nearly 20% males in that category. While highest percent of males at 22.2% had completed the primary level, only 2.4% of the males and 1.4% of the females had completed their bachelor's degree.

2.7 Occupation

Figure 6: Major occupation of the surveyed households.

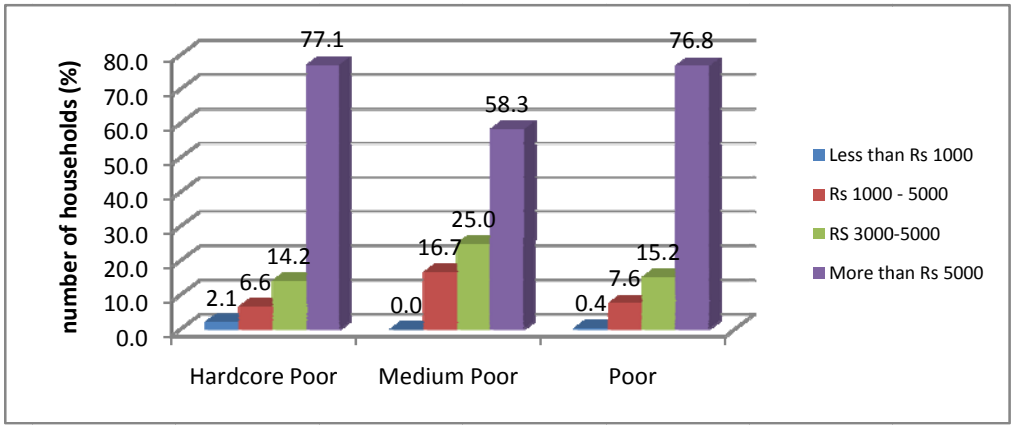


The main occupation of the respondents is agriculture (60.7%) followed by wage/labor (28.5%) and business (7.4%). Most of the households that are involved in service have one or more of their members working outside the country.

2.8 Cash income of the households

Interestingly, despite high poverty levels (from visual observations as well as from food sufficiency perspectives), most of the households had good level of cash income. The households who earned cash income of more than Rs. 5000 per month were 77.1% for hardcore poor household groups, 58.3% for medium poor households and 76.8% for poor households. Those with low income levels were more in the hardcore poor (2.1%) (see Figure 7). However, cash income did not vary significantly among the poor groups.

Figure 7: Average monthly income of the households in different poverty groups.



2.9 Types of houses

The type of houses and its condition is often an excellent indicator of the poverty level of a household. The choice of construction materials and the state of repair or disrepair gives an indication of how much wealth a family has. The study has reviewed the status of the house of the respondents and the findings are summarized in table 5. For example, a tile or tin roof shows that the owners are wealthy while the family with thatch roof standing on a mud wall is relatively poor families. The poorest families often visibly leave their houses in a state of disrepair.

A higher percentage of houses in Nawalparasi (37.5%) are made from thatch whereas 83.9% of the houses in Kanchanpur have a tile roof. Similarly, 51.6% of the houses in Kanchanpur have wooden walls whereas a majority of the houses in Saptari (71.4%), Siraha (81.0%), Rautahat (96.6%), Nawalparasi (63.1%), Dang (90.8% and Bardiya (58.3%) have a mud wall (see Table 5).

Table 5: Type of house and wall of the households in the surveyed districts

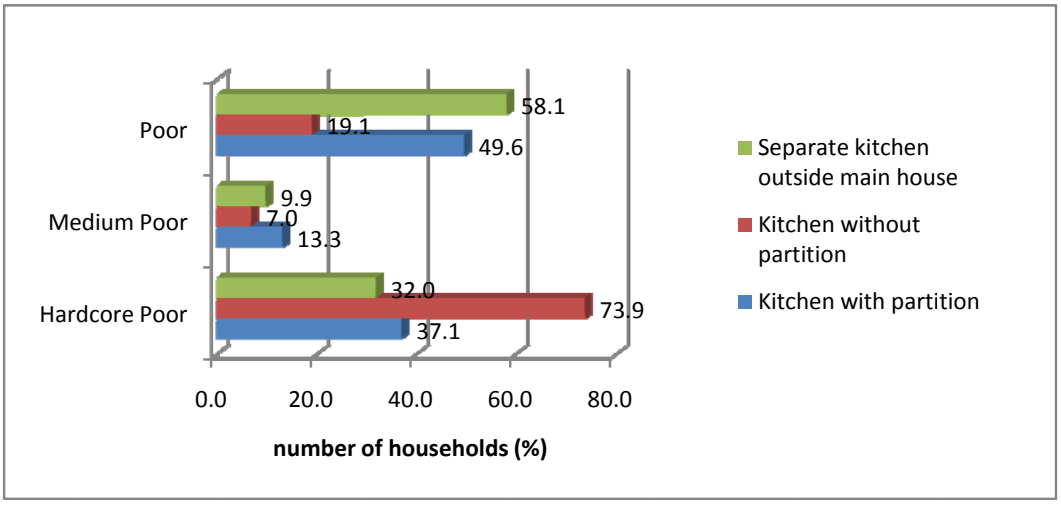
Type of house	Saptari		Siraha		Sarlahi		Rautahat		Nawalparasi		Kapilbastu		Dang		Bardiya		Kailali		Kanchanpur	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Thatched	13.0	18.6	7.0	11.1	1.0	1.1	4.0	4.5	24.0	37.5	16.0	24.6	1.0	1.5	2.0	2.8	0.0	0.0	2.0	3.2
Concrete	4.0	5.7	0.0	0.0	3.0	3.3	1.0	1.1	3.0	4.7	24.0	36.9	0.0	0.0	3.0	4.2	3.0	3.3	3.0	4.8
Tile roof	15.0	21.4	52.0	82.5	64.0	69.6	83.0	94.3	5.0	7.8	18.0	27.7	6.0	9.2	39.0	54.2	38.0	42.2	52.0	83.9
Tin roof	38.0	54.3	0.0	0.0	23.0	25.0	0.0	0.0	28.0	43.8	4.0	6.2	20.0	30.8	6.0	8.3	10.0	11.1	3.0	4.8
Other	0.0	0.0	4.0	6.3	1.0	1.1	0.0	0.0	4.0	6.3	3.0	4.6	38.0	58.5	22.0	30.6	39.0	43.3	2.0	3.2
Total	**70.0**	**100.0**	**63.0**	**100.0**	**92.0**	**100.0**	**88.0**	**100.0**	**64.0**	**100.0**	**65.0**	**100.0**	**65.0**	**100.0**	**72.0**	**100.0**	**90.0**	**100.0**	**62.0**	**100.0**
Type of wall of the house	**Saptari**		**Siraha**		**Sarlahi**		**Rautahat**		**Nawalparasi**		**Kapilbastu**		**Dang**		**Bardiya**		**Kailali**		**Kanchanpur**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Brick wall	16.0	22.9	8.0	12.7	43.0	48.9	3.0	3.4	7.0	10.8	43.0	65.2	5.0	7.7	24.0	33.3	21.0	25.3	8.0	12.9
Stone wall	3.0	4.3	1.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	3.0	4.5	1.0	1.5	1.0	1.4	0.0	0.0	0.0	0.0
Mud wall	50.0	71.4	51.0	81.0	34.0	38.6	86.0	96.6	41.0	63.1	14.0	21.2	59.0	90.8	42.0	58.3	19.0	22.9	14.0	22.6
Thatched wall	1.0	1.4	2.0	3.2	0.0	0.0	0.0	0.0	13.0	20.0	5.0	7.6	0.0	0.0	3.0	4.2	25.0	30.1	8.0	12.9
Wooden wall	0.0	0.0	1.0	1.6	11.0	12.5	0.0	0.0	4.0	6.2	1.0	1.5	0.0	0.0	2.0	2.8	18.0	21.7	32.0	51.6
Total	**70.0**	**100.0**	**63.0**	**100.0**	**88.0**	**100.0**	**89.0**	**100.0**	**65.0**	**100.0**	**66.0**	**100.0**	**65.0**	**100.0**	**72.0**	**100.0**	**83.0**	**100.0**	**62.0**	**100.0**

CHAPTER 3: KITCHEN AND COOKING PRACTICES

3.1 Kitchen conditions

A higher percentage of poor households (58.1%) when compared to the medium poor (9.9%) and hardcore poor (32.0%) have a separate kitchen outside the main house. Majority of the hardcore poor households (73.9% have a kitchen inside their house without any kind of partition.

Figure 8: Orientation of the kitchen of the different poverty groups.

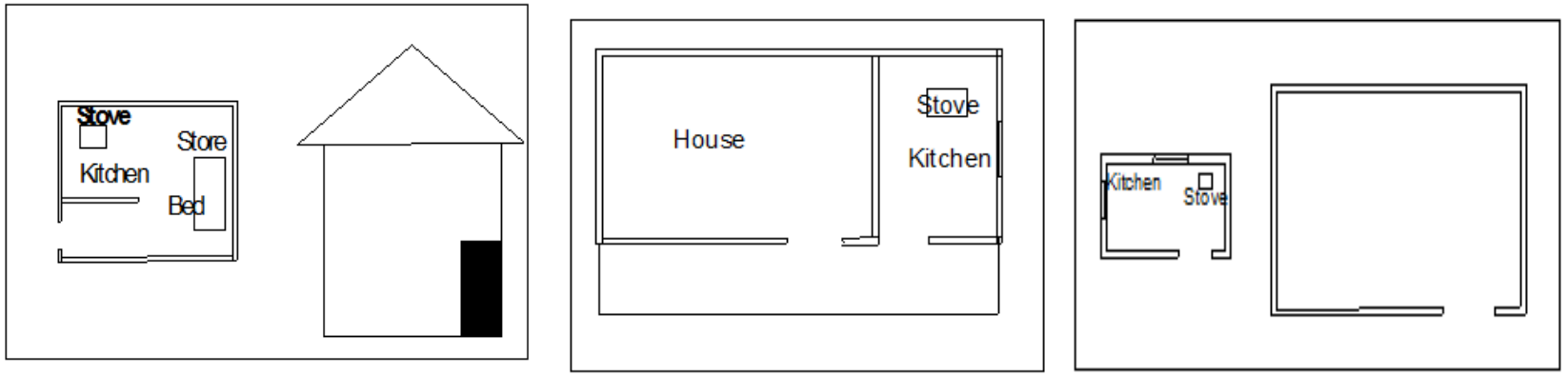


From district-wise perspectives, table 6 shows that more than 50% of the households in Saptari, Siraha, Sarlahi, Rautahat, Nawalparasi, Dang and Bardiya have a kitchen with partition which shows that these households have less chance of indoor air pollution. The households in Kapilbastu (31.1%), Dang (31.3%), Bardiya (36.1%) and Kanchanpur (51.6%) have a separate kitchen outside the main house which shows that they at least have a door to let all the smoke out.

Diagrammatic representation of the kitchen is shown below. Families that had a separate kitchen outside the main house

Table 6: Location of the kitchen in the surveyed households

Indoor kitchen condition	Saptari		Siraha		Sarlahi		Rautahat		Nawalparasi		Kapilbastu		Dang		Bardiya		Kailali		Kanchanpur	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Kitchen with partition	50.0	74.6	40.0	76.9	55.0	65.5	60.0	73.2	33.0	53.2	25.0	41.0	39.0	60.9	40.0	55.6	44.0	49.4	24.0	38.7
Kitchen without partition	5.0	7.5	1.0	1.9	14.0	16.7	17.0	20.7	24.0	38.7	17.0	27.9	5.0	7.8	6.0	8.3	19.0	21.3	6.0	9.7
Separate kitchen outside main house	12.0	17.9	11.0	21.2	15.0	17.9	5.0	6.1	5.0	8.1	19.0	31.1	20.0	31.3	26.0	36.1	26.0	29.2	32.0	51.6
Total	**67.0**	**100.0**	**52.0**	**100.0**	**84.0**	**100.0**	**82.0**	**100.0**	**62.0**	**100.0**	**61.0**	**100.0**	**64.0**	**100.0**	**72.0**	**100.0**	**89.0**	**100.0**	**62.0**	**100.0**



Diagrammatic representation of the kitchen from left a) Kitchen with partition inside the house, b) Kitchen on the veranda and c) Separate kitchen outside the main house.

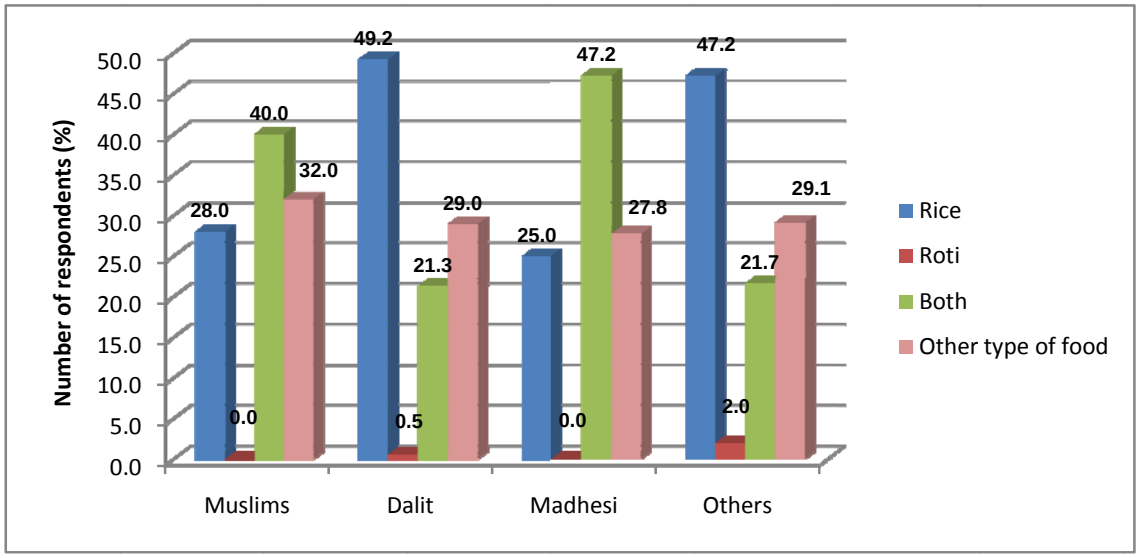
3.2 Cooking practices

The cooking practice varies from place to place and from tribe to tribe. In central and western Terai such as Nawalparasi, Kapilbastu, Dang and Bardia, rice was added in water and cooked where as in Eastern Terai such as Siraha and Saptari water was boiled and rice was added after boiling water and once rice was cooked, the liquid from the rice - starch (*mad*) was removed and given to the animals. Likewise, while cooking vegetables, some of them fry it where as others make gravy. However, cooking dal was more or less same in all areas except in some cases they put oil and little spices in the beginning where as in others they added it after the dal was cooked.

Types of food cooked

Majority of the Tharus (others) and Dalits cook rice where as Madeshi and Muslims cook both rice and *roti* as shown in figure 9.

Figure 9: Types of food that the different ethnic groups cook in their mud stoves.



Note: "Other" in ethnic group includes Hill tribe settlers and Indigenous Terai people
"Other type of food" includes vegetables cooked.

3.3 Cooking time

The cooking time also varied from place to place and the varieties of food they cooked. However, 84% of the respondents spend 1-3 hours a day in the kitchen followed by 12.6% spend 3-5 hours and 3.4% spend more than 5 hours in the kitchen as shown in table 7.

Table 7: Time required cooking in the surveyed districts

DISTRICT	VDC	1 - 3 hrs		3 - 5 hrs		More than 5 hrs	
		N	%	N	%	N	%
Saptari	Bakdhawa	26.0	3.5	3.0	0.4	0.0	0.0
	Jandole	38.0	5.2	3.0	0.4	0.0	0.0
Siraha	Bhadaiya	12.0	1.6	11.0	1.5	9.0	1.2
	Padariya	13.0	1.8	14.0	1.9	4.0	0.5
Sarlahi	Haripur	44.0	6.0	0.0	0.0	0.0	0.0
	Hariun	46.0	6.3	1.0	0.1	1.0	0.1
Rautahat	Dumariya	27.0	3.7	5.0	0.7	0.0	0.0
	Chandranigahapur	33.0	4.5	13.0	1.8	10.0	1.4
Nawalparasi	Mukundapur	30.0	4.1	1.0	0.1	0.0	0.0
	Divyapuri	33.0	4.5	1.0	0.1	0.0	0.0
Kapilbastu	Pakadi	27.0	3.7	5.0	0.7	0.0	0.0
	Banganga	30.0	4.1	3.0	0.4	0.0	0.0
Dang	Shreegaun	25.0	3.4	5.0	0.7	0.0	0.0
	Dhikpur	35.0	4.8	0.0	0.0	0.0	0.0
Bardiya	Jamuni	35.0	4.8	2.0	0.3	0.0	0.0
	Sorahawa	32.0	4.4	3.0	0.4	0.0	0.0
Kailali	Shreepur	37.0	5.0	9.0	1.2	0.0	0.0
	Geta	40.0	5.5	4.0	0.5	1.0	0.1
Kanchanpur	Jhalari	27.0	3.7	5.0	0.7	0.0	0.0
	Krishnapur	26.0	3.5	4.0	0.5	0.0	0.0
Total		**616.0**	**84.0**	**92.0**	**12.6**	**25.0**	**3.4**

3.4 Types and sizes of cooking utensils used

The type of utensils used was quite diverse. Most families were using small, medium and large size *karai*, *kasaudi*, pressure cookers and other utensils as given in table 8.

Table 8: Types of utensils used by different ethnic groups

Types of utensils used		Muslims		Dalit		Madhesi		Others*	
		N	%	N	%	N	%	N	%
Karai	Small	7.0	15.9	67.0	19.5	14.0	17.9	228.0	16.0
	Medium	9.0	20.5	55.0	16.0	8.0	10.3	242.0	17.0
	Large	2.0	4.5	8.0	2.3	4.0	5.1	35.0	2.5
Kasaudi/ Handi	Small	6.0	13.6	64.0	18.6	15.0	19.2	158.0	11.1
	Medium	9.0	20.5	47.0	13.7	10.0	12.8	229.0	16.0
	Large	2.0	4.5	8.0	2.3	3.0	3.8	26.0	1.8
Pressure cooker	Small	2.0	4.5	20.0	5.8	5.0	6.4	91.0	6.4
	Medium	3.0	6.8	25.0	7.3	6.0	7.7	121.0	8.5

Types of utensils used		Muslims		Dalit		Madhesi		Others*	
		N	%	N	%	N	%	N	%
	Large	0.0	0.0	2.0	0.6	0.0	0.0	14.0	1.0
Other utensil	Small	2.0	4.5	22.0	6.4	7.0	9.0	119.0	8.3
	Medium	2.0	4.5	23.0	6.7	5.0	6.4	126.0	8.8
	Large	0.0	0.0	3.0	0.9	1.0	1.3	38.0	2.7
Total		**44.0**	**100.0**	**344.0**	**100.0**	**78.0**	**100.0**	**1427.0**	**100.0**

** Note:*

- *Others- Indigenous Terai groups and Hill tribes*
- *Small – less than 3 litres*
- *Medium – 3-5 litres*
- *Large – more than 5 litres*

3.5 Food habits in the Terai

Types of food eaten by the families affect the type of pots used, the type of fuel used, duration of cooking, the quantity of fuel used and therefore the design of mud stoves they use.

The Terai Janjatis mainly consume rice (98.7%) followed by maize (48.3%). This points out that their staple does not just constitute rice. In comparison, the Muslims consume 100.0% of rice and only 22.4% of maize. The AEPC's report on "Identifying Cooking Requirements according to Geographic Location, Fuel, Cooking Systems in Nepal" states that a good consumption pattern is dictated by the consumption of rice, tubers, meat milk, pulses, vegetables, oil, sugar/salt. Thus, the Terai Janjatis, Madhesis and Muslims only consume a substantial amount of rice which points out inadequacy in their caloric intake and corresponds to the food poverty percentage shown in table 9 below.

Table 9: Ethnic groups in the Terai and their corresponding cooking stoves, food type and fuel type

Regions of Terai	Major Ethnic Groups	Population and Poverty level		Types of Stoves used (%)			Per Capita Per Day Food Consumption (grams)			Household using different fuel type (%)	
		Total Population	% Below poverty	Open fireplace	Mud	Kerosene/ gas	Rice	Maize	Wheat	Firewood	Cowdung
Western Terai	Terai Janjati	799863	38.60	7.35	82.09	6.92	319.74	35.30	98.56	75.53	16.26
	Madhesi	88220	17.60	-	-	-	-	-	-	-	-
	Muslim	101348	41.30	5.44	71.38	12.54	316.93	9.25	116.21	81.22	6.24
Central Terai	Terai Janjati	2216878	26.60	4.34	91.08	2.44	404.13	28.60	72.52	41.64	53.77
	Madhesi	1847194	17.60	-	-	-	-	-	-	-	-

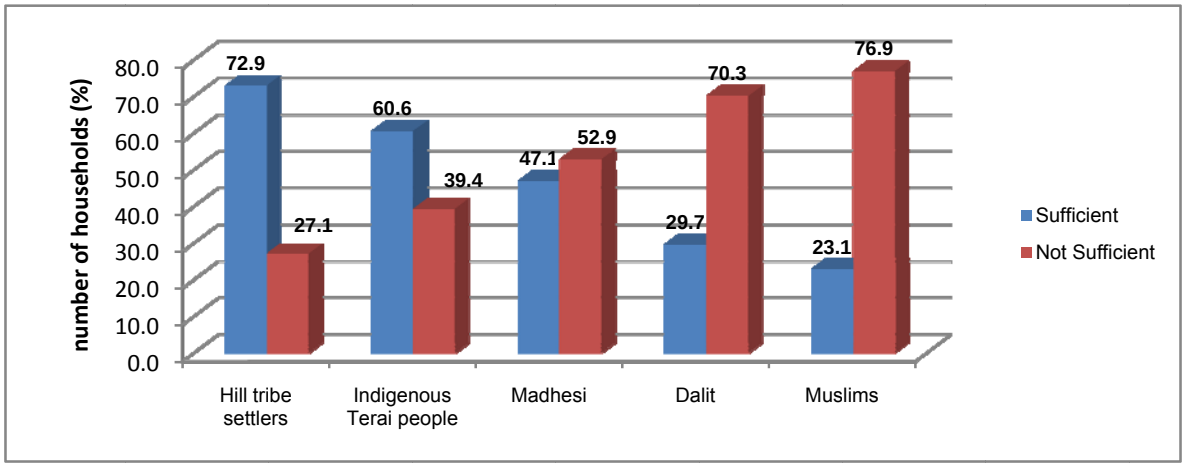
	Muslim	588164	41.30	5.03	89.81	5.16	344.29	15.04	93.33	35.19	59.65
Eastern Terai	Terai Janjati	782822	38.60	4.49	93.47	1.28	387.82	34.34	84.28	59.11	28.17
	Madhesi	1847194	17.60	1.70	91.63	5.74	363.11	12.76	141.91	30.45	58.99
	Muslim	588164	41.30	1.75	96.29	1.96	336.71	10.49	99.18	38.01	33.44

Source: Final Report on Identifying Cooking Requirements according to Geographic Location, Fuel, Cooking Systems in Nepal, AEPC (date not provided)

3.6 Sufficiency of food produced

Those households that had extra land for agriculture produced their own staple such as rice, millet, wheat, rice, etc. However, due to the limitation of the amount of land they owned, all the households could not grow enough food for their family for the whole year.

Figure 10: Sufficiency of the food produced for a year by different ethnic groups



Of those households that produce millet, maize or rice, 72.9% of the Hill tribe settlers have said their produce is enough to feed their family the whole year. Greater than 50% of the Madhesis, 70.3% of the Dalit households and 76.9% of the Muslim households said the food they produce is not enough to feed them for the whole year which could be because they lack space to grow food enough for their family (see Figure 10).

CHAPTER 4: COOKING FUEL USED IN TERAI

4.1 Types of cooking fuel used in Terai

People used three main types of biomass energy for cooking purposes: firewood, cow dung (locally known as Guitha in Terai) and agricultural residues. For this study purposes, however, cooking fuels are classified into four categories: a) firewood, b) cow dung c) agricultural residue and d) others.

Wood logs, and wood twigs were the predominant types of fire wood used as firewood. Most of the households were found using mixed types of fuel including wood logs, wood twigs, cattle dung and agricultural residues. Dung cakes were used more widely in Eastern Terai districts followed by Central Terai and Western Terai (see Table 10).

a) Firewood

The firewood used was mostly twigs and branches of the tree and less of wood log. Kindling and agricultural waste was used for lighting fire in eastern regions where as plastic or rubber was used in the western regions.

b) Cow dung

Cow dung was common in the Madheshi ethnic group (56%) and Muslim (34%). Usage of cow dung was extensive in the Terai clusters with maximum users in eastern Terai (34%) followed by central Terai (22%) and western Terai (10%).

c) Agricultural residue

Agricultural residues along with firewood were used in most of the households that were surveyed. Agricultural residues, such as maize stalk, was used in Dang whereas maize cobs was used in Rautahat and rice/wheat straw and dry sorghum plants were used in Saptari. Among the Muslim communities, 20% were seen to be using agricultural waste. Only limited use of the agricultural residues, mentioned above, was noted in most of the districts except in Dang where maize stalk were used for 2-3 months in a year.

d) Others

Besides agricultural residues, people were also using dry grasses such as thatch, mixed with fire wood, in Nawalparasi, Kapilbastu and Dang for cooking their food. In other districts such as Bardia, Kailali and Kanchanpur thatch was used for lighting fire wood. These dry grasses were only used in small quantities in the surveyed districts.

4.2 Trends and cost in using different types of fuel

The level of consumption of firewood is relatively similar (around 150-175kg/household per month) in all of the development regions except the Western Development Region where the average firewood consumption was recorded to be 210 kg/month. Consumption of saw dust,

while cooking in the mud stoves, is greater in CDR (100.0 kg/month) and MWDR (83.8 kg/month).

Cost is the most important factor affecting choices made on type of fuel used. Table 10 shows that there is a decrease in the price of firewood (per kg) from the east to the west. The price of LPG gas in the Eastern Development Region and Western Development Region is higher than that of the rest of the regions because they buy gas per kilogram.

Table 10: Types and price of fuel usage

Types of fuel used	EDR		CDR		WDR		MWDR		FWDR	
	Consumption (per month)	Price (Rs./kg, litre, cyl)	Consumption (per month)	Price (Rs./kg, litre, cyl)	Consumption (per month)	Price (Rs./kg, litre, cyl)	Consumption (per month)	Price (Rs./kg, litre, cyl)	Consumption (per month)	Price (Rs./kg, litre, cyl)
Firewood (kg)	166.0	10.3	176.0	10.7	210.0	7.8	152.0	6.3	152.0	4.3
Crop residue/dried grass (kg)	134.0	2.0	30.0	2.7	44.0	2.4	58.0	-	80.0	-
Dung (kg)	120.0	0.4	70.0	-	112.5	8.2	67.5	-	82.5	-
Coal (kg)	-	2.0	5.0	13.3	5.0	71.8	50.0	-	-	-
Kerosene (litre)	-	78.6	2.8	78.6	-	75.5	-	76.8	-	77.1
LPG (cylinder)	-	1768.1	-	1528.2	-	1344.1	-	1373.3	-	1367.0
Saw dust (kg)	-	2.0	100.0	2.0	14.4	16.4	83.8	2.7	14.0	2.7



Different types of fuel used in the surveyed districts

4.3 Relation between fuel type used and poverty

It is important to link different types of mud stove users with the type of firewood they use in order to feed to the stove improvement process. The survey (see Table 11) shows that a range of poor, irrespective of the poverty level, is predominantly using firewood (wood logs as well as twigs and branches as available) in the range of 55 to 65%. The agricultural residues are used less at 8% by the hardcore poor, possibly due to absence of agricultural activities among these groups. Poor and the medium poor as also using dung cakes, many of them sourcing from their own livestock or collecting from the streets.

Table 11: Poverty level of the households and their choice of fuel type

Which fuels are used in this mud stove?	Hardcore Poor		Medium Poor		Poor	
	N	%	N	%	N	%
Wood log	168.0	54.2	48.0	63.2	220.0	64.3
Wood twigs and branches	175.0	56.1	54.0	68.4	208.0	61.2
Agricultural residue/ dried grass	27.0	8.8	15.0	20.5	70.0	21.3
Dung cakes	20.0	6.5	12.0	17.1	91.0	27.7
Mixed	9.0	2.9	6.0	9.1	17.0	5.4

The above observation is also supported by the quantity of different fuel used by different households (see Table 12). Hardcore poor (177.9kg/month) and poor (176.1kg/month) households use a larger amount of firewood when compared to medium poor (145.9kg/month) households. The consumption of crop residue is greater within medium poor (100.7kg/month) and poor (201.4kg/month) households. LPG has only been seen to be used in "poor" (1 Cyl/month) category households and none by the "hardcore poor" and "medium poor" households.

Table 12: Poverty level of the households in the Terai, with average consumption of fuel

	Firewood (Kg/month)		Crop residue (Kg/month)		Dung (Kg)		Quantity of coal in kg		Quantity of kerosene in litre		Quantity of LPG in cylinder		Quantity of saw dust in kg	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hardcore Poor	177.9	100.1	83.2	52.9	121.0	90.9	5.0	0.0	2.8	1.1	-	-	46.9	81.3
Medium Poor	145.9	73.4	100.7	69.2	116.7	74.8	-	-	2.8	0.8	-	-	16.8	10.1
Poor	176.1	14.8	201.4	294.8	145.0	116.5	27.5	31.8	2.9	1.2	1.0	1.0	99.8	107.6
Total	**170.9**	**90.9**	**120.9**	**133.3**	**120.6**	**84.1**	**16.3**	**22.5**	**2.8**	**1.1**	**1.0**		**51.2**	**80.3**

4.4 Relation between fuel type used and ethnicity

In the same way as with the different poverty levels, the link between different ethnic groups and their fuel consumption helps in understanding the need for an improvement in their mud stoves. Table 13 shows that the Indigenous Terai people, Madhesis, Dalits and the Muslims consume a higher amount of firewood (175.2kg/month, 195.0kg/month, 174.1kg/month and 184.4kg/month respectively) when compared to the Hill tribe settlers who consume only 148.0kg of firewood per month. Consumption of crop-residue, dung and coal, by the Hill tribe settlers, is also less compared to the other ethnic groups. This shows that the Hill tribe settlers are more conscious towards using less fuel and as a consequence, more open towards installing an ICS.

Table 13: Ethnic groups in the Terai, with average consumption of fuel

	Firewood (Kg/month)		Crop residue (Kg/month)		Dung (Kg)		Quantity of coal in kg		Quantity of kerosene in litre		Quantity of LPG in cylinder		Quantity of saw dust in kg	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hill tribe setllers	148.0	57.8	84.3	29.9	88.3	37.1	5.0	-	3.2	0.4	-	-	90.7	138.3
Indigenous Terai people	175.2	92.4	146.8	168.7	130.6	93.2	20.0	26.0	2.8	1.6	1.0	-	21.4	31.7
Madhesi	195.0	131.8	-	-	-	-	-	-	2.3	0.8	-	-	-	-
Dalit	174.1	98.6	87.5	61.9	98.8	60.7	-	-	3.6	0.7	-	-	80.7	101.0
Muslims	184.4	100.9	100.0	24.5	160.0	84.1	-	-	-	-	-	-	25.0	-
Total	170.9	90.9	120.9	133.3	120.6	84.1	16.3	22.5	2.8	1.1	1.0	-	51.2	80.3

More than 45.0% of the households of the Hill tribe settlers, Indigenous Terai people, Madhesis and Dalit use wood twigs and branches fuel for cooking in their mud stoves as it is easier and more accessible than felling trees for wood logs. A higher proportion of Muslims (33.3%), out of all the ethnic groups, are also predominantly using agricultural residues most likely because it is harder for them to access forests (see Table 14).

Table 14: Types of fuel used in the mud stoves by different ethnic groups

	Hill tribe settlers		Indigenous Terai people		Madhesi		Dalit		Muslims	
	N	%	N	%	N	%	N	%	N	%
Wood log	92.0	69.2	226.0	55.1	27.0	96.4	85.0	61.2	6.0	33.3
Wood twigs and branches	114.0	84.4	233.0	56.7	13.0	46.4	70.0	50.4	7.0	38.9
Agricultural residue/dried grass	27.0	21.3	64.0	16.1	2.0	7.1	13.0	9.4	6.0	33.3
Dung cakes	33.0	26.6	81.0	20.1	1.0	3.6	5.0	3.6	3.0	16.7
Mixed	3.0	2.6	19.0	4.8	1.0	3.6	7.0	5.1	2.0	11.1

4.5 Access to and source of firewood

a) Access to firewood

Availability of firewood was limited in Sarlahi, Rautahat, Kailali and Nawalparasi. Firewood was relatively more accessible in Dang and Bardia which are known to have some forest cover left. The table below shows the accessibility of firewood to communities.

Figure 11: Availability of firewood in the surveyed districts.

b) Sources of firewood

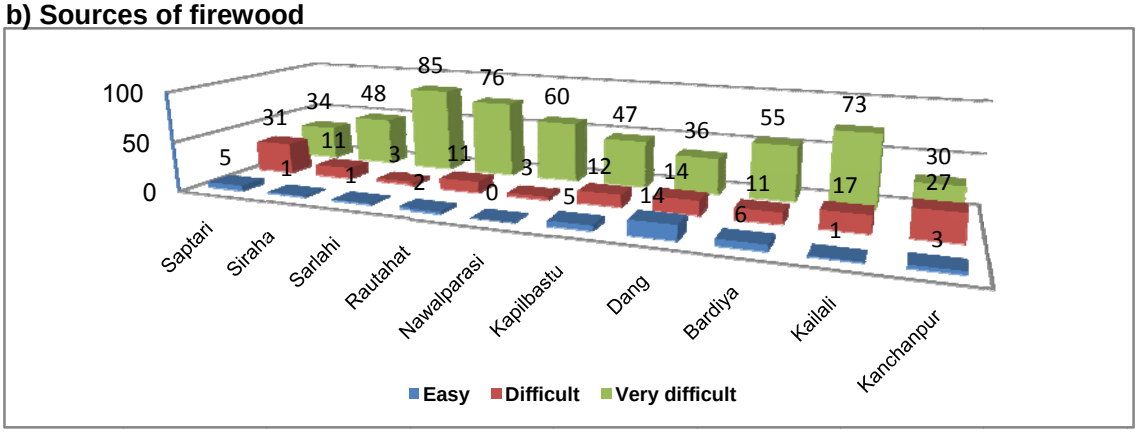
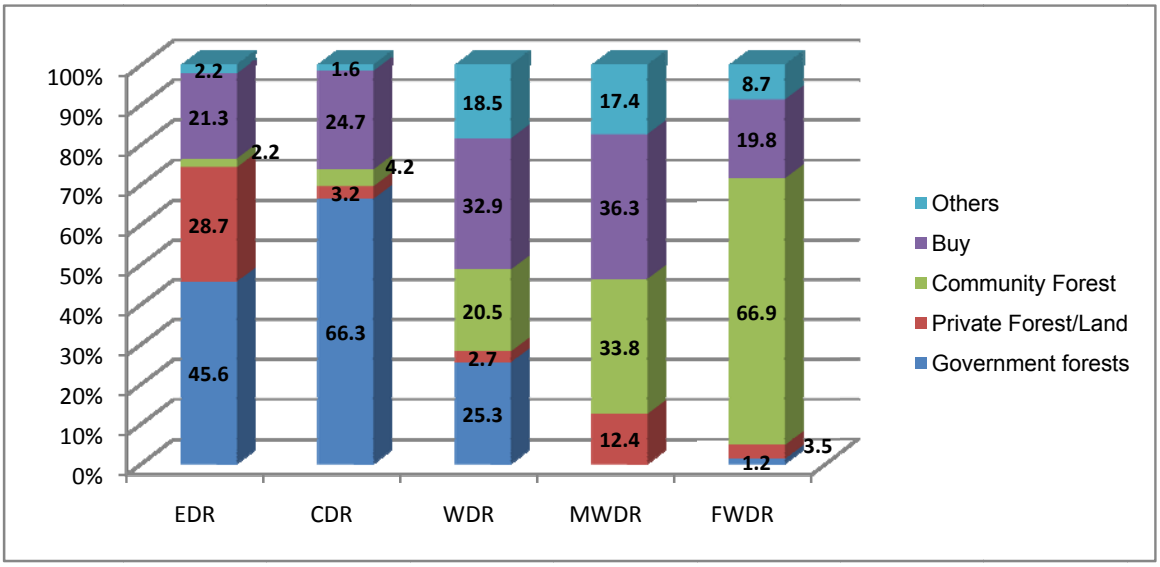


Figure 12: Source of firewood for the households in the surveyed districts.

When compared to the households in EDR and CDR, a greater percentage of households in



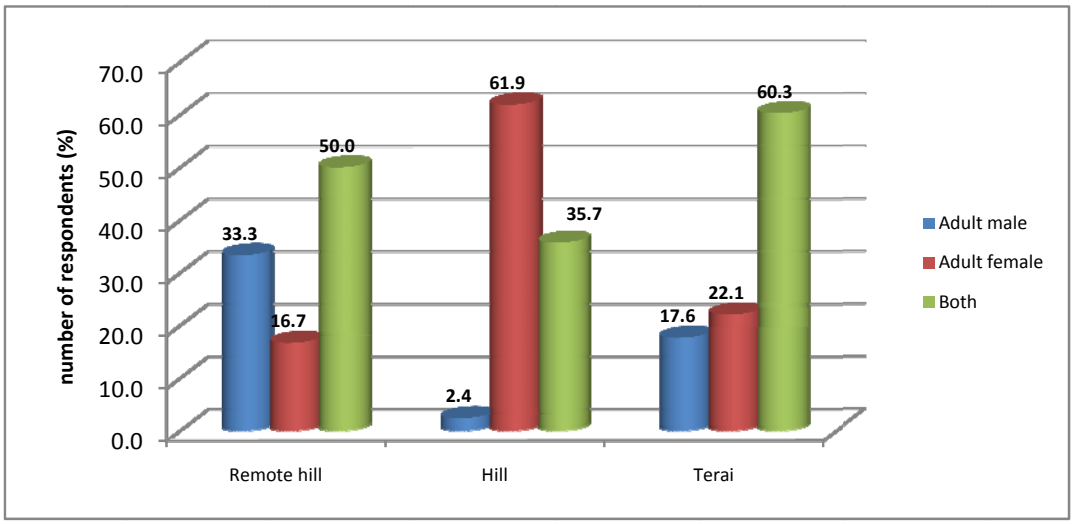
FWDR (66.9%), MWDR (33.8%) and WDR (20.5%) obtain their firewood from the community forest. However, a large proportion of the households in the CDR (66.3%), EDR (45.6%) and WDR (25.3%) use the government forest to collect firewood. One main reason for this could be because these households did not have access to a private forest from where they could get firewood.

The availability or access to forests is different for different regions of Terai; the degree of access to firewood is illustrated in figure 11 above. The way they access firewood is shaped by the availability of fuel. For example, 21.3% of the households in EDR, 24.7% of the

households in CDR, 32.9% of the households in WDR, 36.3% of the households in MWDR and 19.8% of the households in FWDR buy their firewood (see Figure 12). The households are using cash to buy firewood. No cases of the surveyed households were noted to have been selling the firewood or other types of fuel for their livelihoods.

c) Responsibility of collecting firewood

Figure 13: Responsibility of collecting firewood in the Biogas Users' Survey



Source: Biogas Users' Survey, Activity 1, AEPC, 2010/2011.

According to the Biogas Users' Survey 2010/2011, a higher proportion (60.3%) of both males and females were responsible for collecting firewood in Terai. In only 22.1% of the households, females were responsible for collecting firewood. In nearly 18% households, the responsibility of collecting firewood was given to the males.

CHAPTER 5: MUD STOVES PRACTICES

5.1 Prevalence of mud stoves

A study by TRUST i.e. Identifying *cooking requirements according to geographic location, fuel, cooking systems in Nepal,* AEPC (no date) indicates that about 79% of the households in Terai have a mud-stove, and 9 % open fire place but *not an ICS-mud stove* (see Table 15). Mud stove is widespread in Terai ethic group viz. Muslim (91%), Madheshi (91%) and Terai Janjati (86%). Fewer households belonging to Newar, Madheshi Muslim and ethnic groups belonging to other groups used open fire stoves. Kerosene/gas stoves were used by limited numbers i.e. 6.92% by Terai Janjatis and 12.54% by Muslims in the Western Terai region.

Table 15: Types of stoves used in Terai

Region	Open fire place	Mud stove	Smokeless stove	Kerosene/ gas stove	Others	Total %
Terai	8.9	78.7	1.4	10.6	0.5	100

Source: Central Bureau of Statistics (2003/04)

It is therefore logical that any initiative to impact energy efficiency in cooking has to understand well how mud stoves are used and what changes are sought by its users. This is also the focus of this study.

The mud stoves could be mono functional or multi functional. Mono functional stoves are used only for one function such as cooking or heating whereas multi function stoves have several functions such as cooking, room heating, roasting etc. The widely used mud stoves are basically of mono function type. Mud stoves are normally built with clay, agricultural residues, dung and bricks or mud.

The design processes of such stoves are as follows:

Table 16: Design process of mud stoves

Process	Heat transfer	Conduction	
		Convection	Natural
			Forced
		Radiation	
	Fluid flow	Laminar	
		Turbulent	
	Combustion	Mass	
		Heat	
		Thermodynamic	
		Kinetic	
	Material sciences	Thermal properties	
		Chemical properties	

Combustion process depends on physio-chemical conditions of fuel (such as size, shape, density, moisture and carbon contents) wood, quality and mode of air supply, conditions of surroundings etc.

5.2 Types of mud stoves used in Terai

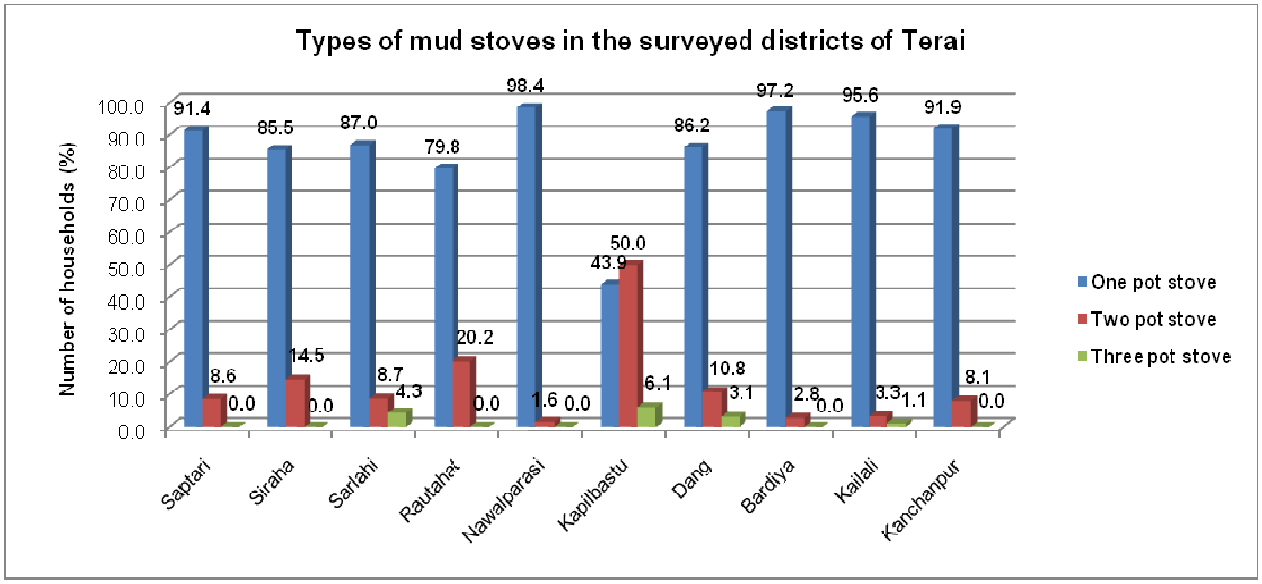
Stoves used in Terai are predominantly one pot or two pot mud stoves with or without brick wall.

In eastern districts such as Siraha and Saptari, mostly single pot mud stove were found to have 10-25 cm deep combustion chamber for collecting charcoal and ash inside the chamber. Additionally, those households also owned an extra two pot mud stove outside the main house for cooking food for animals. These stoves were with larger pot holes so that only big pots would fit in such stove. The stoves in these districts were predominantly of closed types.

In western and far western districts such as Nawalparasi, Dang and Kanchanpur, the mud stoves were predominantly one pot. Combustion chambers of such stoves were not deep but in some cases they had outer border to contain coal and ash. The households in Saptari, Siraha, Nawalparasi and Rautahat had more than one mud stove or in some cases sawdust stove in their houses. These stoves were made up of mud, and pieces of straw, rice husks or dry grasses. These stoves were open in the front side where fire wood is placed (see Section 7.2 (a) for open type mud stoves). In some cases such as in Dang, such stoves were found to be movable. These stoves have three pot-rests where as in case of Kailali there are *Rana stoves* with four pot rests.

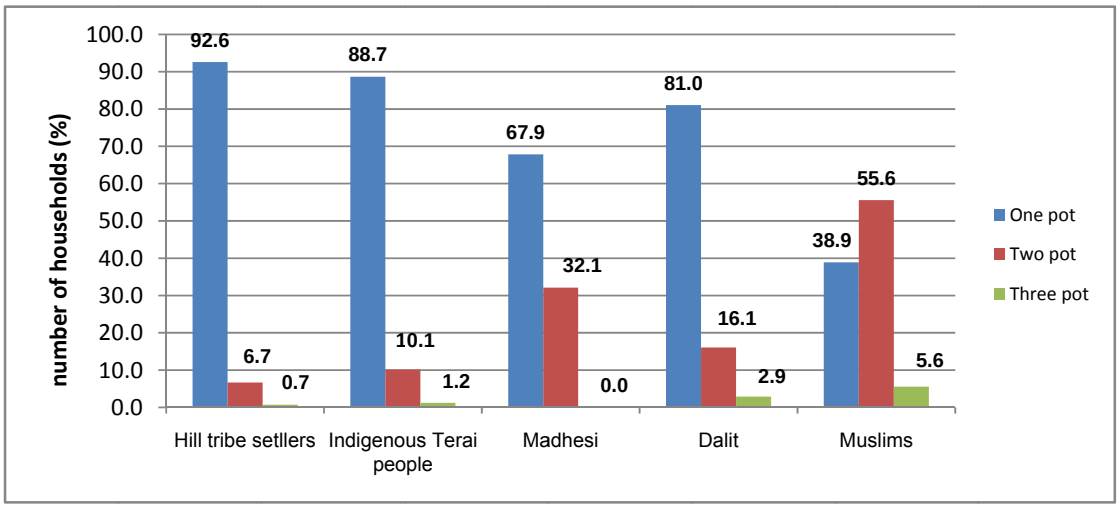
The study showed that more than 75% of the households in all the 10 surveyed districts, except Kapilbastu, have one pot stove. In Kapilbastu, 43.9% of the households use one pot stove and 50.0% of the households use two pot stoves (see Figure 13).

Figure 14: Types of mud stoves used in the surveyed districts of Terai.



Madhesi (67.9%) and Dalit (81.0%) use single pot stoves. In the other hand, 55.6% of the Muslim households have a two pot mud stoves (see Figure 15).

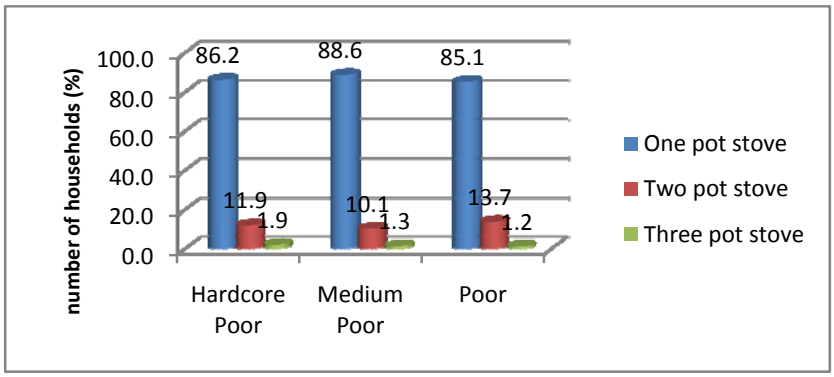
Figure 15: Types of mud stoves used by different ethnic groups.



5.3 Choices of stove types by poverty groups

The above choice of general communities is also reflected when analyzed for different poverty groups. Figure 16 shows that the all of the households in the three poverty categories: hardcore poor (86.2%), medium poor (88.6%) and poor (85.1%) are mainly using one pot stoves. Very few of the households are using three pot stoves.

Figure 16: Types of stoves being used by different poverty levels



5.4 Practice of having multiple stoves in a family

In Saptari, Rautahat, Sarlahi, Kailali and Kanchanpur some of the families had more than two stoves. In Saptari bigger stoves were kept outside especially for cooking food for animals and boiling paddy and the other for cooking their food. In Rautahat, two stoves were used, one for cooking vegetarian food and the other for non-vegetarian food whereas in Sarlahi one stove was made just for making local alcohol. When families had stoves more than one, one of the stoves was usually an improved cooking stove (ICS), particularly in Rautahat.

In other districts two or more stoves were used when they needed to cook more efficiently for more guests in their houses. In Kailali and Kanchanpur there were three single pot stoves together as well. In some districts such as Siraha they cook food inside during rainy seasons where as in the dry seasons they preferred to cook outside and hence had two stoves.

In Kailali, some of the households replaced ICS with traditional mud stoves because the ICS consumed more firewood while cooking and produced more smoke. However, in Rautahat, even when ICS was being freely distributed with some cooking utensils, the households dismantled these stoves, after they were installed, to get more benefit from the programme.

From left a) Closed type mud stove, b) closed type mud stove with an elevated border for collection of ash, c) Open type mud stove, d) Two pot stove

All these stoves are flexible to use different types of fuel available. However, in some cases such as in Saptari, combustion chambers are deeper so that firewood mixed with cattle dung

can be used and a amount of ash and charcoal can be collected inside. The bigger stoves made outside the houses in Saptari have bigger pot holes to fit bigger pots. In such cases, the use of agricultural residue such as rice or wheat straw cut in pieces as fuel was common. However, in western districts of Kapilbastu, Kailali and Kanchanpur, combustion chambers were made at the floor level with boundaries outside the stove made to contain charcoal and ash.

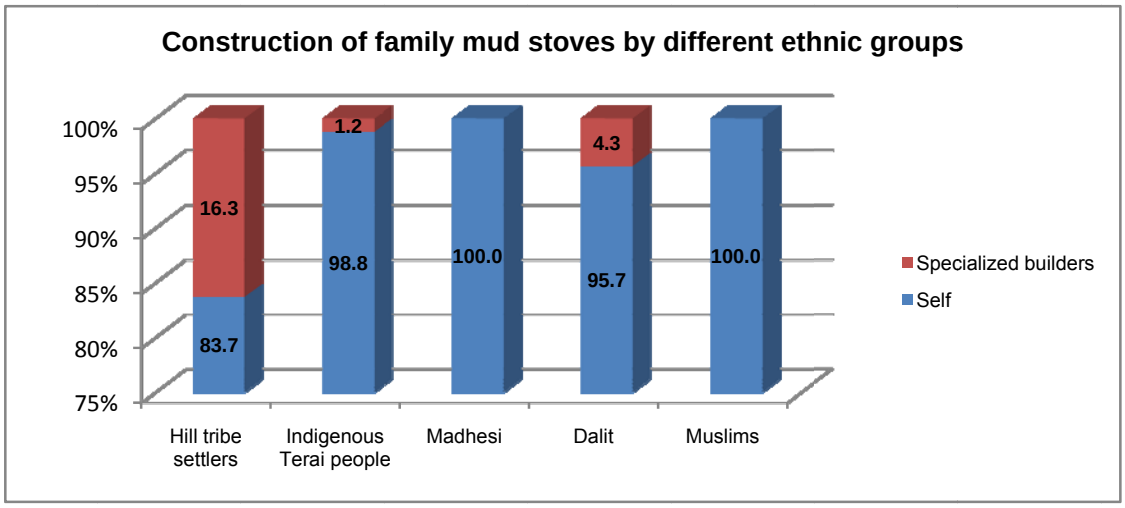
5.5 The making of a family mud stove

Majority of the stoves in the surveyed households have been built by the owners themselves, avoiding instances to pay for labour. Only a few of the households in Siraha (1.6%), Nawalparasi (10.8%), Kapilbastu (6.1%), Dang (13.8%), Bardiya (8.3%), Kailali (5.5%) and Kanchanpur (1.6%) hired specialized builders to make their stoves (see Table 17)

Table 17: Construction of family mud stoves

Who made the mud stove?	Saptari		Siraha		Sarlahi		Rautahat		Nawalparasi		Kapilbastu		Dang		Bardiya		Kailali		Kanchanpur	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Self	70.0	100.0	62.0	98.4	90.0	100.0	87.0	100.0	58.0	89.2	62.0	93.9	56.0	86.2	66.0	91.7	86.0	94.5	61.0	98.4
Specialized builders	0.0	0.0	1.0	1.6	0.0	0.0	0.0	0.0	7.0	10.8	4.0	6.1	9.0	13.8	6.0	8.3	5.0	5.5	1.0	1.6
Total	**70.0**	**1.6**	**63.0**	**100.0**	**90.0**	**100.0**	**87.0**	**100.0**	**65.0**	**100.0**	**66.0**	**100.0**	**65.0**	**100.0**	**72.0**	**100.0**	**91.0**	**100.0**	**62.0**	**100.0**

Figure 17: Construction of family mud stoves by different ethnic groups



All of the Madhesi and Muslim households that were surveyed said they built their mud stoves by themselves. The greatest proportion of Hill tribe households (16.3%) said they hired specialized builders to construct their stoves (see Figure 17). This shows that the Hill

tribe settlers are more willing to spend, or have more money that they can spend to have a stove close to an ICS.

5.6 Households' priorities for their mud stoves

Importance to "cooking fast" was given the first priority by the mud stove users. This was followed by economy of fuel or "saving fuel" and "less cost" as shown in table 18. This shows that the households put more emphasis on cooking faster rather than decreasing the smoke in the kitchen or saving fuel.

Table 18: Priority of the surveyed households on different aspects of their stoves

Importance to different aspects of the stove	EDR	CDR	WDR	MWDR	FWDR
Saving fuel	3.0	2.0	2.0	3.0	3.0
Cooking fast	1.0	1.0	1.0	2.0	1.0
Less costly	2.0	4.0	4.0	1.0	2.0
Less smoke	5.0	3.0	3.0	4.0	6.0
Keeps the house warm	4.0	5.0	5.0	5.0	5.0

(Note: 1 is ranked as highest priority and 6 is ranked as the least in priority)

5.7 Patterns of design in prevalent mud stoves

a) Floor level of the combustion chamber

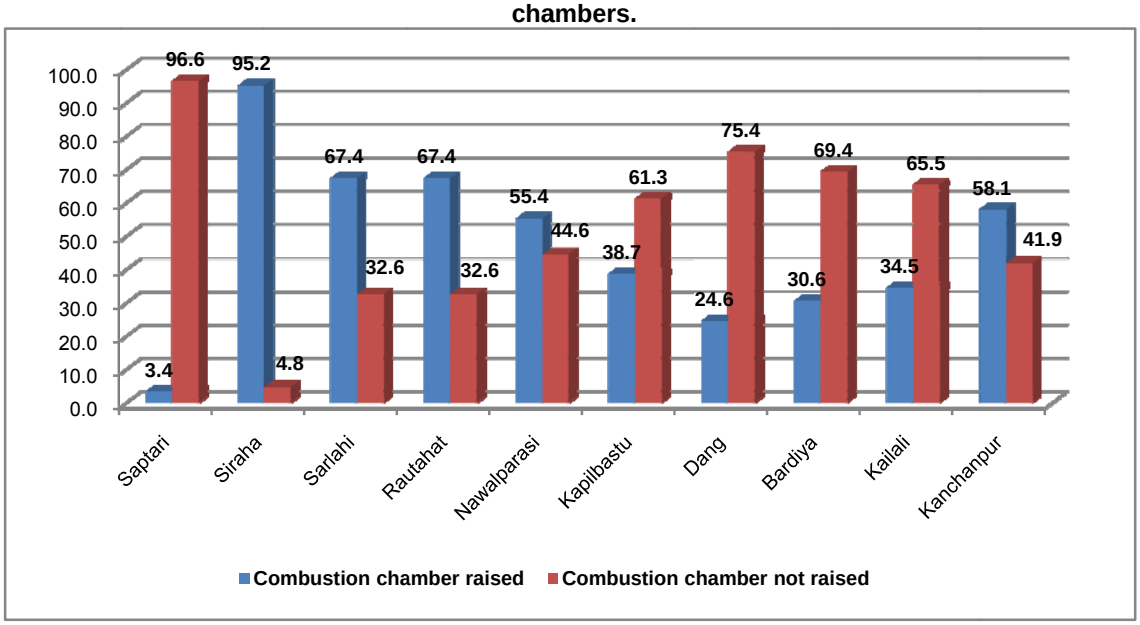
Households in Saptari (96.6%), Dang (75.4%), Bardiya (69.4%), Kailali (65.5%) and Kapilbastu (61.3%) said they did not raise their combustion chambers whereas the households in Siraha (95.2%), Sarlahi (67.4%), Rautahat (67.4%), Nawalparasi (55.4%) and Kanchanpur (58.1%) said that they have raised the floor of their combustion chamber (see Figure 18). Majority of the respondents said they made this change because they wanted to collect and store ash. Other reasons are listed in table 19 below.

Table 19: Reasons that the respondents raised or did not raise the floor of their combustion chamber.

S.N.	Why did you raise or did not raise the floor of the combustion chamber?	EDR	CDR	WDR	MWDR	FWDR	Total
1	To collect and store ash.	9	82	38	28	11	168
2	Easy and faster.	0	14	10	35	33	92
3	It is easy to burn fire as it keeps stove warm for a long period and keeps the food warm and tasty.	6	12	12	8	9	47
4	It reduces smoke.	2	1	0	0	0	3
5	Keeps the house warm in winter.	0	4	0	5	2	11
6	Less fuel is consumed.	0	7	3	11	0	21
7	Moveable and long - lasting.	0	1	5	1	1	8
8	To avoid the fire to spread outside the stove.	1	6	9	0	1	17

S.N.	Why did you raise or did not raise the floor of the combustion chamber?	EDR	CDR	WDR	MWDR	FWDR	Total
9	To feed fuel.	0	3	5	0	3	11
10	To prevent damage.	0	5	2	3	50	60
11	Traditional stove.	0	9	20	15	11	55
12	Not important.	1	6	9	0	1	17

Figure 18: Proportion of households that raised or did not raise the floor of their combustion chambers.



b) Experience with and proximity of current designs with ICS models (e.g. BESP/ESAP stoves)

The study was also assessing the prevalence of improved cooking stoves in the areas of survey. In the communities visited, the ICS was observed in a number of areas. These were mostly in Rautahat, Dang and Kailali. However, the experiences of the ICS owners were variable. For example, in Rautahat, some house-owners were using it for special occasions, or some had even dismantled ICS 'in hope for better incentives', while in Kailali, the design drift had caused the owners to feel that ICS was consuming more firewood. The users in Dang were most satisfied. ICS programmes in Terai, which have built these improved stoves, include a number of programmes of different donors including but not limited to BESP.

Table 20: Comparison of mud stove with BESP/ESAP stoves according to the surveyed households.

Is this stove similar to the BESP/ ESAP mud stove or different?	EDR		CDR		WDR		MWDR		FWDR	
	N	%	N	%	N	%	N	%	N	%
Similar	-	-	7.0	7.4	-	-	-	-	-	-
Different	3.0	37.5	1.0	1.1	1.0	1.9	2.0	3.3	12.0	38.7
Don't know	5.0	62.5	87.0	91.6	52.0	98.1	58.0	96.7	19.0	61.3
Total	**8.0**	**100.0**	**95.0**	**100.0**	**53.0**	**100.0**	**60.0**	**100.0**	**31.0**	**100.0**

From quantitative perspectives, Table 20 shows that 7 out of 95 respondents in CDR alone said the BESP/ESAP mud stoves are similar to their stoves. Majority of the households said they don't have any idea about the program.

The respondents of FWDR (38.7%) said the major difference was that there was some kind a chimney that lets smoke outside the house in a BESP/ ESAP stove (see Table 20).

The efficiency testing results of WBT in section 7.5 and CCT in section 7.7 shows that the efficiency of the tested stoves (16%) are slightly above the level specified by ESAP (traditional mud stove efficiency below 15%). The BESP/ESAP ICS stoves are said to be more than 20% efficient. This shows that the efficiency of the stoves tested is closer to the efficiency of the ICS stoves. Although there are many design differences, the traditional cooking stoves need fewer changes in design in order to have the same efficiency as an ICS.

Table 21: Response on how different BESP/ESAP stoves are from ordinary mud stoves

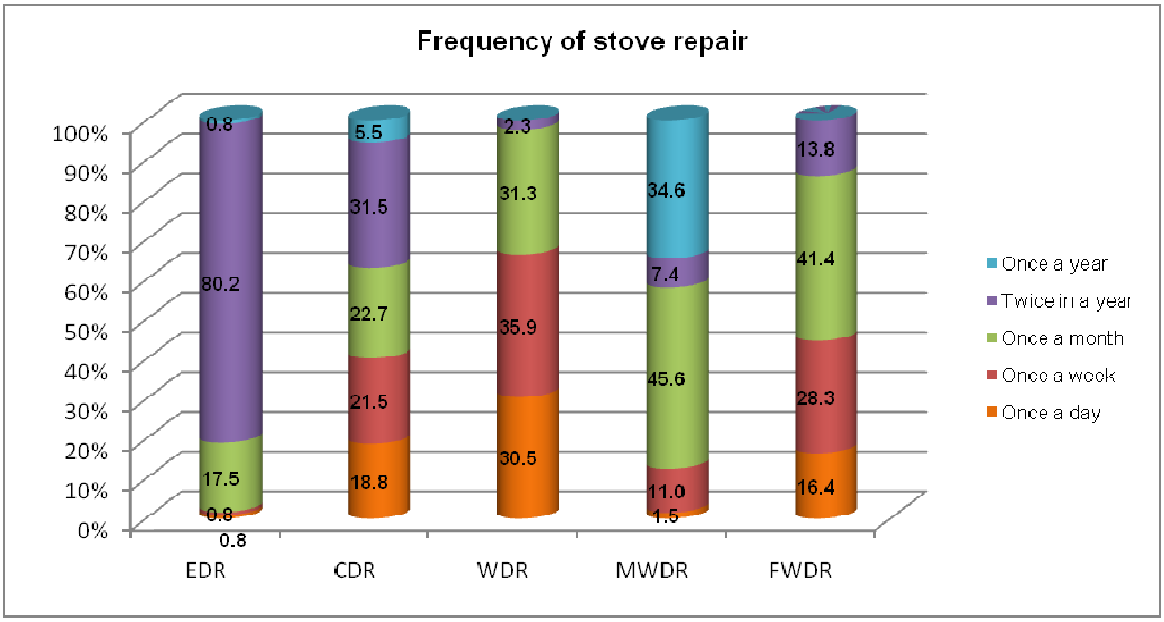
How is the household stove different from BESP/ESAP stoves?	EDR		CDR		WDR		MWDR		FWDR	
	N	%	N	%	N	%	N	%	N	%
In improved stove, smoke passes out.	-	-	1.0	100.0	-	-	2.0	100.0	10.0	83.3
In improved stove, it is warm for a long time.	-	-	-	-	-	-	-	-	1.0	8.3
In improved stove, less fuel is consumed	-	-	-	-	-	-	-	-	1.0	8.3
Total	-	-	1.0	100.0	-	-	2.0	100.0	12.0	100.0

c) Robustness of existing designs

The efficiency of existing designs of the surveyed mud stoves (16% efficient) were found slightly above the traditional mud stove (which are often less than 15%) and close to ICS (20-25% efficiency levels). Secondly, these designs are suitable for mixed fuels such as fire wood mixed with cow dung or firewood mixed with agricultural residues. This means that, even after simple improvements, such stoves could increase their efficiencies. However, there is also a need of improving ventilation and addition of smoke outlet device or chimney from the kitchen.

In the other hand, with small increments in cost, ICS with higher efficiency could be installed and relatively, ICS are better in terms of consuming less firewood (efficient), clean burning and with better kitchen management. What is important is to achieve a behavior changing programme as there are not many differences in the costs of such stoves with traditional ones except some bricks, chimney and rods.

Figure 19: Frequency of stove repair in the surveyed households in the development regions.



Most of the households in the EDR (80.2%) repair their stoves twice in a year. The fact that households in CDR (18.8%), WDR (30.5%) and FWDR (16.4%) repair their stoves every day shows that the stoves in these regions are fairly less durable than those in the other regions (see Figure 19). The stoves in the EDR are seen to be long lasting and only a few types of repair such as polishing and filling cracks were done twice a year.

5.8 Users' feedback on their mud stoves

a) How satisfied are they with their existing stoves

Although only a few of the surveyed households have said they want to improve their existing stoves; a majority of the households (in Table 22 below) in Nawalparasi (83.9%), Sarlahi (72.8%), Dang (63.5%), Rautahat (59.1%), Bardiya (41.7%) and Kanchanpur (41.9%) have said they are not happy with the performance of their existing stoves.

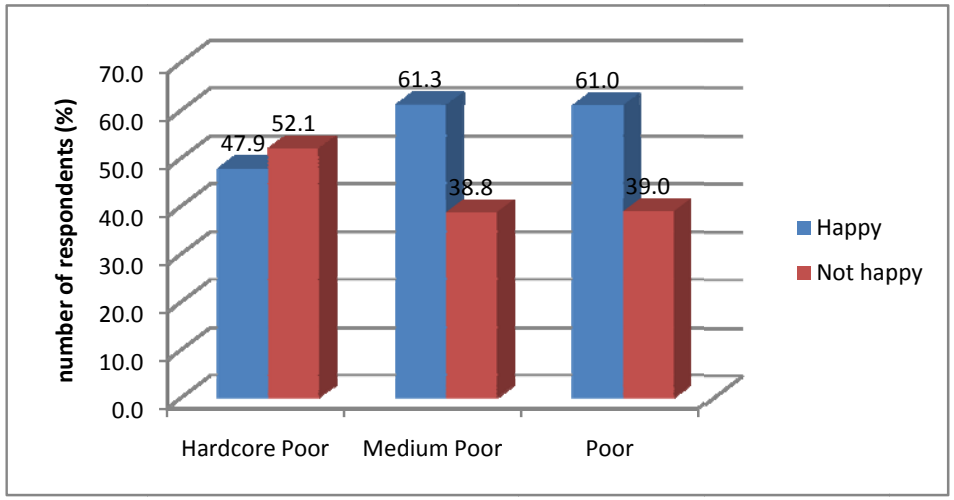
In Saptari, and Siraha the respondents were satisfied with their stoves, whereas in Nawalparasi, Sarlahi and Dang they were not satisfied with their stoves as shown in table 22. In these districts they were interested to have ICS because of clean burning fuel, better kitchen management and efficiency of the stove.

Table 22: Satisfaction of the households with the performance of their stoves

Are you happy with the performance of this stove?	Saptari		Siraha		Sarlahi		Rautahat		Nawalparasi		Kapilbastu		Dang		Bardiya		Kailali		Kanchanpur		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Yes	65.0	92.9	56.0	90.3	25.0	27.2	36.0	40.9	10.0	16.1	40.0	61.5	23.0	36.5	42.0	58.3	70.0	76.9	36.0	58.1	403	55.5
No	5.0	7.1	6.0	9.7	67.0	72.8	52.0	59.1	52.0	83.9	25.0	38.5	40.0	63.5	30.0	41.7	21.0	23.1	26.0	41.9	324	44.5
Total	**70.0**	**100.0**	**62.0**	**100.0**	**92.0**	**100.0**	**88.0**	**100.0**	**62.0**	**100.0**	**65.0**	**100.0**	**63.0**	**100.0**	**72.0**	**100.0**	**91.0**	**100.0**	**62.0**	**100.0**	727	100

i) Satisfaction of the different poverty levels

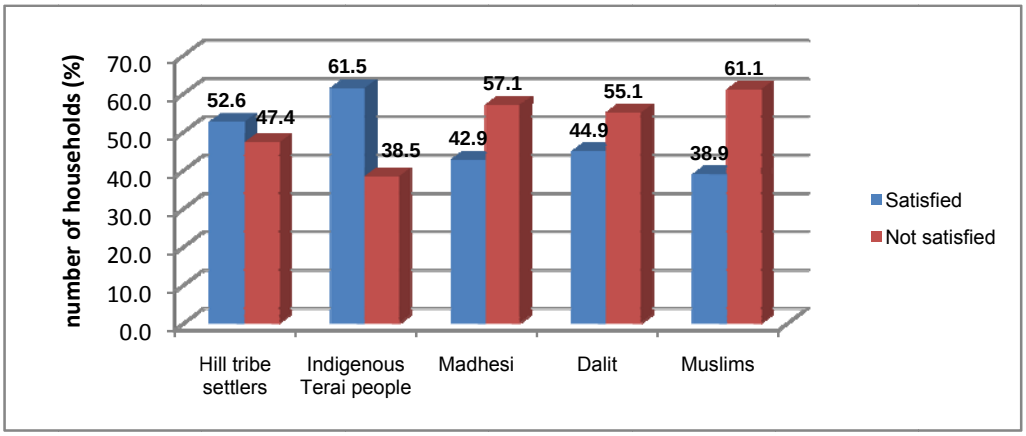
Figure 20: Households' satisfaction with the performance of their existing stoves



More than 60% of the households in the "medium poor" and "poor" category were happy with the performance of their stoves whereas only 47.9% of the "hardcore poor" were happy. One of the reasons these households gave as to why they were happy was that they had no other alternative. These households also said that they had been using this kind of traditional mud stove from generations before and were used to cooking in it (see Figure 20).

ii) Satisfaction of the different ethnic groups

Figure 21: Satisfaction of different ethnic groups with the performance of their existing stoves.



Majority of the Madhesi households (57.1%), Dalit households (55.1%) and Muslim households (61.1%) are not satisfied with their existing stoves whereas 52.6% of the Hill tribe settlers and 61.5% of the Indigenous Terai people are still satisfied with the mud stoves that they have. For the Hill tribe settlers, this might be because some of them have hired specialized builders to build an efficient stove. Even then, almost an equal proportion (47.4%) of the Hill tribe settlers is not satisfied with the way their stoves work (see Figure 21).

b) What users like about their stoves

The users like their own stoves because this is the only type of stove that they have had for a long time and it costs nothing except their labor charge. Other reasons that they like their stoves are because it is easy to cook, food cook fast and it is free. Most of the households also said they don't have any other option but to like their stoves.

In Kapilbastu, the households preferred a smaller sized, single pot stove as it consumed less firewood and it produced less smoke and was self made.

c) What users do not like and want to change about their stoves

Table 23: Households' suggestion on improvements to reduce smoke

Improvement in order to reduce smoke	EDR	CDR	WDR	MWDR	FWDR	Total	Total (%)
Make a chimney and a combustion chamber	0	34	57	48	49	188	25.5
Make an open kitchen	0	19	2	2	0	23	3.1
Make the firewood leaner and dry	0	12	0	0	0	12	1.6
Install an Improved cooking	121	54	20	29	44	268	36.4

Improvement in order to reduce smoke	EDR	CDR	WDR	MWDR	FWDR	Total	Total (%)
stove							
Proper ventilations should be made	0	23	15	34	24	96	13.0
Don't know	10	37	33	18	34	132	17.9
No need for changes	12	2	1	1	1	17	2.3
Total	143	181	128	132	152	736	100.0

In all the surveyed households, 41.6% (see Table 28) of the houses were poorly ventilated. This had an adverse effect on health of the family member. Most of these households complained that increased smoke in the kitchen caused them to spend more time in the kitchen because they couldn't cook their food efficiently.

Since the amount of smoke is very high in the kitchen, 25.5% out of 736 households (see Table 20), recommended for the installation of a chimney and 13.0% realized the need to have proper ventilation. Improper ventilation, in these households, resulted in soot covering the walls, roofs of the house and clothes. There is a need for cross ventilation in the kitchen with at least 2 windows to reduce smoke and soot.

The lighting in the kitchen of the surveyed households in Nawalparasi (51.6%) and in Rautahat (55.1%) was very poor (see Supplementary Document 4). Due to this, most of the households in these districts said they wanted to add more windows to be able to have good lighting and as a consequence, good ventilation.

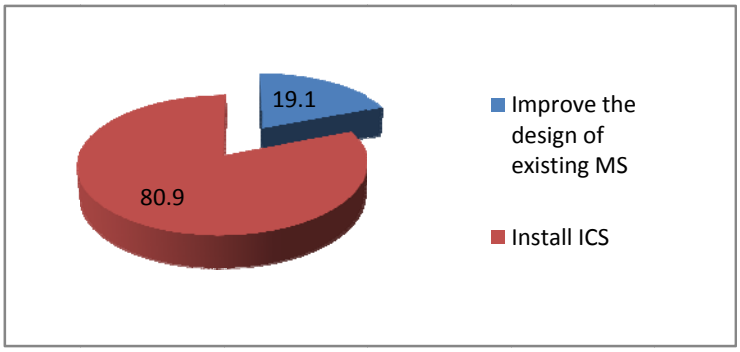
Proper combustion also leads to a decrease in the volume of smoke that is produced while burning firewood to cook. The size of the combustion chamber is not appropriate for proper combustion in 25.5% of the households and due to this reason, 188 out of 736 households said they want to improve the size of the combustion chamber. Size of the combustion chamber should be made based on the type of fuel used, amount of food cooked and size of the households.

In at least 30% of the households, the size of the hole through which firewood is inserted was small and does not allow proper combustion. In the households where the size of the space/hole through which firewood was inserted was large, excess firewood was consumed. Most of the Madhesi and Muslim households, that use cow dung, said they wanted to construct a larger sized hole for insertion of dung cakes.

In majority of the households in all the districts, the size of the pot hole did not exactly match the size of the pot. When the pothole was bigger in size than the pot, excess amount of heat was being lost through the pot hole and when the pothole was smaller than the pot, food was not being cooked properly. These households suggested that, in order to improve their stoves, they need to construct the pothole according to the size of their pot.

In addition to these suggestions for improvement when the surveyed households were asked if they would improve their existing mud stoves or would adopt an ICS, 80.9% of the households said they are willing to adopt an ICS even when only 44.5% of the 727 (see Table 22) households said they are not happy with the performance of their stoves. This shows that when given an opportunity, more of the households that said they are happy with the performance of their stoves would be willing to install an ICS.

Figure 22: Households' response to improving mud stoves



5.9 Possible models evolving from currently practiced traditional mud stoves

Some of the existing mud stoves currently being used in Terai were basically single pot, double pot and in some cases three pot mud stoves. These stoves are open towards fire wood side and others are closed towards fire wood side and hence named as open and closed types (also refer to Section 7.2).

a) Open stove

Open stoves are also known as *Tharu chulo*. In some cases such stoves are portable whereas in other cases they are fixed. The dimensions of such stoves differ from place to place as there is no standard and quality control of such design.

Open type mud stove

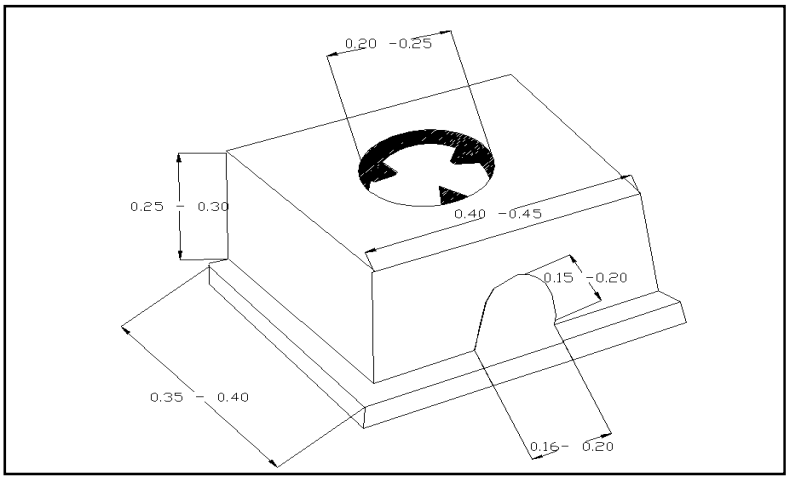
b) Closed stove

Two pot hole closed type stoves are also known as *Bahun Chulo*. These closed type traditional mud stoves, were also made up of different dimensions without considering their effectiveness. Most of them were built by the users themselves based on their experiences or knowledge that they have.

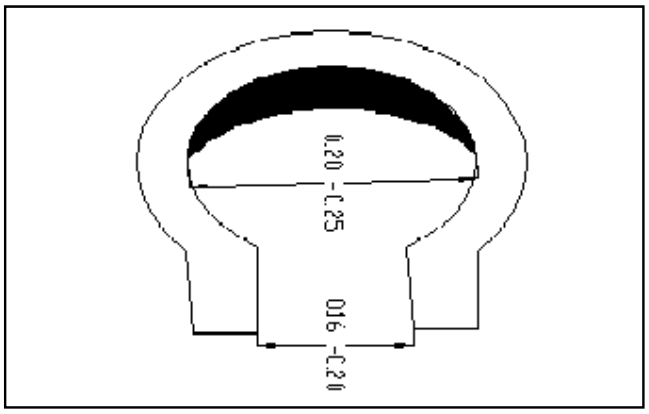
Closed type mud stove

All of the different types of stoves that were found in the surveyed districts had different height (13 – 36 cm), different dimension of the combustion chambers (depth up to 28 cm), different diameter of pot holes (12 - 24 cm) and different size of the opening for insertion of firewood (12-22 cm). Hence, it is recommended to have uniform dimensions for such stoves especially when using firewood although they vary according to size of the family, types of fuel used and cooking items. Therefore, the figures given below are some standard designs of such traditional single pot as well as two pot hole closed type mud stoves.

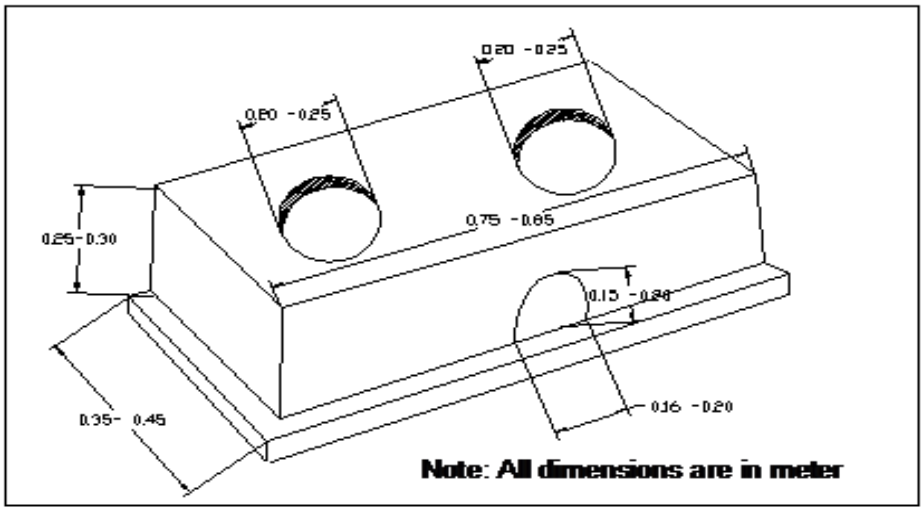
Single pot hole closed type mud stove



Single pot hole open type mud stove (Tharu cholo



Double pot hole closed type mud stove (Bahun Chulo)



Note: All dimensions noted in the figure are in meter.

5.10 Viable options for self help approach on how to improve the traditional mud stove

1. Develop at least 4-5 types of mud stove designs that can accommodate different types of fuels used (i.e. multi-fuel) or mixed fuel used and based on the number of family members. These stoves will have more flexible approach for pot and pot hole interface, optimal height and area of the combustion chambers and the opening of the fire insertion hole and chimney outlet. This approach is suitable mostly for those who are not willing or capable to pay.
2. Provide awareness training to the users regarding the installation process and operation and maintenance of such stoves including proper ventilation of the kitchens.
3. Promotion of ICS to be carried out by local organizations that will identify interested households either for improvement or for installation of new ICS. This approach is more suitable for those who are willing to install and pay for the ICS.

CHAPTER 6: USERS' WILLINGNESS TO CHANGE AND PAY

6.1 Perception of the Users on their stove

As discussed in Section 5, the users of the mud stoves have mixed feelings about their stoves. While they are generally satisfied (average 55%), they also seek their stoves to be fuel efficient, cooking process to be rapid and healthy (see Section 5). It can therefore be construed that there is always a scope for users to adopt better technologies if that is going to address some of their needs or desires.

We therefore consider that despite relative satisfaction with their current stoves, there is willingness to change among the households. These are also reflected in the nature of changes the people have expressed (see Figure 16).

However, it is important to explore whether or not the households are willing to pay for the changes and this is important from the sustainability point of view of the programmes that seek to support the households to change.

6.2 Priorities of expenditure of the households

In order to assess how much priority the households give when it comes to paying for the improvements of their stoves, the survey asked the households how they would spend their spare money if different needs arose at the same time.

The households in EDR, MWDR and FWDR said they would give first priority to buy extra food if they had spare money. All of the development regions said they would give least priority to buy toys for kids if they had spare money. The investment on stoves comes just below the midpoint, i.e. people are willing to spend money on the stoves when their other key priorities of food sufficiency and house maintenance have been accomplished.

Table 24: Priority of the surveyed households to use of spare money

Priority in use of spare money	EDR	CDR	WDR	MWDR	FWDR
To buy extra food	1.0	2.0	2.0	1.0	1.0
To repair house	2.0	1.0	1.0	2.0	2.0
To buy new clothes	3.0	3.0	3.0	4.0	4.0
To improve stove	4.0	4.0	4.0	3.0	3.0
To buy toys for kids	5.0	5.0	5.0	5.0	5.0

Note: 1 is highest priority and 5 is the lowest priority

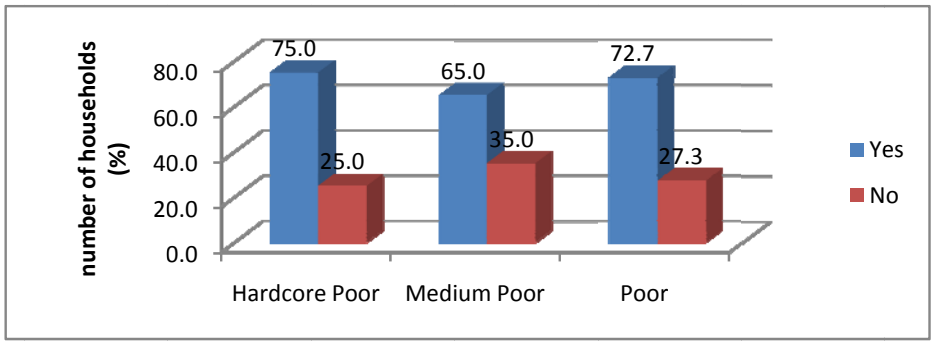
6.3 Willingness to pay for the improvement of stoves

However, when confronted with direct question of whether or not they would pay for the desired improvement of their traditional mud stoves, there were almost similar positive responses from all categories of poor (see Fig 23).

Interestingly, the hardcore poor were more willing (at 75%) to pay for the services, almost at par with the less poor group (72%) of people. The medium poor are relatively less prepared to pay with 65% willing to pay. What is important is that all categories of poor have high level of willingness to pay. This is despite overall level of satisfaction with their existing stoves being high, which could be a response reflecting more of the cultural values of the

communities to appreciate what they have than their real acknowledgement that their stoves are performing well from technical perspectives.

Figure 23: Willingness of the different poverty groups to pay to improve their stoves

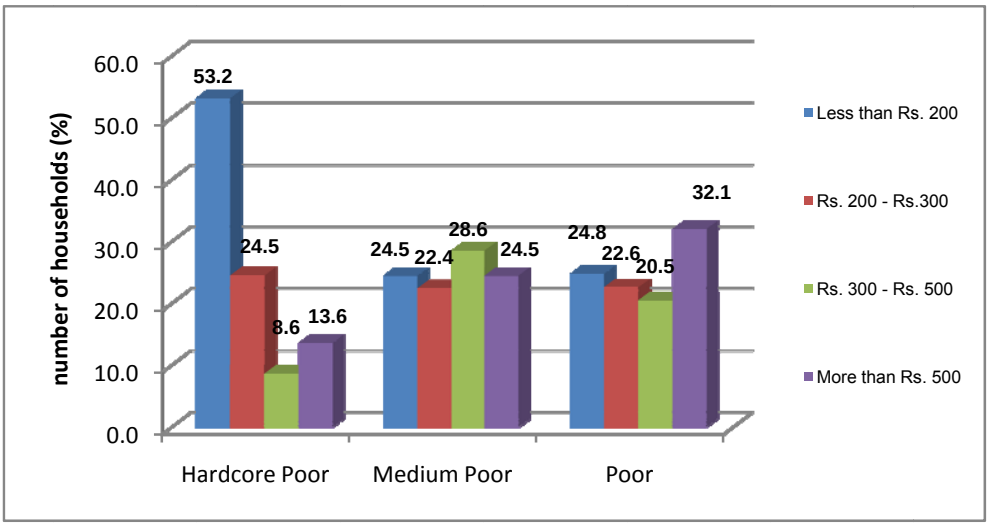


6.4 Amount households are willing to pay

It was now important to know in general how much the people were willing to pay for the services to improve their mud stoves.

Figure 24 shows that 53.2% (117 of the 220 households) in hard core poor category said they are willing to pay up to Rs. 200 for an ICS. There are relatively equal amount of households in the "medium poor" category that have said they are willing to pay a certain amount of money (i.e., 24.5% willing to pay less than Rs. 200, 22.4% willing to pay Rs. 200-Rs.300, 28.6% willing to pay Rs. 300 – Rs. 500 and 24.5% willing to pay more than Rs. 500). The highest numbers of households willing to pay more than Rs. 500 are from the poor households (32.1%) whereas this number is also significant among the hardcore poor group.

Figure 24: Amount of money the different poverty levels are willing to pay for an ICS



The survey shows that there is general willingness among people to pay, and a realization that the services do not come free. While the amount they are willing to pay varies, the most of the hardcore poor are able to pay up to Rs. 200 while signification numbers of households (around 200 households out of 736 surveyed) are willing to pay between Rs. 200 to Rs. 500.

Figure 25: Amount of money the different ethnic groups are willing to pay for an ICS

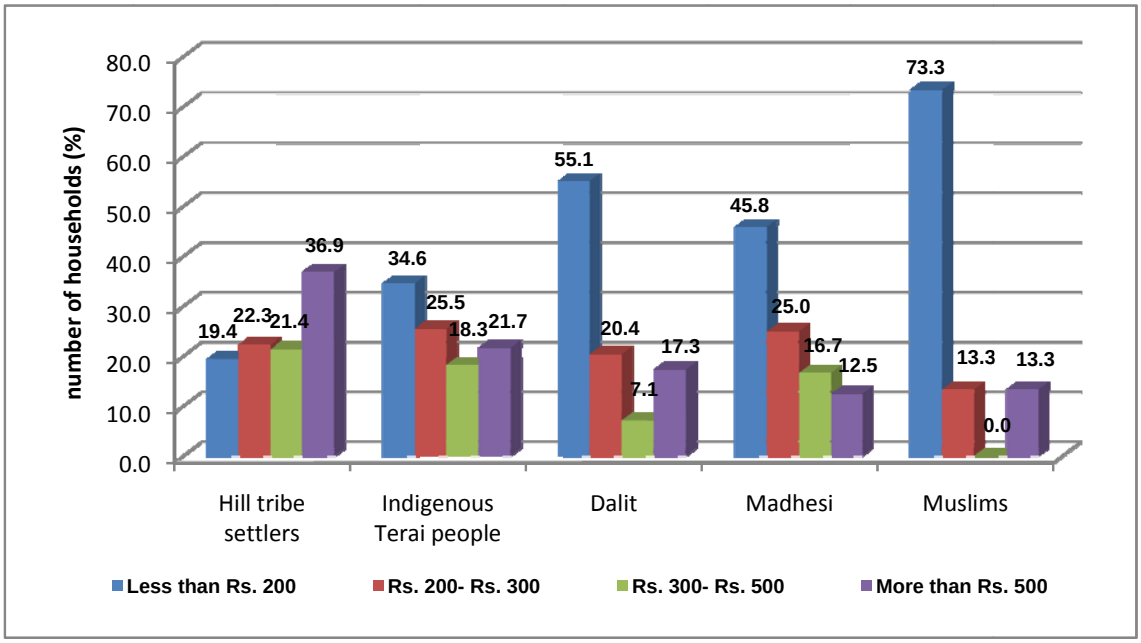


Figure 25 shows that 38.9% (38 out of the 103 households) of Hill tribe settlers are willing to pay more than Rs. 500 for an ICS as compared to 34.6% of Indigenous Terai group (91 out of 263 households), 55.1% of Dalits (54 out of 98 households), 45.8% of Madhesi (11 out of 24 households) and 73.3% of Muslims (11 out of 15 households), who would rather pay less than Rs. 200 for an ICS. The trend that is observed in figure 25, shows that more of the households are willing to pay Rs. 200 - Rs.300 (i.e., 25.5% of Indigenous Terai people, 20.4% of Dalits and 13.3% of the Muslims) and more than Rs. 500 (i.e., 21.7% of Indigenous Terai people, 17.3% of Dalits and 13.3% of the Muslims) whereas less proportion of households are willing to pay between Rs. 300 to Rs. 500 (i.e., 8.3% of Indigenous Terai people, 7.1% of Dalits and 0.0% of the Muslims)

CHAPTER 7: EFFICIENCY OF MUD STOVES IN USE

7.1 The choice of testing methods

In general, tests of stove performance range from lab-based water boiling and control cooking tests to qualitative and quantitative surveys of stove users in the field. There are advantages and disadvantages of both types of tests. Lab-based tests are more appropriate at the early stages of stove development to compare various technical aspects of stove design. For example, Baldwin recommends lab-based tests for comparing and optimizing different dimensions and other design details of the stove. Lab-based tests are also more appropriate when comparing stoves that are used in different regions of the world.

In order to accommodate many aspects of stove performance testing those designers of improved cooking stoves face, the protocols described in Supplementary Document 1 include procedures for two types of lab-based tests. The lab tests include a modified version of VITA's Water Boiling Test (WBT) as well as a Controlled Cooking Test (CCT).

While lab-based tests allow stove developers to differentiate between well-designed and poorly-designed stoves, they give little indication of how the stoves are actually used by the people who are targeted by stove projects. In order to know if stove projects are having the desired impact (whether it is fuel conservation, smoke reduction, or both), the stoves are generally recommended to be measured under real conditions of use.

This study uses simple test methods of WBT and CCT that are commonly used in the 5 Development Regions of Nepal. The results derived from the use of these methods are discussed in sections 7.3 (for WBT) and 7.4 (for CCT) below.

7.2 Identification of stove types for testing

WBT and CCT were carried out in 2 types of stoves that were predominantly used in the surveyed districts. One was the open type mud stove which was basically used in Kanchanpur, Kailali, Bardiya, Dang, Nawalparasi and Sarlahi. The second type of stove, closed type mud stoves was normally used in Rautahat, Saptari and Siraha. Descriptions of the two types of stoves tested are as follows:

Open type mud stove

Open type mud stoves also known as *Tharu Chulo,* are made with three pot rests (*chamkas*) placed on the circumference of a semi circle made up of a mixture of cow dung, rice husk and clay leaving the diameter of the semi circle open. The open part of the stove is used to insert firewood. These stoves can either be fixed in one place or can be moved.

Grouping of stoves in WBT and CCT

- In WBT, 9 tests (carried out in open type mud stoves) were grouped into 3 groups with 3 tests in each group.
- In CCT, 6 tests (carried out in open type mud stoves) were grouped into 1 group.

a) Closed type mud stove

The closed type mud stoves are also made with three pot rests (*chamkas*) placed in a circular wall made up of a mixture of cow dung, rice husk and clay. The stove is elevated to a certain level (usually 25- 30 cm) to allow space/hole for insertion of firewood at the bottom.

Grouping of stoves in WBT and CCT

- In WBT, 6 tests (carried out in closed type mud stoves) were grouped into 2 groups with 3 tests in each group.
- In CCT, 6 tests (carried out in closed type mud stoves) were grouped into 1 group.

The data for each of the tests were then entered onto the excel data entry sheet for WBT and CCT efficiency testing. The results for WBT are shown in table 22 and for CCT are shown in table 23 below.

7.3 Stove types according to the fuel used

The testing households were selected in a random manner. Most of the households selected for testing use firewood as the primary source of fuel. For both types of stoves (open type and closed type), firewood was normally the only kind of fuel used to cook. However, households in Saptari and Siraha were using firewood along with mixed dung cakes as their fuel and households in Sarlahi and Rautahat were using firewood with maize cobs and other agricultural residues outlined Chapter 4.

7.4 Water Boiling Test (WBT)

The WBT was carried out in 20 households with 2 households in each of the 10 survey districts. The list of the households where these tests were carried out is given in Supplementary Document 2.

The processes followed in carrying out these tests are given in Supplementary Document 1. The results for the individual sets of WBT are listed in Supplementary Document 3. Summary tables extracted from those results are as follows:

Table 25: (A) Open type stoves, (B) Closed type stoves

(A) Open type stoves

i) Specific fuel consumption values

	Specific fuel consumption g/liter			Average specific fuel consumption g/liter
1. HIGH POWER TEST (COLD START)	110.5	189.4	214.2	171.4
2. HIGH POWER TEST (HOT START)	124	154.5	207.3	161.9
3. LOW POWER (SIMMER)	196	131.5	430.9	252.8

ii) Efficiency of the stove

	Efficiency (%)			Average Efficiency (%)
1. HIGH POWER TEST (COLD START)	12	10	18	13
2. HIGH POWER TEST (HOT START)	15	14	17	15
3. LOW POWER (SIMMER)	21	19	20	20

(B) Closed type stoves

i) Specific fuel consumption values

	Specific fuel consumption g/liter		Average specific fuel consumption g/liter
1. HIGH POWER TEST (COLD START)	162.7	302.6	232.65
2. HIGH POWER TEST (HOT START)	138	176.1	157.05
3. LOW POWER (SIMMER)	239.4	123.7	181.55

ii) Efficiency of the stove

	Efficiency (%)		Average Efficiency (%)
1. HIGH POWER TEST (COLD START)	13	10	12
2. HIGH POWER TEST (HOT START)	18	13	16
3. LOW POWER (SIMMER)	17	25	21

7.5 Analysis of the WBT results

For the open type stove, the test results for the specific fuel consumption (average of set 1, set 2 and set 3) for the high power test (cold start) was 171.3 g/lit with 13% efficiency, high power test (hot start) was 161.9 g/lit with 15% efficiency and low power test (simmer) was 252.8 g/lit with 20% efficiency.

For the closed type stoves, the specific fuel consumption (average for set 4 and set 5) for high power test (cold start) was 232.65g/liter with 11% efficiency, high power test (hot start) was 157.05g/liter with 15% efficiency and low power test (simmer) was 181.55g/liter with 21% efficiency.

According to ESAP, efficiency of traditional mud stove is usually below 15% whereas for ICS it is above 20%. From the experience of CRT/N, efficiency of ICS in the Hills is 19-21% whereas for Terai it is 25-28%. However, for the stoves designed for carbon trading, under CRT/N, the efficiency has been claimed to be 30-33%.

The results in table 25 show that the efficiencies of both types of stoves are similar and are in the range 11% to 21%. The overall efficiency for both the stoves is 16% (average 16.2% for open type stoves and 16.0% for closed type stoves) which shows that the efficiency of the traditional mud stoves is slightly more than what ESAP has specified (i.e. below 15%). Although the efficiency of these stoves is higher than 15%, which shows that these stoves are efficient in reducing consumption of firewood and time spent in the kitchen, it is still lower than the efficiency of ICS (above 20%).

The distinction between traditional cooking stoves and ICS, with respect to its efficiency, would be comparable if tests, for the same types of ICS as the traditional cooking stoves and using similar type of firewood, were carried out. For a number of reasons, such comparative tests could not be carried out during the course of this Study.

7.6 Control Cooking Test (CCT)

CCT was carried out in 20 households, 2 tests in each of the 10 districts. The list of the households where these tests were carried out is given in Supplementary Document 2.

The data from the tests were entered onto the excel sheet according to stove types and groups specified in section 7.2.

The results from the CCT are as follows:

Table 26: (A) Efficiency for open stove in CCT, (B) Efficiency for closed stoves in CCT.

(A) Set 1: Comparison of open type stoves.

	Unit	% difference	T-test	Sig @ 95%?
Specific fuel consumption	g/kg	20%	0.37	No
Total cooking time	min	39%	0.78	No

(B) Set 2: Comparison of closed type stoves.

	Unit	% difference	T-test	Sig @ 95%?
Specific fuel consumption	g/kg	19%	0.23	No
Total cooking time	min	3%	0.12	No

7.7 Analysis of the test results

When comparing the two controls cooking test data in table 26, there is no significant difference between the types of stoves used. Since the T-test value (0.37 for specific fuel consumption and 0.78 for total cooking time) is greater than P value (0.05); there is no significant difference between the open type stoves. Similarly, the T-test value for the closed type stoves (0.23 for specific fuel consumption and 0.12 for total cooking time) is greater than the P value (0.05), which shows that there is no significant difference between the tested stoves.

7.8 Remaining tests that were not taken into account

One of the reasons the remaining 5 tests, out of the 20 tests that were carried out for WBT and 8 tests out of the 20 tests that were carried out for CCT, could not be included in these results was because there were a mixture of fuel used (firewood with dung) which could not be entered onto the excel file. Another reason was that there were not enough tests for the same stove type to be included for calculation. This is because the excel data entry sheet that was used gives an output only when enough tests (of the same type stoves) are included.

CHAPTER 8: INDOOR AIR POLLUTION

8.1 Characteristics of the kitchen rooms

There are some general patterns in the way kitchens are designed and located, impacting the quality of kitchen air. In eastern Terai, kitchens are either in separate house or in separate rooms whereas in western Terai, kitchens are in the same room with *low* partition. Such kitchens including the house was made up of tile roof and bamboo mud wall in eastern Terai where as in western and central Terai, they were mostly with brick wall and tin roof. However, the floors of all houses were mud plastering.

From the point of view of IAP, the ventilation in the kitchen is very important aspect of kitchen design. The study shows that most of them were poorly ventilated with only small windows and holes to enable the air to pass through and a door functioning as a passage. All of the households in the surveyed districts have either 1 or 2 doors. The number of windows were maximum of two whereas the holes ranged from 5 -10. The windows were mostly of small dimensions (average around {0.8 m X 0.8 m}) and holes in average 20 - 30 cm diameter.

Table 27: Average number and types of ventilation present in the surveyed households.

Districts	Ventilation (windows, holes)	Door
Saptari	0	1
Siraha	0	1
Sarlahi	1.03	1.07
Rautahat	1	1
Nawalparasi	1.08	1.03
Kapilbastu	1.15	1.16
Dang	1.84	1.05
Bardiya	1.29	1.06
Kailali	1.46	1
Kanchanpur	1.5	1
Total	1.39	1.05

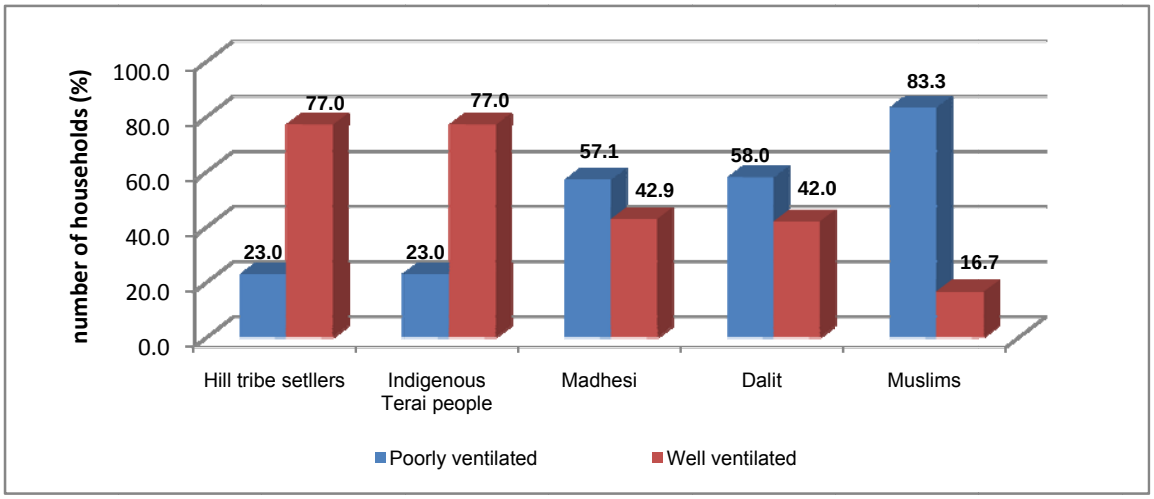
The figures show limited practices of installing openings on the kitchen walls. As a result, most of the indoor based kitchens are poorly ventilated. The qualities of ventilation in the households as observed during the survey are summarized in table 28. The table shows that that 70.8% of the households in Rautahat, 66.2% of the houses in Nawalparasi, 53.0% of the households in Kapilbastu and 47.8% of the households in Kailali have a poorly ventilated kitchen (see Table 28). Rest of the districts have majority of the households which have a well ventilated kitchen.

The variation in the level of ventilation is impacted by the location of the kitchen and type of walls surrounding it. Where the walls are half high and outside, ventilation is not a major issue. However, many households have confined kitchens with small and poorly located openings leading to high level of indoor air pollution.

Table 28: Assessment of quality of ventilation in the kitchens

Ventilation condition in the kitchen	Saptari		Sirahа		Sarlahi		Rautahat		Nawalparasi		Kapilbastu		Dang		Bardiya		Kailali		Kanchanpur	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Poorly ventilated	15.0	21.7	5.0	7.9	35.0	38.0	63.0	70.8	43.0	66.2	35.0	53.0	14.0	21.5	27.0	37.5	43.0	47.8	25.0	40.3
Well ventilated	54.0	78.3	58.0	92.1	57.0	62.0	26.0	29.2	22.0	33.8	31.0	47.0	51.0	78.5	45.0	62.5	47.0	52.2	37.0	59.7
Total	**69.0**	**100.0**	**63.0**	**100.0**	**92.0**	**100.0**	**89.0**	**100.0**	**65.0**	**100.0**	**66.0**	**100.0**	**65.0**	**100.0**	**72.0**	**100.0**	**90.0**	**100.0**	**62.0**	**100.0**

Figure 26: Ventilation condition in the kitchen of different ethnic groups



Equal proportions of Hill tribe settlers and Indigenous Terai households (77.0% each) have a well ventilated kitchen whereas majority of the Madhesi households (57.1%), Dalit households (58.0%) and Muslim households (83.3%) have poorly ventilated kitchen. This would provide a negative impact on the amount of smoke that is present in the kitchen which is shown by the fact that more than 88% of the Muslim, Dalit and Madhesi kitchens are very smoky while the mud stove is being used (refer to Figure 27 for "amount of smoke in the kitchen")

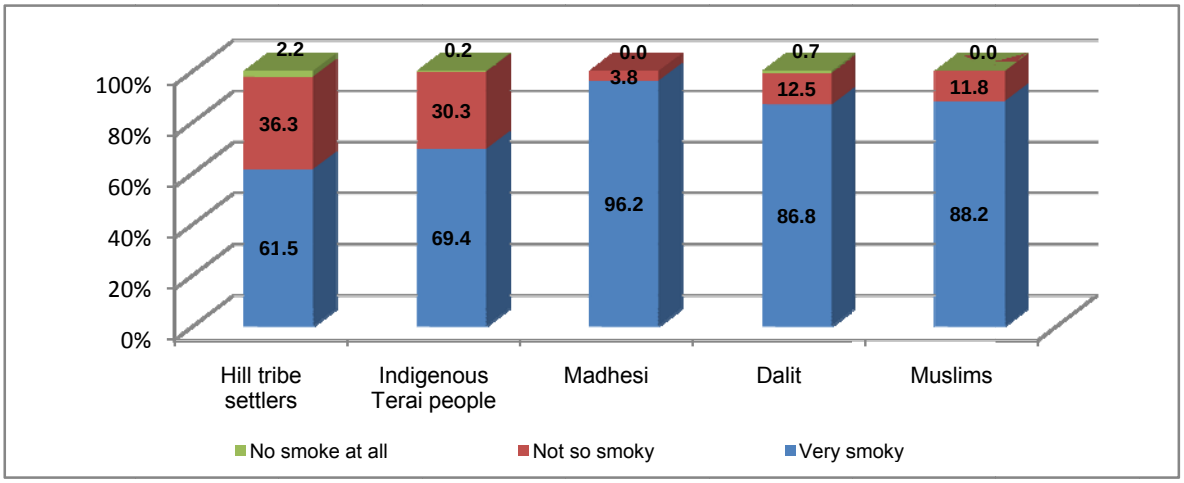
8.2 Presence of smoke in the kitchen

Most of the 736 kitchens visited by the Study were smoky kitchens. Table 29 shows that a majority of the households across the districts and ethnic groups had their kitchen very smoky. The smoke was mainly due to poor design of stoves and the type of firewood used.

Table 29: Amount of smoke in the kitchen while cooking in the surveyed districts

	Saptari		Siraha		Sarlahi		Rautahat		Nawalparasi		Kapilbastu		Dang		Bardiya		Kailali		Kanchanpur	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Very smoky	56.0	82.4	7.0	11.5	90.0	97.8	78.0	91.8	54.0	84.4	55.0	87.3	38.0	58.5	50.0	69.4	56.0	61.5	41.0	66.1
Not so smoky	12.0	17.6	53.0	86.9	2.0	2.2	6.0	7.1	10.0	15.6	8.0	12.7	25.0	38.5	22.0	30.6	35.0	38.5	20.0	32.3
No smoke at all	0.0	0.0	1.0	1.6	0.0	0.0	1.0	1.2	0.0	0.0	0.0	0.0	2.0	3.1	0.0	0.0	0.0	0.0	1.0	1.6
Total	**68.0**	**100.0**	**61.0**	**100.0**	**92.0**	**100.0**	**85.0**	**100.0**	**64.0**	**100.0**	**63.0**	**100.0**	**65.0**	**100.0**	**72.0**	**100.0**	**91.0**	**100.0**	**62.0**	**100.0**

Figure 27: Smoke in the kitchen of the households in the different ethnic groups



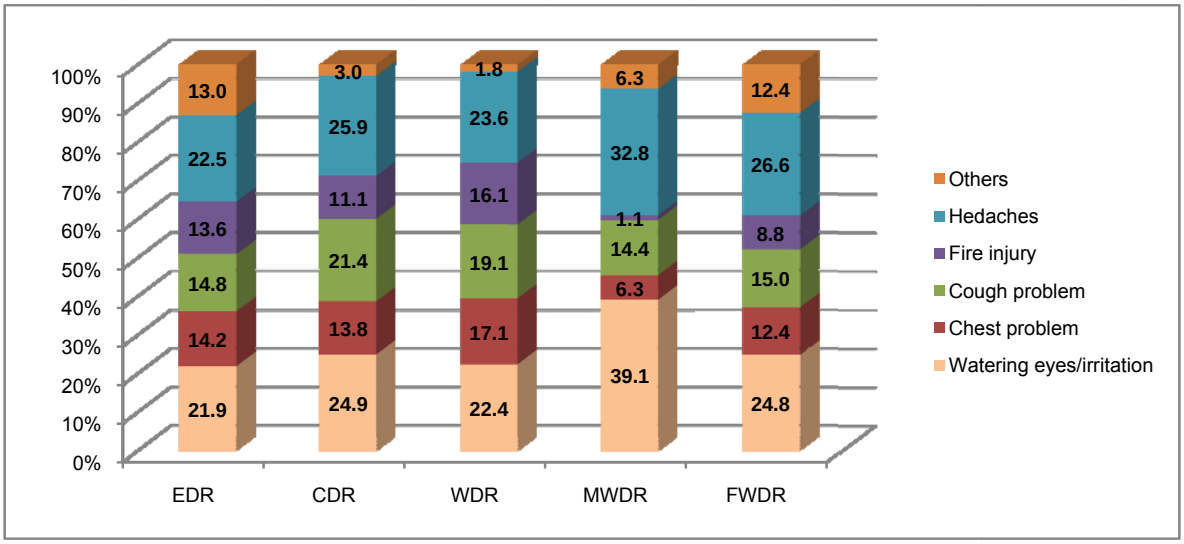
More than 85% of the Madhesi, Dalit and Muslim kitchens are very smoky which points out that the numbers of ventilations in those kitchens are minimal. However, 36.3% of the kitchens of Hill tribe settlers and 30.3% of the kitchens of Indigenous Terai people are not very smoky which is an indication that more of these households are aware about reducing smoke in the kitchen and improving the condition of their stoves.

8.3 Impact of IAP on the population

The study noted that users of the mud stoves felt a range of illness or disorder related to IAP. Irritation of eyes and headaches were found to be prevalent in majority of the households in all the development regions. The highest incidence of eye irritation was found in 39.1% of the 174 households surveyed in MWDR while the incidence of headaches was found in 32.8% of

the households in the same Development Region. There was a common trend in the occurrence of cough problems, chest problems and fire injury in all of the surveyed households as shown in the graph below. Fire related injuries were also common, with an average 10% of the surveyed 736 households experiencing such incidences.

Figure 28: Prevalence of diseases among mud stove users



8.4 Improvement in ventilation in poor households

Most traditional Nepali households are poorly ventilated because they are designed with few windows (mainly to conserve heat) and without chimneys. Therefore, concentration of IAP is believed to be extremely high within the rural households. A study by Nepal Health Research Council and others (2001) indicates that PM10 concentration for cooking areas, where wood is burned, is as high as 8,207 µg/m3 , which is almost twice and four times as high as the concentration for kitchens using kerosene (3,414 µg/m3) and LPG (1,504 µg/m3), respectively (Panta and Pattnaik).

The flow or ventilation of air in the kitchen is directly affected by a number of factors that include the following:

a. Location of the kitchen (i.e. indoors or outdoors)
b. The type of kitchen (i.e. closed with full partitions, half partition walls etc), and
c. The location and size of ventilation openings or apertures.

This study notes (see Section 8.1) that the level of IAP is relatively low in kitchens with specific locations, types and opening systems. This means that there is demonstrable correlation between certain types of designs of kitchens prevalent in Terai and IAP levels. The study therefore recommends that, irrespective of the fuel type used for cooking in Terai, a thorough study on the kitchen designs (including its location, type and openings) be carried out as part of the stove improvement process.

This activity component can be carried out in the following manner:

1. When the ICS intervention area is identified to the VDC level, a VDC wide preliminary assessment of kitchen systems (i.e. location, design and aperture locations) is carried

out by an expert team. This shall give a general understanding and scale of kitchen intervention required in the area.

2. Based on study above, a generalized kitchen improvement plan should be designed taking into consideration the cultural practices and geographical orientation (for air flow, rain patterns etc) of the area.
3. Depending on the areas identified for improvement in kitchen designs, two approaches for interventions can be explored:
   a. Kitchen improvement support can be provided to interested households even when stove improvements are not necessary or sought by the family.
   b. Kitchen improvement included as a necessary package for the family when it seeks to improve its stove.
4. It is also suggested that when major restructuring of the kitchen design is recommended for a given household by the technical reviewers, then some form of incentive package be explored as the cost of kitchen reorganization could be higher than the stove improvement costs.

CHAPTER 9: ORGANISATIONAL MAPPING AND ASSESSMENT

9.1 Current level of engagement in Terai

There are no major actors (institutions and programmes) that are active in the Terai working to improve cooking practices (i.e. fuel efficiency, IAP etc) and this was evident from the low level of awareness among our survey groups about the ICS or programmes working to support ICS. Even where efforts have been made, these have been isolated, or of poor quality especially when this is carried out by small NGOs with limited quality monitoring and professional inputs (therefore resulting in design drifts) and inadequate in comparison with the knowledge gap that exists or scope of works that needs to be accomplished.

There was a lot of positive feedback concerning the frame conditions of the ICS sector. The government framework (AEPC) is supportive as there are working concepts, policies and strategies; targets are set and supported by government; sufficient resources for the subsidy system and long term commitment to ICS.

Some weaknesses are also evident. There is no systematic mechanism for donor coordination by government in the field of ICS; the government program for ICS is highly dependent on donor agencies. Therefore there is no sustainability in the current programme. There is a data gap on biomass supply and consumption at the district level.

Despite this, focus of some programmes into Terai is becoming more prominent and some sincere efforts are being made by these programmes to provide services in ICS sector in Terai. The section below discusses some of the actors and possible way forward.

9.2 Organizations and programmes working in Terai in ICS dissemination

BESP/ESAP is the major programme, with focus in Terai as well as other regions, for dissemination of improved mud stoves. BESP/ESAP implements this programme through its implementing partners, the Regional Renewable Energy Service Centers, RRESC. Each RRESC offers services for 3 to 5 districts in which again 3 to 5 local partner organizations are selected for cooperation. These could be NGOs which already have an implementation structure and established relationship with communities. BESP partners included in RRESC are:

- Regional Renewable Energy Service (RRES), Dhaulagiri;
- Community Resource Development Centre (CRDC), Baglung;
- Beautiful Nepal Association (BNA), Surkhet;
- Rural Empowerment Society (RES), Damauli;
- Research Management and Rural Empowerment Centre (REMREC), Kavre;
- Rural Economic Development Association (REDA), Palpa;
- Rural Development Service Centre (RDSC), Doti ;
- Namsaling Community Development Centre (NCDC), Ilam ;
- Centre for Rural Technology Nepal (CRT/N), Lalitpur;

- Renewable Energy Water Supply and Sanitation Promotion Centre (REWSSPC), Rautahat;
- Kailali Kanchanpur Rural Electrification Umbrella Organization (KKREUO), Kailali;
- District Environment and Energy Sections (DDC/DEES), Darchula,;
- Development Concern Society (DECOS), Dang and
- Janaki Women Awareness Society (JWAS) Janakapur.

These implementing partner organizations and programmes provide training to the local community representatives to construct, install, promote and disseminate ICS, create awareness, and perform monitoring of the programme in their working areas.

The study extensively interacted with two of the partners, REWSSPC, in Rautahat and CRT in Kathmandu.

b) CRT/N

CRT is a professional non-governmental organization involved in developing and promoting appropriate and rural and renewable energy technologies. CRT/N has been promoting ICS since 1991 and playing a key role in the promotion of ICS. Since 2000, about 2500 promoters (45% are women) are being trained at district levels. CRT is also involved in Terai ICS carbon project covering Bara, Parsa, Rautahat, Sarlahi, Mahotari and Dhanusa covering 20 VDCs in each district. CRT/N alone has installed 25,260 ICS in the year 2009/10 and it is in the increasing trend. As their involvement is in development and promotion of ICS and indoor air quality monitoring, CRT Nepal, with a good team in their organization, could be one of the potential partners for the dissemination of ICS in the country.

b) Other organizations working for dissemination of ICS.

There are other organizations involved in the promotion and dissemination of ICS. These include but are not limited to:

- WWF national park buffer zone project
- Winrock international;
- DFID Forest Livelihood project and
- Practical Action

However, it was not possible to know in detail the scope of activities undertaken by these institutions. The programmes and organizations working in the surveyed districts are given in Table 30 below.

Table 30: Organizations and programmes working in surveyed districts

Name of Organizations	Working Districts									
	FWDR		MWDR		WDR		CDR		EDR	
Practical Action	Kailali	-	-	-	Kapilbastu	-	Bara	-	-	-
CRT/N	Kailali	Kanchanpur	-	-	Kapilbastu	Nawalparasi	-	-	Morang Siraha	Saptari Sunsari

Name of Organizations	Working Districts									
	FWDR		MWDR		WDR		CDR		EDR	
BESP/ESAP	Kailali	Kanchanpur	-	-	-	-	Mohotari Bara Rautahat	Dhanusa Sarlahi Parsa	Jhapa	Sunsari
NEEP Mud Stove Survey	Kailali	Kanchanpur	Bardiya	Dang	Kapilbastu	Nawalparasi	Sarlahi	Rautahat	Siraha	Saptari

9.3 Physical achievements and targets of ICS programmes

So far, 450,000 ICS have been installed by various organizations. At present, total annual installation of ICS in Nepal through various organizations is estimated to be around 60,000 (conversation with GIZ). The estimated target of reaching out to 100,000 per year needs to be supported with additional focus on delivery approaches and media.

This may be achievable with good linkage and coordination established between users, manufacturers and biomass fuel producers; the coordination amongst the promoters at grass root level (NGOs/INGOs) and the coordination at national and district level.

9.4 Partnership with other stakeholders and actors

ICS programme would be more effective if worked with partnership with the stakeholders and actors. The partnership could be for awareness on and development for improved cooking technologies using different traditional fuels, technology standardization for cooking, heating and ventilation, indoor air pollution and health monitoring and so on.

Some of the potential partners that a programme dedicated to achieving energy efficiency in Terai and a tentative approach for engagement could be as follows:

a. DEEU and DEES

At district and village levels, the DEEUs/DEESs have been established to provide support for planning and coordination. AEPC/ESAP has set up nine Regional Renewable Energy Service Centres and RERL programme of UNDP and World Bank has its District Energy and Environment Sections (DEES) in 40 districts whereas in other districts AEPC has established District Energy and Environment Unit (DEEU) within DDC.

DEES are within District Development Committee (DDC) with a team of engineers, social mobilizers and other supporting staff. DEEU, on the other hand, are working with limited human resources even though DEEU has significant potential to support in planning and promotion of ICS in their districts. Hence DEEU/DEES could be useful partners for the planning, promotion and monitoring of ICS stoves at the district or local level.

In brief, DEEU/DEES could play a role in the dissemination chain as follows:

1. DEEU/DEES could play an effective role in the dissemination process only when the DDC assigns resources for these units. . These resources may be financial support for the staff involved in the promotion and dissemination of mud stove, both traditional and improved.

2. These DEEI/DEES staff to be oriented and informed of the quality parameters and tools to be used in planning, installation as well as promotion and dissemination of ICS stoves in their areas or VDCs.
3. DEEU and DEES will be in good position to monitor on sampling basis the quality of the stoves installed by various institutions and undertake internal reporting with feedback on areas of improvement.

b. FECOFUN

Federations of Community Users Forest Nepal (FECOFUN) are engaged in policy advocacy, biodiversity and climate change. FECOFUN is a formal network of Forest Users Group from all over Nepal. Since its inception in July 1995 FECOFUN, has grown in to a social movement organization and are promoting and protecting forest users' rights.

The community forestry users groups in Nepal have reached more than 15 thousand and have covered more than 40% of the total population of Nepal. Its district and local federations are in all the districts and actively functioning with the coordination of both government and non-government organization. FECOFUN is recognized as strong civil society and community based organization at local, regional and central level.

While FECOFUN does not have ICS expertise at professional level, its network and member base can be useful asset in the promotion and dissemination of improved cook stoves in Terai.

c. Others

A number of NGOs locally established in Terai, though few in number, can be useful asset to achieve energy efficiency in Terai. A dedicated NGO, the Renewable Energy Water Supply Sanitation Promotion Centre (REWSSPC) based in Chandranigahapur, Rautahat is also promoting ICS in the areas of Rautahat and Sarlahi districts and could be one of the potential organizations for the promotion of ICS in these areas.

Similarly, the Indoor Air Pollution and Health Forum Nepal (www.indoorair.org.np) is a member based organization working in the IAP sector with strong linkages with energy efficiency. This organization and its members could be strengthened to support initiatives in Terai.

These organizations need both technical and financial support in order to promote and disseminate ICS in their programme areas. These could be training on the installation of stoves, awareness creation and promotion through several promotional materials such as posters, brochures, leaflets etc. Standardization of the technology, quality control and monitoring are areas which programmes such as NEEP/GIZ can support for the strengthening of these local organizations.

CHAPTER 10: KEY OBSERVATIONS AND CONCLUSIONS

A) Prevalence of poverty and cooking habits

Among the 736 survey households, 42.4% were hardcore poor, 10.9% medium poor and 46.7% were poor using a standard Poverty Alleviation Fund (PAF) categorization approach. This was based on the food sufficiency approach. However, the consequences of poverty on possible update of energy efficiency services were balanced as most of the poor households also had access to remittance and local wage based cash income. As a result, there was not much significant difference on preferences related to ICS based on poverty levels.

B) Cooking fuels used

The type of cooking fuel predominant in all of the surveyed districts is firewood followed by cow dung, agricultural residue (rice husks, maize cobs and wheat straw) and other (grass and thatch). Cow dung was common in the Madheshi ethnic group (56%) and Muslim (34%). Similarly, Muslim ethnic group was the one who used most agricultural residue (20%) as their primary cooking fuel. In Bardia, Kailali and Kanchanpur, thatch was used for lighting firewood whereas in Nawalparasi, Kapilbastu and Dang plastic pieces were used.

Wood twigs and branches, logs, dung cakes and agricultural residues are the main sources of fuel used in these stoves.

C) Poverty level and types of cooking fuel used

Hardcore poor (177.9kg/month) and poor (176.1kg/month) households use a larger amount of firewood when compared to medium poor (145.9kg/month) households. The consumption of crop residue is greater within medium poor (100.7kg/month) and poor (201.4kg/month) households and the use of dung as fuel is greater in poor households (145.0kg/month). LPG has only been seen to be used in poor (1 Cyl. /month) households and none by the hardcore poor and medium poor households.

D) Stove types

Prevalence of a higher number of two pot stoves was found only in Kapilbastu (50.0%) whereas more than 80% of the households in the other districts had single pot stoves.

The most prevalent cooking stove is the one pot traditional mud stove, which is widely used all over the Terai. In eastern regions the combustion chambers of such stoves varies from 10-25 cm deep from the floor level to collect charcoal and ashes and such stoves are half closed towards the fire wood. In case of western regions these stoves are open to one side and are even movable. Most of the households installed such stoves by themselves where as others asked for their neighbours to install it.

E) Users' priority on expenditures

The households in EDR, MWDR and FWDR said they would give first priority to buy extra food if they had spare money. All of the development regions said they would give least priority to buy toys for kids if they had spare money. The investment on stoves comes just below the midpoint, i.e. people are willing to spend money on the stoves when their other key priorities of food sufficiency and house maintenance have been accomplished.

F) Construction of stove

Majority of the stoves in the surveyed households have been built by the owners themselves. Only a few households in Siraha (1.6%), Nawalparasi (10.8%), Kapilbastu (6.1%), Dang (13.8%), Bardiya (8.3%), Kailali (5.5%) and Kanchanpur (1.6%) have hired specialized builders to make their stoves.

G) Design variations

All of the different types of stoves that were found in the surveyed districts had different height (13 – 36 cm), different dimension of the combustion chambers (depth up to 28 cm), different diameter pot holes (12 - 24 cm) and different size of the opening for insertion of firewood (12-22 cm). Hence, it is recommended to have uniform dimensions for such stoves especially when using firewood although they vary according to size of the family, types of fuel used and cooking items.

Variation in designs for ICS should consider traditional single pot as well as two pot hole both open and closed type mud stoves as these are widely preferred and used by the households.

H) Kitchen conditions

Burning of fuel wood in traditional low-efficiency stoves produced significant amount of indoor air pollution in terms of Total Suspended Particulate (TSP) not only in kitchen but also in living room as well as outside.

The kitchen conditions were found in separate house or room but with poor ventilation where as in other cases kitchens are in the same room with half partition. Such kitchens are dark with poor light or ventilation.

I) Willingness to change and pay for improved efficiency of stoves

The hardcore poor were more willing (at 75%) to pay for the services, almost at par with the less poor group (72%) of people. The medium poor are relatively less prepared to pay with 65% willing to pay. What is important is that all categories of poor have high level of willingness to pay. This is despite overall level of satisfaction with their existing stoves being high, which could be a response reflecting more of the cultural values of the communities to appreciate what they have than their real acknowledgement that their stoves are performing well from technical perspectives.

The survey shows that 117 of the 220 households in hard core poor category said they are willing to pay up to Rs. 200 for an ICS. There are relatively very few households in the "medium poor" category that have said they are willing to pay a certain amount of money and

this is because the number of medium poor households surveyed is less compared to the hardcore poor and poor households. The highest numbers of households willing to pay more than Rs. 500 are from the poor households (75) whereas this number is also significant among the hardcore poor group.

J) Efficiency results

WBT

For the open type stove, the test results for the specific fuel consumption (average of set 1, set 2 and set 3) for the high power test (cold start) was 171.3 g/lit with 13% efficiency, high power test (hot start) was 161.9 g/lit with 15% efficiency and low power test (simmer) was 252.8 g/lit with 20% efficiency.

For the closed type stoves, the specific fuel consumption (average for set 4 and set 5) for high power test (cold start) was 232.65g/liter with 11% efficiency, high power test (hot start) was 157.05g/liter with 15% efficiency and low power test (simmer) was 181.55g/liter with 21% efficiency.

Conclusions *The results show that the efficiencies of both types of stoves are similar and are in the range 11% to 21%. The overall efficiency for both the stoves is 16% (average 16.2% for open type stoves and 16.0% for closed type stoves) which shows that the efficiency of the traditional mud stoves is slightly more than what ESAP has specified (i.e. below 15%). Although the efficiency of these stoves is higher than 15%, which shows that these stoves are efficient in reducing consumption of firewood and time spent in the kitchen, it is still lower than the efficiency of ICS (above 20%).*

CCT

When comparing the two control cooking test data, there is no significant difference between the types of stoves used. Since the T-test value (0.37 for specific fuel consumption and 0.78 for total cooking time) is greater than P value (0.05); there is no significant difference between the open type stoves. Similarly, the T-test value for the closed type stoves (0.23 for specific fuel consumption and 0.12 for total cooking time) is greater than the P value (0.05), which shows that there is no significant difference between the tested stoves.

Conclusions*: There are already good stove technologies with high potentials available in Nepal that could be promoted to satisfy a variety of household needs. The efficiency of the surveyed stoves (16%) were found to be slightly above the efficiency of the traditional (less than 15%) stove but below the efficiency of the ICS (20-28%).*

CHAPTER 11: RECOMMENDATIONS

Based on the findings and observations, the following recommendations are made:

- To address design drift, the ICS programmes need to put additional priority on proper orientation and training*. For this purpose, it is important that AEPC develops a stringent quality control plan to be used by all stakeholders, including small NGOs, working in ICS development.*
- The survey shows that people have ownership and affinity towards the current models of mud stoves that they are using. *The study suggests ways forward to build on these existing practices, and this is achievable in a more sustainable manner.*
- People are least aware about the design aspects of kitchen rooms. Simple changes in the location of the apertures could make significant air movement reducing stagnation of air and accumulation of pollutants. *A region wide awareness and incentive package to reorganize openings in close kitchens could be highly beneficial to address IAP.*
- Change in users' behavior is rather necessary to decrease the IAP level. *This include encouraging people to open all the doors and windows while cooking food or doing indoor works, use of masks by the cook and use of pot lid while frying vegetable etc can significantly reduce IAP level.*
- The educational system – particularly the education of girls – offers an opportunity to raise awareness amongst the new generation. *The young girls of the family are to be targeted for initiatives to achieve higher energy efficiency in cooking.*
- Locally based institutions such as DDC, DEEU, and FECOFUN could be valuable institutions to associate in promoting energy efficient tools. *However, detailed study on the modality of association needs to be worked out in achieving meaningful and effective engagement.*
- There are evidences that financial support to adopt ICS have been counterproductive, with households dismantling their ICS to invite another program to make similar 'donation' of cash or even pots. It is strongly recommended that people are urged to pay for the services in adopting ICS.
- *After sales services, though there is limited demand, are to be strengthened.* Many households have suggested that there are no reliable partners to go when performance is poor or when expert service is needed in maintaining the stove.

REFERENCES

- Sanchez Teodoro, Ron Dennis, Prof. Keith Pullen “Cooking and Lighting Habits in Rural Nepal and Uganda SCORE Project”;
- Samuel Adinoyi Ayo, “Design, Construction and Testing of an Improved Wood Stove” Department of Mechanical Engineering, Federal University of Technology Minna, Nigeria.
- ENPHO, “Assessment of effectiveness of improved cooking stove in reducing indoor air pollution and improving health”, AEPC/ESAP, July 2008
- Mani Nepal, Apsara Nepal, Kristine Grimsrud “Unbelievable but improved cook-stove are not helpful in reducing firewood demand in Nepal”.
- Narayan Adhikari, Dr. Christoph Messinger; “How can NEEP most effectively support AEPC (ESAP) in achieving governments goal of 100.000 ICS sales per year?”, NEEP/GIZ, Jan 2011.
- Practical Action “Bridging the funding gap to ensure energy access for the poor” (no date).
- Practical Action “Powerful solution to poverty” (no date).
- Practical Action “Nepal- Study to determine outline plans for eliminating energy poverty in Nepal”, August 2009.
- TRUST “Identifying cooking requirements according to geographic location, fuel, cooking systems in Nepal”, AEPC (no date).
- University of Oldenburg “Efficiency test of a biomass cook stove”, 2003.