“Testing “New Technologies” for the Terai”

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Practical Action Nepal Office

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Acronyms and Abbreviations

AEPC	Alternative Energy Promotion Centre
BEC	Biomass Energy Component
BSP	Biogas Support Program
CBS	Central Bureau of Statistics
CO	Carbon Monoxide
CRT/N	Centre for Rural Technology Nepal
CWSN	Child Welfare Scheme Nepal
DDC	District Development Committee
DEECC	District Energy and Environment Coordination Committee
DEEU	District Energy and Environment Unit
DESR	District Energy Situation Report
ESAP	Energy Sector Assistance Programme
FOST	Foundation for Sustainable Technologies
HEH	Household Energy and Health Programme
HHs	Households
ICS	Improved Cook Stove
IDS	Integrated Development Society
INGO	International Non-Governmental Organization
Kg	Kilogram
LFP	Livelihoods and Forestry Programme
LPG	Liquefied petroleum gas
NAST	Nepal Academy of Science and Technology
NEEP	Nepal Energy Efficiency Programme
NGO	Non-Governmental Organization
NRs	Nepalese Rupee
RECAST	Research Centre for Applied Science and Technology
RET	Renewable Energy Technology
RRESC	Regional Renewable Energy Service Centre
SWOT	Strength, Weakness, Opportunities and Threat
VDC	Village Development Committee
WHO	World Health Organisation

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1. Introduction

1.1. Background

The distances to forests for the people residing in the Southern Terai region are very high, thus creating difficulties in collection of firewood for cooking purposes. As a result the use of dung cake as a cooking fuel is very high there. The National Living Standards Survey (2003/04) of Nepal shows that 10.33% of the total households (HHs) (0.44 million HHs) in Nepal are using dung cake as the primary cooking fuel, needless to say the dung cake using HHs of the Terai are the major contributors to the national average.

"Dung Cake" is considered to be the most polluting fuel for cooking, and therefore lies at the bottom of the energy ladder. Usually, it is used by the poorest of the poor people. The dung cakes are produced at the household level and burnt in traditional open fires or mud stoves, resulting emission of dangerous cocktail of hundreds of pollutants to which women and young children are exposed on a daily basis.

There are several options to improve this precarious situation. Various technologies are already in use that is capable of alleviating the condition. Biogas technology is one of the easiest and best options. It is a clean and efficient technology that also utilises animal dung. Biomass briquette is another option to replace dung cake use. Likewise, improving the way dung is used can also minimize the problem. There are also various technologies available to improve the processing of dung to make it a better burning fuel. Similarly, there are stoves which aid in better fuel combustion as compared to the local mud stoves. Gasification of dung could also be one of the solutions to the problem.

Past studies and experiences indicate that acceptance of any particular stove or energy technology for that matter, depends on various aspects like availability and price of fuel, socio-cultural and ethnic values and practices, geographic and climatic conditions, cooking behaviours and practices, size/design of kitchen, economic status etc. The Terai populace have different socio-cultural traditions compared to the people living in the hills and mountain areas of Nepal. Likewise, access to natural resources and access to other infrastructure also varies between the Terai, hills and the mountain region. In Terai, majority of the houses are made of thin walls and with thatched roofs. It is also common to cook outside of the kitchen in some districts of Terai. Therefore, there is also a need to consider/check these aspects to identify the best technology options for cooking in the Terai.

Nepal Energy Efficiency Programme (NEEP/GIZ) is committed to promote energy efficiency in the household, commercial and industrial enterprises. NEEP aims to expand the product range and accelerate the dissemination of the energy efficient cooking stoves. NEEP also aims to support the effort of AEPC/ESAP to accelerate the stove sales per year (increase sales of ICS from 60,000/year to 100,000/year). NEEP also believes in achieving scaling-up of the dissemination of technologies by supporting the on-going efforts of other stakeholders involved. In this regard, NEEP carried out a number of studies in order to obtain sufficient information on the status of present cooking stove dissemination practice and potential new approaches, which will be the base for further planning and implementation.

1.2. Objectives

The “Testing new technologies for the Terai” study aims to find suitable stoves/technologies to improve the situation of dung cake burning households in the Terai region of Nepal.

The specific objectives of the study include:

- Identify organisations, products/technologies available in the Terai in the field of non-wood based biomass fuels and cooking. Analyse the scale and area of intervention. Likewise, analyse the capacity and plan of these organizations in the position to further develop, field test and disseminate these technologies.
- Analyse the current stage of existing technologies.
- Test the performance of the technologies with respect to fuel consumption, indoor air pollution, user convenience and durability. Compare it with the previous tests.
- Compile current cost of technologies/product. Calculate the projected end user price on the long run.
- Analyse the current efforts and gaps in the context of contribution in overall development of the Terai.
- Identify the role for NEEP in the pursuit of these technology development and testing processes in following areas:
    - Technical advice / new technologies
    - Capacity development of staff
    - Testing equipment
    - Financing
    - Increasing participation of the target groups and producers in the technology development process

The study tries to identify organisations as well as technologies that are in various modes of operation in the Terai and make recommendations on possible NEEP interventions for both technology and organisations.

2. Dung fuel use – A review

Half (50.15%) of the total population of Nepal live in the Terai region (CBS, 2011) from which a large proportion (21.5%) of households (HHs) are dependent on using dung cake as a source of cooking energy. The dependency is observed more in rural areas compared to urban areas. Likewise, the use is highest in the Eastern part of Nepal. The number of dung users increases moving from western to eastern part of Nepal (Table 2.1).

Table 2.1: Distribution of HHs by various sources of fuel use for cooking

Area	Wood %	Kerosene %	LPG %	Biogas %	Dung %	Others %	Total %	Total HHs
Settlement								
Urban	33.2	34.1	27.3	1.8	2.5	1.0	100.0	664,400
Rural	72.4	9.8	4.0	1.7	11.5	0.6	100.0	3,510,058
Ecological Belt								
Mountain	95.5	3.2	0.4	0.1	0.7	0.2	100.0	285,229
Hill	72.3	16.0	8.9	1.9	0.1	0.8	100.0	1,950,822
Terai	55.6	12.8	7.7	1.7	21.5	0.7	100.0	1,938,407
Development Region								
Eastern	66.3	9.9	4.3	1.2	17.7	0.6	100.0	1,000,362
Central	55.6	19.3	11.2	1.2	11.4	1.3	100.0	1,465,813
Western	65.3	13.1	10.3	3.4	7.6	0.3	100.0	863,049
Mid-western	81.0	11.3	4.3	1.1	2.1	0.2	100.0	479,817
Far-western	90.8	5.5	1.9	1.5	0.1	0.3	100.0	365,417
Nepal	**66.2**	**13.7**	**7.7**	**1.7**	**10.1**	**0.7**	**100.0**	**4,174,458**

Source: CBS, 2002

The use of traditional stoves is also very high in the Terai region with around 87.6% of the households using them for cooking purposes (CBS, 2004).

Table 2.2: Distribution of households by type of stove used

	Open Fireplace %	Mud Stove %	Smokeless Stove %	Kerosene Stove %	Other %	Total %
Development Region						
East	24	66.3	0.7	7.3	1.7	100
Central	20.1	55.5	0.6	23.1	0.7	100
West		36.6	4.6	16	0.4	100
Mid-western	40	47.6	3.9	8.3	0.3	100
Far-western	19.5	73	1.3	5.7	0.5	100
Ecological Zone						
Mountains	53.5	39.2	4.6	0.3	2.6	100
Hills	44	31.7	2.1	21.4	0.9	100
Terai	8.9	78.7	1.4	10.6	0.5	100
Consumption Quintile						
Poorest	36	62.3	0.4	0.1	1.2	100
Second	34	63.5	0.8	1.1	0.6	100
Third	32.8	60.2	2.4	4.1	0.6	100
Fourth	25.8	61.7	3.4	8.5	0.6	100
Richest	16.5	32	2.1	48.2	1.2	100
Nepal	**28**	**54.5**	**1.9**	**14.7**	**0.8**	**100**

Source: CBS, 2004

2.1. Health cost of dung use

Use of dung cake as fuel increases the risk of asthma by 1.5% and eye diseases by 4.7%. Taking the two diseases together the annual cost of health for each household is NRs 1220/year (Pant KP, 2010). This however does not include the pain and sufferings the patients and their kith and kin bear.

2.2. Nature of dung

Dung is bulky with large ash content. It has large volatile content, whereas the carbon content and burning ratio is low. It has low energy and high formation of ash (20-50% by weight) compared to wood fuel. Dung ash tends not to break down into fine pieces and powder; it stays about the same size as the original dung piece unless agitated (APROVECHO, 2006).

2.3. Appropriate stoves for dung burning

When dung burns in a mud ICS (early design), the combustion chamber fills up with a high amount of ash within a few minutes. Ash easily clogs the stove, blocking the pathway for primary air and resulting in a smoky, air-starved fire. Even when the dung is placed on a grate with very large openings, ash does not fall down through the grate on its own (APROVECHO, 2006). Thus, there is need for designing a mechanism for handling the ash, while the stove is in operation. Likewise, the ash holding area should be large enough so that the stove can be cleaned out less frequently.

The stove designed by Kumar and Shende in India is based on the principle of fluidized bed combustion in which pulverized dry cow dung is burnt in preheated air. The design involves preheating air before it combusts and fluidizes simultaneously with the cow dung. Air is blown in to the oven in the opposite direction of the flow of cow dung powder to produce fuel through 'counter-current'. The air is initially heated up to the ignition temperature of fuel at the bottom of the chamber. Pulverized cow dung is introduced to the preheated air and combustion takes place in the fluidized state. Provision of a grate has been made to deal with the ash. This stove is up to 4 times more efficient than a normal stove. In 2001, Jose Humberto Bernilla and Klas Heising, GTZ, designed a stove (Inkawasi Stove) based on rocket principle in the village of Ayamachay, Peru. Its highland version is appropriate for dung burning. Between 2005 and 2007, around 14,000 Inkawasi stoves were installed by different institutions in the northern and southern Peruvian Andes. The stove has provision of a shelf for directing firewood into a tall combustion chamber, sunken pots, and a well-defined airflow. The pot-holes are customised for specific pot diameters. Actual modification substitutes the typical shelf through a grate and separate inlets for air and fuel. Depending on the fuel predominantly used different types of grates are used.

3. Research methodology

This study is focused on identifying suitable technology solutions for non-wood based biomass fuel processing and fuel processing stoves, particularly in the Terai. Analysis is carried out with particular focus to the following technologies:

- Improved stoves for dung cake including gasifier stoves
- Improvement in dung cake
- Fuel switching –
    - Possibility of methanol/ethanol stoves, plant oil stoves like Protos by BSH, LPG
    - Biomass briquettes/biochar and stoves for briquettes/biochar

3.1. Study design

Overview of the current interventions is carried out using primary as well as secondary information as following:

3.1.1. Primary data

For primary data collection, three districts from the Terai (Bara, Kapilbastu and Siraha) were selected purposively for sample survey. The districts were selected so as to reflect an east-west geographical diversity as well as with the knowledge of the districts being a high dung using districts. Primary data were collected as described below:

HH survey, indoor air quality monitoring and stove performance test

Household survey

Household survey was administered in 200 households in three districts using structured questionnaire. The questionnaire includes questions on demographic characteristics, resources, skills, climate, household characteristics, energy/stove use, income, health status, their willingness to change the stove etc. Random stratified sampling methodology was applied to select the survey household. The sampled population is stratified on the basis of types of stoves/technologies being used.

Table 3.1: Surveyed districts and village development committees

Siraha		Bara		Kapilbastu	
VDCs	**HHs**	**VDCs**	**HHs**	**VDCs**	**HHs**
Nahararigaul	10	Bissrampur	10	Jahadi	10
Madaiya	5	Buniyad	10	Kopawa	10
Ta.Gabindapur	10	Chhatawa	10	Dharmapaniya	10
Mahadeva portaha	10	Pipar Pati	10	Tilaurakot	10
Bishnupur katti	10	Manaharba	10	Maharajganj	3
Bastipur	10	Dumarwana	10	Timlihawa	4
Asanpur	10	Umajan	10	Hathausa	8
Bhardaya	5				
Total	**70**	**Total**	**70**	**Total**	**60**

Indoor air quality monitoring

Among the sampled HHs, indoor air quality monitoring (mainly carbon monoxide) was performed in 100 (50%) HHs. To measure carbon monoxide (CO), the Industrial Scientific ISC GasBadge Pro real-time, single gas monitor was utilised. The machine gives real time monitoring results. Once monitoring takes place, the data can be immediately downloaded to a computer. In the kitchen that is to be surveyed, a CO monitor is set up 1.3m vertically and 1.3m horizontally away from the stove. For each of the surveyed HHs the CO monitoring was conducted for 24 hours.

Stove performance test

The thermal efficiency of various stoves was tested in the field by conducting water boiling test (WBT v 3.0) adopted from the Household Energy and Health Programme (HEH), Shell Foundation.

Key informant survey

Key informant survey with the aid of a checklist was carried-out with the various organization and individuals listed below.

- Producers/manufactures associated with technology promotion
- Researchers/research organization involved in stove design
- Organisations involved in stove promotion, bio-briquettes and dung processing (AEPC/ESAP, BSP, NAST, RECAST, CRT/N, FOST, IDS Nepal etc.)
- District level organizations and line agencies (DDC/DEEU/DEES, I/NGOs, private sector, associations, experts in the field etc.)
- Private sector including stove promoters/masters, biogas manufacturers, rice husk stove manufacturers etc.

Stakeholders meeting

A stakeholder meeting was carried-out in each of the three survey districts to get information and feedback on the study. The main participants of the workshop were:

- DDC/DEEU/DEES
- VDC representatives
- District level organizations and line agencies (I/NGOs, private sector, associations, experts in the field etc.) active in stove promotion
- Private sectors (stove promoters/masters, biogas manufacturers, etc.)

Focus group discussion

Using checklist focus group discussions were held with women who use dung cake for cooking. Focus group discussions were held mainly to help extract information related to need, priorities, willingness etc.

Market mapping

Gaps in the supply chain of existing stoves are determined by mapping the market of cooking stoves and the fuel sub-sector. The distribution and value chain between a supplier and final users, taking into account the various buying mechanisms found in a market, including the part played by 'influencers' and policies is identified and mapped. Special focus is given on few value chains for possible interventions e.g. i) existing wood fuel, ii) fossil fuel cooking chains and iii) any stove/appliance chains in place.

Analysis of innovative capacity of organizations

Institutional assessment of relevant organizations is carried out using tools such as coverage matrix, actor constellation mapping, and SWOT analysis. Additionally, 4R's, the analysis of relationships, rights, responsibilities and revenues is carried-out to analyse actors. Coverage matrix provides the information on degree of involvement of actors in providing various services related to renewable energy. Actor constellation is used to identify the relationships between these actors in terms of participation, funding and coordination with each other. SWOT analysis stands for strength, weakness, opportunity and threat, and the analysis intends to find out the same for an organization in relation to its involvement in cooking technology.

3.2. Secondary data

Various literature and relevant documents, information, reports, legislations, policies and programs from various sources in the field of non-wood based and other cooking technologies appropriate for the Terai were collected and reviewed thoroughly. Technology that is capable of improving or replacing the traditional dung cake based technology in Terai has been given more focus in the review.

The project documents of GIZ were reviewed with respect to the guiding questions. Additional literatures were reviewed to collect information on performance of the technologies with respect to fuel consumption, indoor air pollution, user convenience and durability. Organizations/programmes operating in the field of non-wood based biomass fuel processing and respective stoves are listed through literature reviews and consultation with key stakeholders. Likewise, efforts are made to identify information gaps in the area of stove/technology promotion in Terai to the non-wood based biomass user households.

3.3. Data analysis

All the data and information collected from primary as well as secondary sources were compiled and systematically entered, processed, and analysed using SPSS and interpreted to recommend the appropriate and economic options for the cooking technologies in the Terai. Simple statistical tools such as frequency, percentage, mean, etc. are used for the analysis of quantitative data. The qualitative information is also transcribed, analysed and interpreted into descriptive method systematically. The framework for categorization is as follows:

- Demographic and socio-economic
- Geophysical and energy potential, supply and demand
- Potential to take intervention of new technologies
- Awareness and acceptance towards new cooking technologies
- Household affordability and access to credit services

4. Characteristics of the surveyed households

4.1. Family size and population

The average family size is 7.36 amongst the surveyed households. Among the surveyed districts, the average family size is highest in Bara followed by Kapilbastu (Table 4.1).

Table 4.1: Average family size in surveyed areas

Name of district	0-5 Years	6-14 Years	15 – 60 Years	60+	Total
Siraha	1.70	2.07	4.00	1.21	6.89
	(24.75)	(30.01)	(58.09)	(17.63)	(100.00)
Bara	1.80	2.31	4.41	1.24	7.63
	(23.60)	(30.27)	(57.87)	(16.23)	(100.00)
Kapilbastu	1.50	2.17	4.58	1.24	7.58
	(19.78)	(28.57)	(60.44)	(16.35)	(100.00)
Total	1.68	2.19	4.32	1.23	7.36
	(22.90)	(29.76)	(58.74)	(16.72)	(100.00)

About 58.7% of the surveyed population is economically active population (15-59 years). Ratio of dependent population including young children and old people is 70.3% comparatively less than the national average of 89%.

4.2. Ethnicity

In the survey sample, 41% of households belong to the Terai non Dalit group, 34% are Janajatis, 10% upper caste and 8% Dalits (Figure 4.1).

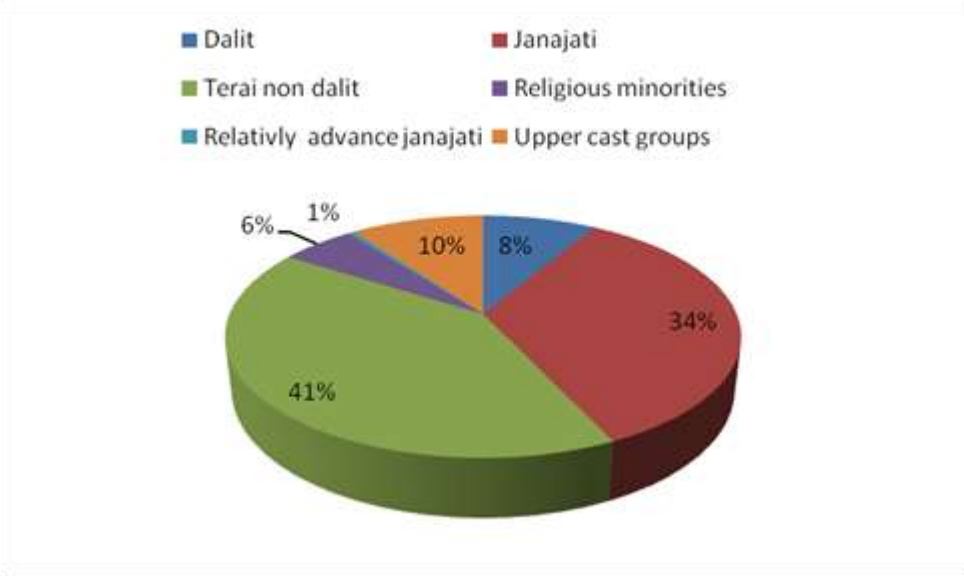

Figure 4.1: Ethnicity of surveyed households

4.3. Occupation of surveyed population

Majority (64.7%) of the economically active population is involved in agriculture, followed by students (16.3%). Number of people working in a daily wage basis is also significant (2.6%). Likewise, around 2.1% of people from the surveyed areas are working abroad (Table 4.2).

Table 4.2: Primary occupation of economically active population (in %)

Occupation	%
Agriculture	64.7
Student	16.3
Housewife	7.3
Daily wages	2.6
Service	3.7
Foreign job	2.1
Business	1.2
Other skilled manpower	2.2
Total	**100.0**

4.4. Income and expenditure

Average annual family income is NRs 176,185/HH/year. The total average is little bit lower than the national average of NRs 46,020 per capita national income. This may be due to inclusion of just cash income in our calculation. There is very little savings and that also by very few households. Almost all the earning is spent to meet family needs.

Table 4.3: Cash Income and expenditure (in Nepalese Rupees)

Name of district	Average HH income	Average per capita	Average expenditure
Siraha	181,848	28,050	160,826
	(96,375)	(15,827)	(83,029)
Bara	150,229	20,691	138,087
	(118,610)	(13,981)	(99,195)
Kapilbastu	200,261	30,132	154,108
	(128,358)	(21,677)	(97,537)
Total	**176,185**	**26,079**	**150,900**
	(115,706)	**(17,596)**	**(93,314)**

Note: i) This income is cash income only (excludes agriculture production consumed by themselves)
ii) The figures within the parentheses are standard deviation.

4.5. Association with local groups/organization

In all the districts around half of the households are associated with the local saving and credit groups or with cooperatives.

Table 4.4: Association of households on local saving and credit groups

Name of district	Member of saving & credit groups		
	Yes	No	Total
Siraha	41.4	58.6	100.0
Bara	67.1	32.9	100.0
Kapilbastu	38.3	61.7	100.0
Total	**49.5**	**50.5**	**100.0**

5. Fuel use and stoves for cooking in Terai

5.1. Fuel use and stoves

Use of fuel mix is common in the Terai for cooking purpose. Dung is mostly mixed with wood or residues. Dung is the primary cooking fuel for majority (57.0 %) of the households followed by wood. For about 18.5% households dung is the second most important fuel while for 1.5% household it is the third most used fuel. Overall, dung is a source of fuel for about 77.0% of the households (Table 5.1).

Table 5.1: Fuel use for cooking

Fuel Type	Mostly used fuel (in %)			
	Primary	Secondary	Third	Total
Wood	38.0	39.5	7.5	85.0
Dung	57.0	18.5	1.5	77.0
Agricultural residues	1.5	20.0	26.5	48.0
Other residues	0.5	3.5	0.0	4.0
Bottled gas	0.5	0.5	1.0	2.0
Biogas	2.0	0.5	0.0	2.5
LPG	0.5	0.5	0.0	1.0
Electricity	0.0	0.0	1.0	1.0
Total	**100.0**	**83.0**	**37.5**	

In terms of stove use, 22.0% HHs use more than one stove. Around 91.5% of the households are using traditional mud stoves followed by ICS (14.0%). In total 71.5% households solely dependent on traditional mud-stoves while additional 20.0% households are using it with other types of stoves (Table 5.2). The users of LPG, rice cooker, biogas and kerosene are also significant but these stoves are also in use complementary to traditional mud-stove or ICS (Table 5.2).

Table 5.2: Types of stove in use

Stoves in use	Name of district			
	Siraha (%)	Bara (%)	Kapilbastu (%)	Total (%)
Single stove users	57.1	81.5	98.3	78.0
Mud stove	51.4	71.4	95.0	71.5
ICS	4.3	2.9	3.3	3.5
LPG	1.4	1.4	0.0	1.0
Tripod	0.0	2.9	0.0	1.0
Rocket stove	0.0	2.9	0.0	1.0
Multiple-stove users	42.9	18.5	1.7	22.0
ICS and mud-stove	12.9	2.9	0.0	5.5
Mud stove and LPG	8.6	0.0	0.0	3.0
Mud stove and biogas	1.4	7.1	0.0	3.0
LPG, rice cooker and rocket stove	5.7	0.0	0.0	2.0
Mud-stove and rice cooker	2.9	1.4	0.0	1.5
LPG, ICS and mud stove	4.3	0.0	0.0	1.5
ICS and rocket stove	0.0	2.9	0.0	1.0
LPG, kerosene, rice cooker	2.9	0.0	0.0	1.0
Mud stove and rice husk stove	1.4	0.0	1.7	1.0
ICS and kerosene	0.0	1.4	0.0	0.5
Mud stove and kerosene	0.0	1.4	0.0	0.5
Mud stove and rocket	0.0	1.4	0.0	0.5
LPG, kerosene, ICS, mud stove	1.4	0.0	0.0	0.5
Kerosene, ICS, electric, mud	1.4	0.0	0.0	0.5
Total	**100**	**100**	**100**	**100**

5.2. Dung fuel use and stoves

Dung is used in 78% (156) of the households. It is the primary fuel for 57.5% HHs, secondary for 19.0% and third for 1.5% HHs.

Table 5.3: Dung fuel use in households

Districts	Dung as mostly used fuel (%)			
	Primary	Secondary	Third	Total
Siraha	46.7	40.0	1.7	88.3
Bara	48.6	14.3	0.0	62.9
Kapilbastu	75.7	5.7	2.9	84.3
Total	**57.5**	**19.0**	**1.5**	**78.0**

Around 61.5% of all dung cake using HHs use dung with other fuel such as wood and residues. The number of HHs that use dung cake only is about 3.8% (Table 5.4).

Table 5.4: Practice of dung-cake burning in Stove

Fuel use	HHs	%
Dung cake only	6	3.8
With wood	36	23.1
With residues	18	11.5
With wood and residues	96	61.5
Total	**156**	**100.0**

About 75% of respondents stated that the primary reason for using dung fuel was due to the difficulty faced in collection of adequate firewood. About 21.2% replied they are unable to make investments in better and cleaner fuels while 2.6% households think supply of clean fuel like LPG is not regular so they can't fully rely on it. About 1.3% households are using dung fuel because they think that the food prepared on it tastes better (Table 5.5).

Table 5.5: Reasons for using dung fuel

Reasons	Households (%)
Difficult to collect fuelwood	75.0
Unable to purchase other fuels	21.2
Food prepared on dung cake fire has good taste	1.3
There is no regular supply of better quality fuels	2.6
Total	**100.0**

In focus group discussions, participants reported that dung fuel is the preferred fuel for boiling milk and making curd. Likewise, there is a practice of burning dung to repel mosquitos. However the stoves used for these activities are different. Most of the dung fuel is prepared by the HHs themselves by mixing dung with residues and pressing by hand. Few (3.2%) households are also dependent on collecting dung from open lands. About 2.6% households dependent on buying dung cake while rest make it themselves. HHs that use collected dung cake use pure dung while almost all the other HHs make dung cake by mixing dung with other materials like rice husk and agriculture residues.

Table 5.6: Methods of dung cake preparation

Methods	Households (%)
Mixing with agricultural residue only	2.7
Mixing with rice husk only	3.4
Mixing with agricultural residue & rice husk	51.4
Mixing with agricultural residue, rice husk and twigs	42.6
Total	**100.0**

The mixing materials are seldom bought but are by products of the household's agriculture practice. Around 17.3% HHs collect materials from public places whereas about 1.9% households buy them. The dung is mixed with other materials to save dung as well as to increase its burning efficiency. Likewise, mixing dung with other materials reduces the time taken for dung to dry and increases the ease of dung handling. Normally, it takes around 11 days for the dung cake to dry. However, it varies with season and the materials used. Overall, dung cake can dry in a minimum of 7 days to a maximum of 20 days.

Among dung fuel using HHs, the use of traditional mud stove is predominant. Among these HHs, 83.1% HHs solely dependent on mud stoves and 9.8% use it with a combination of other stoves. ICS is used in some 2.7% of the total households.

Table 5.7: Percentage of stoves in households with dung as primary fuel for cooking

Stoves in use	Name of district			
	Siraha	Bara	Kapilbastu	Total
Mud-stove	57.7	79.4	98.1	83.0
ICS	3.8	2.9	1.9	2.7
Rocket stove	0.0	2.9	0.0	0.9
Mud-stove & ICS	15.4	2.9	0.0	4.5
Mud-stove & LPG	7.7	0.0	0.0	1.8
Mu-stove and rice-cooker	0.0	2.9	0.0	0.9
Mu-stove and rocket stove	0.0	2.9	0.0	0.9
Mud-stove, ICS & LPG	3.8	0.0	0.0	0.9
Mud stove, ICS, LPG & Kerosene	3.8	0.0	0.0	0.9
ICS and rocket stove	0.0	5.9	0.0	1.8
LPG, rice-cooker & rocket stove	7.7	0.0	0.0	1.8
Total (%)	100.0	100.0	100.0	100.0
HHs. having dung as primary energy	26	34	52	112

Fuel use is less in ICS compared to traditional stoves. The average solid fuel use is 5554 Kg with traditional stoves while it is around 3727 Kg with ICS. Most of the households use a mix of dung, wood and residues. The traditional stoves can be categorized into four categories (portable mud stove, mud stove, tripod stove and three stone stoves). Among them, fuel consumption is lowest with the portable mud stove followed by the mud stoves.

Table 5.8: Quantity of fuel use (in Kilograms)

Categories	Traditional stoves					ICS				
	Dung	Wood	Agri-residues	Total (kg)	User HHs	Dung	Wood	Agri-residues	Total (kg)	User HHs
Dung only	3786	0	0	3786	6	0	0	0	0	0
Dung and wood	2711	2297	0	5008	31	2367	1367		3734	3
Dung and Agri-residues	3507	0	591	4098	11	0	0	0	0	0
Dung, wood & residues	2147	2568	839	5554	69	1800	1691	236	3727	11
Total					**117**					**14**

The World Health Organisation (WHO) recommends an 8 hour average of CO (ppm) below 9 ppm. The 24 hour average level should be much lower than that. Our findings indicate that the 24 hour average CO level in dung fuel using HHs is 14.53 ppm. Table 5.9 shows that there is not much difference in CO level with ICS use in dung fuel user HHs.

Table 5.9: Carbon monoxide level (measured in PPM)

Fuel users	Main type of stove used					
	Traditional stove		ICS		Rocket stoves	
	Mean CO (PPM)	N	Mean CO (PPM)	N	Mean CO (PPM)	N
Wood only	12.53	10	6.41	2		
Dung only	14.53	6				
Dung and wood	13.62	21	5.65	2		
Dung and residues	15.48	6				
Dung, wood and residues	10.51	32	12.75	4	4.21	3

5.3. Stove preferences

About 36.8% of ICS users and 33.3% of rocket stove users seem happy with their stove when used with dung. Around 60% of ICS users think that it generates too much smoke and is very time consuming. In the case of rocket stoves, it was reported that the main problem is in the generation of high smoke as the stove design has no chimney. None of the HHs that use traditional stoves are unhappy with their stove. 82.5% of traditional stove users think it generates too much smoke while 76.3% think it consumes too much time to cook.

Table 5.10: Problem with the existing stoves

Stove type	More Fuel consuming (%)	More Time consuming (%)	Smoky (%)	Happy (%)	Total respondents (Nos.)
Traditional stoves	33.8	76.3	82.5	0.0	80
ICS	5.3	57.9	57.9	36.8	19
Rocket stoves	33.3	33.3	66.7	33.3	3
Total	**28.4**	**71.6**	**77.5**	**7.8**	**102**

Note: Due to multiple answers from same households the sum is greater than 100%.

Around 90% households (even ICS users) who are using dung fuel want to change their stoves. Among them, 76.9% want better improved cooking stoves while 12.8% households want biogas. Only 2% of ICS users seem happy with the existing technology. About 84% of ICS users want to have better quality ICS and about 5% of ICS users want to upgrade to biogas.

A lady in Kapilbastu reported her dissatisfaction with the use of ICS. With the current design she is unable to prepare Daal (lentil soup) using the second pothole. The two potholes of her stove are of different size and the size of the pot that she uses make Dal does not fit in the first pothole so she is compelled to use the second pothole only to prepare Dal. However, it takes very long time to prepare Daal in the second stove.

Table 5.11: Preferences for changes in stove

Stove types	Preferences for changes (%)			
	Better ICS	Biogas	No changes	Total
Traditional stoves	76.9	12.7	14.0	100.0
ICS users	84.2	5.3	2.0	100.0
Rocket stove users	33.3	66.7	0.0	100.0
Total	**76.9**	**12.8**	**10.3**	**100.0**

The only reason behind the lack of actual actions to make improvement in their stove is due to their inability to invest money on stoves. About 90% of them reported that they do not have enough money to pay for stove improvement.

With respect to ICS, majority of households prefer double potholes stoves while the number of HHs wanting to have single pothole stoves is also significant (17.5%). The households from Kapilbastu and Bara are the ones mostly interested in single pothole stove.

Table 5.12: Percentage of preferred ICS types

Stove preferences	Name of district (in %)			
	Siraha	Bara	Kapilbastu	Total
One pothole	1.4	18.6	35.0	17.5
Two potholes	95.7	77.1	60.0	78.5
Three potholes	2.9	0.0	1.7	1.5
Other stoves	0.0	4.3	3.3	2.5
Total	**100.0**	**100.0**	**100.0**	**100.0**

The interested households who want to make improvement to their stoves are willing to invest on it. But their willingness to pay differs according to the type of technology preferred. For a biogas plant they are willing to pay NRs 9,750 and for an ICS they are willing to invest NRs 279. It seems that they are very much familiar with the existing subsidy mechanism.

Table 5.13: Willingness to Pay (in NRs)

Preferred technologies	Mean	Maximum	Minimum
Improved cook stove	278.94	1,000.00	50.00
Biogas	9,750.00	40,000.00	1,000.00
Total	**2,035.17**	**40,000.00**	**50.00**

There does not seem any significant correlation (r = 0.111) between the willingness to pay for stove and income level.

6. Analysis of institutional involvement

Massive level of ICS intervention in the Terai by the Biomass Energy Component (BEC) of ESAP/ESAP started only after July 2010. Before that there was very little, uncoordinated and unsuccessful effort by different organizations. BEC is currently working through their regional and district partner NGOs. Centre for Rural Technology (CRT/N) is also found to be active in Bara and Kapilbastu. There was a programme being run by Livelihoods and Forestry Programme (LFP) in Kapilbastu district. Likewise, few years back PLAN Nepal was active in stove dissemination in Bara district. Detail analysis of institutional involvement is presented below.

6.1. Implementing organizations

6.1.1. AEPC/ESAP Biomass Energy Component

In all the surveyed districts there is presence of AEPC/ESAP Biomass Energy Component activities. It is working with service providing organisations for dissemination of their stove programme. The regionally located service providers are called Regional Renewable Energy Service Centre (RRESC). The field level implementation is fully handed over to the appropriate local institutions, such as RRESCs, and/or any other appropriate outlets identified in the areas. The decentralised approach of the component has identified strong roles for District Energy and Environment Unit (DEEU) to coordinate existing network of partners in the district to plan for efficient use of biomass/natural resources and incorporate it in the periodic plan of DDC. The local NGOs and private sector/service providers have key roles in facilitation of the component's implementation activities. Likewise, the district based local NGOs and community based organizations (CBOs) identified as local partner organisation (LPOs) are implementing the activities at the field level (See Annex 2).

Under ESAP, the ICS model which is quite successful in mid-hill has also been tried in the Terai. Likewise, efforts have been made to introduce rocket stoves. Total number of installation up to June 2011 is as presented in Table 6.1.

Table 6.1: Stoves promoted under ESAP programme till June 2011

Type of stoves	Siraha	Bara	Kapilbastu
ICS-Two potholes	845	540	935
ICS- One pothole	201	48	154
Rocket stove	11	12	11
Total	**1056**	**600**	**1100**

6.1.2. District Energy and Environment Unit

The DEEU is responsible for supporting their respecting District Development Committees (DDCs) in energy, planning, monitoring and promotion of RETs and environmental protection activities. At the district level, energy and environment management committee and energy and environment coordination committee are set up to promote and address the sub-sectored issues. None of the DEEUs from the three surveyed district have been found to be active in ICS promotion. It seems that ICS is not in their priority, while they are actively involved in biogas

and solar home system promotion and monitoring. Likewise, they are also involved in District Energy Situation Report (DESR) preparation.

6.1.3. Centre for Rural Technology Nepal (CRT/N)

Centre for Rural Technology (CRT) is active in promotion of improved stoves since 1990. From 1990-1999 it worked with various national and international organisations, Department of Women's Development and community based organisations (CBOs).During this period, about 14,000 ICSs were installed. During 2000-2003, CRT/N was the only implementer of National Biomass program (AEPC/ESAP). From 2003, other NGOs were brought in as project implementer. From there onwards, CRT/N's business model has changed from being the primary implementer to training other NGOs and local partner organisations (LPOs) to carry out the implementing activities. This was done with the view to expand its outreach and more effectively scale up the programme. Therefore, the number of ICS installed by CRT has declined from 2005. Currently, CRT/N has been working as a service providing partner to AEPC/ESAP and has been facilitating the National Biomass activities in 12 districts through its 2 RRESCs in Dang and Kathmandu. Under the programme, around 185,000 stoves have been disseminated up to June 2010 in 30 districts with the cooperation of trained promoters and local partners' organisations.

CRTN's Terai Carbon Finance Project

CRT/N has been implementing the "Efficient Fuelwood Cooking Stoves in Foothills and Plains of Central Region of Nepal" project in Bara, Parsa, Rautahat, Sarlahi, Mohottari and Dhanusa districts since 2009. The project is pre-financed by Egluro. Under the 1st phase, the project targets to install 22,920 stoves. They are promoting mud ICS with ceramic combustion chamber. They have also worked with LFP to disseminate same type of stoves in Kapilbastu from 2009 to 2011.

6.1.4. INGOs and project involvement

Many projects introduced improved stoves in Terai as a component of a project. The projects include LFP, WWF-Terai Arc Landscape Project, PLAN International etc. In Kapilbastu, LFP worked in partnership with CRT and helped to install about 460 stoves (CRT model). In total, LFP and CRT installed 2700 stoves in Terai. PLAN through RRAFDC (a district NGO) has helped to install 1100 stoves under "Sustainable Environment and Development through Integrated Natural Resource Management Project" in Bara district during 2001-07.

6.1.5. NGOs involvement

There is a good presence of NGOs in all the three surveyed districts. Few of them are actively involved in stove promotion under ESAP programme or with other projects. These NGOs are very good in social mobilisation and awareness creation. They have good linkages with local government and are very much familiar with the local context. However, they lack clear strategy and expertise on private sector promotion. They are highly dependent on external funds.

6.2. Research organizations

IDS Nepal, FOST, CRT/N, NAST and CEEN are carrying out research on briquette technology. They have been providing training to local organizations and local communities as well. CWSN is conducting research on dung briquetting and stove for dung briquette.

6.2.1. CWSN – Research on dung processing

Child Welfare Scheme Nepal (CWSN) with technical support from Engineers without Borders (EWB), Australia has been conducting research on appropriate technologies for the Terai since 2008. They have been working on the following:

- Stove Improvement – working on design modification in Prakiti Stove Model, Chennai, India.
- Dung briquette

However, the researchs are still in progress. According to CWSN, they will be finalising the design by the end of the year (2011).

6.2.2. Nepal Academy of Science and Technology (NAST)

NAST is an autonomous government apex body established in 1982 to promote science and technology in Nepal. In the biomass sector it has been engaged in exploring alternative and renewable energy resources as substitutes for the traditional biomass fuel, which is being extensively exploited. The faculty has developed a biomass laboratory which is providing analytical and testing services for fuel properties of coal, and biomass. The laboratory also has facilities for research, testing and analysis such as water boiling test, cooking test, ignition temperature test, proximate analysis, breaking strength, density of raw material, smoke test, gas emission test etc. Overall the laboratory is providing the following testing facilities.

- Testing of different types of stoves
- Testing of different bio-briquette received from various organisations
- Possibility of briquette production from plastic and paper
- Testing of ignition temperature of raw materials
- Gas emission test (CO, CO_2, NOx, SO_2, O_2)
- Research and development to improve the efficiency of various stoves

Till December 2010, more than 10 different types of bio-stoves using various bio-briquettes and fuels have been tested in the laboratory. Likewise, NAST has prepared a database of different raw materials and biomass with their proximate analysis (moisture content, volatile matter content, ash content and carbon content).

6.2.3. The Research Centre for Applied Science and Technology (RECAST)

RECAST was established on 1977 as a premier research and development (R&D) institution within the organizational framework of Tribhuwan University. Since its establishment, it has been involved in various researches on improved stoves. In the past, it has contributed to develop the following types ICS designs.

- Single, two and three potholes (same and raised surface),
- Institutional (Single, two and three potholes, lapsi and khuwa chulo) and
- Two potholes (with smoke hood)

As a premier R&D institution, RECAST has got a well-equipped mechanical workshop and laboratories. RECAST conducts research projects, designs and fabricates prototypes, offers expertise and consultancy services including instrumental and analytical services. It organises national and international workshops/seminars and provides its laboratory facilities for research purposes to postgraduate students from the Central Department, Faculty of Science, Tribhuwan University.

6.3. Private sector and market

There is no organised or established private sector involvement in ICS promotion in the districts. There are stove masters trained by ESAP programme in different villages and they charge NRs.300 to 500 per stove installation. This is comparatively higher than their daily wage rate in local market but most of them lack entrepreneurship commitment/dedication. They take the job as a volunteer's work and not as a profession. CRT has trained a few local artisans to make ceramic combustion part. Though they are still active, they have been unable to sell their product after the project support.

6.4. Financing institutions

In most parts of the survey districts, there seems to be a good presence of micro-finance institutions (MFIs). With the initiation of Poverty Alleviation Fund (PAF) and Local Governance and Community Development Programme (LGCDP), various saving and credit groups have been formed in the Terai region. Likewise, there are various groups formed by banks like DEPROSC, Rural Development Banks, Nirdhan Bank etc. There are also cooperatives formed by the local people themselves, but mobilizing the resources to stove promotion has not been easy. The cooperatives are not interested on very small investment due to high transaction cost and risk. There is therefore a dire need to devise separate mechanism to link them in stove promotion.

7. Analysis of existing technologies

7.1. Stoves

In survey districts following types of stoves are in use:

- Traditional mud stoves
- Mud ICS (ESAP model)
- Mud ICS with ceramic combustion chamber (CRT model)
- Rocket stove (locally made with technical support from NGOs)
- Briquette & briquette stove
- Rice husk stoves

The analysis of strength and weakness of above stoves are described in Annex 3. In conclusion, all of the stove models mentioned above need modifications to make it suitable for dung fuel burning.

7.2. Household gasifier stove

Household gasifier stoves can be an alternative to the households from Southern Terai where loose biomass fuel such as rice husk, agro-waster and forest waster is available. Gasifier cook stoves are basically devices that produce so called “Producer Gas” through incomplete combustion of biomass such as wood, agricultural residue and coal. The combustion in gasifier stove is completed under controlled condition, so there is maximum utilisation of energy potential available in the biomass which makes this technology very efficient. On the other hand, complete combustion makes this technology cleaner compared to combustion. Technically in a gasifier, biomass fuel is ignited at low oxygen to break it down into carbon monoxide and hydrogen gas also known as producer gas. Secondary air is added to the hot producer gas to create complete combustion and it releases high amount of heat.

The AEPC/ESAP has recognised this technology as a potential stove for the future and are conducting research on it. Additionally, CRTN, STARIC and CEEN are also carrying out research on it. A recent study carried out by STARIC for AEPC/ESAP shows that the gasifier stoves are much more efficient than the traditional cook stoves. The study has recommended for more pilot testing with a larger sample size before commercialisation of gasifier cook stoves.

7.3. Dung processing

Traditional Practice

There are two types of dung fuel in use. One is of circular bread shape which is easy to make and dry. The other is of a stick shape. Positive and negative aspects of the dung fuel according to their shape are presented below:

Table 7.1: Types of dung fuel based on shape

Shape	Positive Aspects	Negative Aspects
Bread shape dung fuel	• Dries easily (good for rainy season) • Easy to make	• More dung use (Less mixture of other residues)
Stick shape dung fuel	• Burns well when properly dried • Can be prepared large amount of fuel from little quantity of fuel • Can be burnt as wood in stove	• Takes time to dry • Need special skill to prepare

Improved Version

In the context of fuel processing, CWS is carrying out research on dung briquette since 2008 with technical support from EWB Australia and a local partner organization (Namuna Integrated Development Council). The LPO also works with local *Aama Samuha* (Mothers' Group) at the village level. They are investigating and supporting the development of two pot improved stoves (Leo design Prakiti model) specifically to burn dung.

They are working in 7 VDCs of southern belt of Rupandehi District and formed 60 (sixty) women's group/7 VDCs. In the preparation of dung briquette, the dung is first washed. Washing the dung removes most of the harmful elements like chlorides. Later paper is used as binder for the production of briquettes. Waste liquid is then watered down to produce fertilizer. The table below shows the analysis and description of dung washing process including methods, inputs and cost:

Table 7.2: Steps to prepare dung briquette and tentative costs

Steps	Activity/Method	Input	Cost (Cash/kind)	
			Fixed	Running
1	**Collection of raw materials locally**	Dung, waste papers	-	500kg/1manday
2	**Processing**			
2.1	Washing dung	Dung, water		for machine and labor cost for 500kg/2 man days
2.2	Mixing of washed dung with waste paper	Dung, waste papers	NRs. 8000 per machine	
2.3	Making dung briquette by pressing machine	Pressing Machine (Screw Type)		
2.4	Dry the dung briquette			

7.4. Fuel switching (Briquette, bioenergy etc.)

7.4.1. Briquette

Briquette could be a viable substitute to dung fuel in Terai. The briquette technology produces high density fuel by compacting combustible raw materials such as charcoal, agricultural residue or waste to increase the net calorific value per unit volume. There are various methods of briquette production and different raw materials can be used for its production. Similarly, different kinds of cook stoves are available for burning briquette. The private manufacturers are involved in development and the sell of the briquette stoves. Since briquettes produce little smoke and propagate consistent heat compared to firewood, they are getting popular in space heating purposes. Research has also shown viability of briquette use in brick kilns as an

alternative to coal. With a few small scale briquette manufacturing industries in Nepal and the growing demand for it, there is scope for establishment of more of such industries. It is wise to improve the capability of entrepreneurs interested to work in the biomass energy sector so that they learn different briquette manufacturing and associated technologies and use the lesson for income generation by selling their products. Briquette making can serve as a small scale micro-enterprise in areas where agricultural residues are in abundance.

Briquette Technology

Loose agro or forest residues are inconvenient fuels and give low thermal efficiencies and more pollutants compared to wood. But this problem can be solved by compacting the agro residues to improve the handling characteristics and provide clean combustion.There are various methods of briquette production (bee-hive briquette, pellet briquette, dung briquette and paper briquette) and different raw materials can be used for its production. Similarly, different kinds of cook stoves are available for burning briquette.There are two ways of making briquettes,

Direct briquetting (paper briquetting)

There are two types of high-pressure briquetting machines and these do not require binders. Another type uses low-pressure and needs special binders like ligno-sulphonates or bentonite clays. The screw press provides the briquettes with a central hole, which facilitates combustion. The ram press briquettes are solids with inferior combustion characteristics compared to briquettes with concentric holes.

Carbonisation briquetting process:

The "Bio- briquettes" (Bee-hive and pellet briquettes) are made from charcoal produced from agricultural residues, such as rice husk and wheat chaff forest "waste" fallen pine needles, pinecones, grassy weeds, lantana, *Banmara jhar* shrubs (Banmara weed or Eupatorium adenophorum, an undesired forest weed). This biomass material is first sun dried until it has humidity below 15%. It is often heated in a 200-litre metal charring drum of 3mm metal sheet. The resulting charcoal is ground to dust and (in Pandung) mixed with 30% dry clay-soil (in volume). Water is then added to make a paste. Using a hand weight, the paste is compressed into a round mould, containing 19 pins. The compacting pressure may vary, but is not more 2-3 kg/cm2.The 19 round pins create 10 mm holes throughout the height of the charcoal briquette after de-moulding. Due to the Honey-comb shape of briquette these are called Bee-hive Briquette. Similarly, the pellet briquette can be made from this char-paste by using pellet machine.

Organizational involvement

AEPC/ESAP has been providing training on briquette making. CRT/N, CEEN and FOST are undertaking activities for briquette technologies by organizing and supporting research and development and training program related to them. Research organisations, such as NAST and Integrated Development Society (IDSN) are involved in developing and disseminating the beehive briquette made from *Banmara*. FOST is involved in research and demonstration of briquette production through HH wastes. FECOFUN and a few district-based NGOs (RRAFDC, REWSSPC) are also involved in community based training on briquette production.

Potentiality of briquette burning for cooking in Terai

To sum up, from the survey of three districts, there are lots of obstacles for promoting briquette use in Terai. The main constraint is on the seasonal availability of agricultural residues, and lack of adequate forest and other residues availability. In the field survey, it was observed that many people from the Terai have tried to start briquette producing enterprises but have not been able to continue due to lack of adequate demand for it. Without large scale social marketing campaign and behavioural change activities it seems that there will be no significant use of briquette in Terai in the near future.

7.4.2. Bioenergy

From the stakeholder workshop (conducted in 3 districts: Siraha, Bara and Kapilbastu), it was found that there are no bio-fuel technologies or Jatropha farming in the survey districts. There is also no technical potential and economic viability for bioenergy for fuel in these areas because of high economic value of production of other agricultural materials (rice, maize and mustard). Furthermore, there is no demand of bioenergy as fuel. There is no possibility to go for its promotion in short term project.

7.5. Biogas

Biogas is another option which can replace the use of dung fuel in the Terai. It is estimated that a total of 1.9 million biogas systems can be installed in Nepal, 57% in Terai, 37% in Hills and 6% in Mountain regions (BSP, 2004). Its use has multiple benefits at the household, local as well as global level. However, the installation cost of biogas is very high. Without subsidy support, it is unlikely that the households from Southern Terai would have sufficient financial incentives to adopt it. To reduce the cost and make it accessible to poor households, efforts have also been made to make community biogas plants(BSP Nepal in partnership with LFP in Kapilbastu, Rupandehi and Nawalparasi district), however there have been issues of management and benefit sharing.

8. Conclusion and recommendation

Dung use has deep roots in the culture in Terai region. A large number of households from Terai, around 430,000 HHs (10.1% of total) use dung as their main cooking fuel. Most of the families prefer to have stoves which are convenient in using both dung and wood as cooking fuel. There is also a culture thus a preference of using two pothole stoves. Without further modification of existing improved stove designs, the stoves are not acceptable to the dung fuel user HHs. Fuel switching does not seem possible in the short run. Overall there is a need of a holistic approach to address the problem while adequate effort has to be given to the following:

- Stove improvement
- Improve combustion efficiency of fuel
- Behavioural changes through awareness creation activities

There must be choices on technology options. The stove should be strong and sturdy with less requirement of maintenance. Likewise, it should be modern and stylish, easy to light fire, less time consuming, and smokeless. Quality (not the price) should be the determining factor. There should be warrantee on stoves (provision of after sales of service). The stove entrepreneurs also need skills on marketing and business development also.

Thus the role of GIZ/NEEP to address the improved cook stove need in the Terai is observed in this front. For future GIZ/NEEP involvement, further recommendations are presented in ensuing chapters.

8.1. Best technology options

To solve the household energy related problem of dung fuel burning households in Terai, there is need for improvement in stove design and fuel processing as mentioned below. Likewise, there is possibility of promoting briquette technology to substitute dung use.

8.1.1. Stove modification

Option A1: Stove modification of ESAP and CRT/N Model (for poor HH)

It is recommended for following modifications in the existing designs:

- The first hole should have a big inner grate as dung has high amount of ash formation after burning
- Provision should be made to takeout ash easily by means of high grate holes
- Dimensions of stoves should vary according to size of a family

After the modification, there seems possibility of disseminating around 70,000 such stoves by year 2014 (see Annex 5 for details).

Option A2: Modification of portable rocket stove

To make the existing design user friendly to the dung fuel use there is need of following modifications:

- Provision should be made to take out ash easily by means of high grate holes
- According to size of family, dimensions of stoves should be vary accordingly

It is estimated that the modified rocket stove will cost around Rs.1800/stove. As the cost is quite high to the rural poor, dissemination of these stoves should be linked with micro-financing mechanism. As per the rough estimates there is possibility of 20,000 portable rocket stoves dissemination in Terai by year 2014 (Annex-5).

Option A3: Modification of CWS Model (Prakti Model – Leo stove)

The CWS is doing a research to make the stove suitable for dung briquette burning. For better-off households, the CWS Model has been proposed. But there is need of few modifications as outlined below:

- Big inner grate should be in the first hole because dung has high amount of ash formation after burning
- Provision should be made to take out ash easily by means of high grate holes

It is estimated that the modified CWS stove will cost around Rs.4000/stove. Dissemination of such stoves should be linked with micro-financing mechanism. As per the rough estimates there is possibility of 5,000 portable rocket stoves dissemination in Terai by year 2014 (Annex-5).

Option A4: Venting smoke using smoke hood (brick & GI sheet)

For those households who are using pots of multiple sizes, the smoke hoods could be right choice. In Terai, the smokehoods with use of brick at the base part may help to reduce cost. It can be used with use with chimneyless improved stove (like Rocket stove). It will cost around Rs.3000 per smoke hood. The estimate shows that there is possibility of 5,000 smokehoods by year 2014 (Annex-5).

8.1.2. Improvement in dung fuel processing

Improvement in existing dung fuel processing methods

Existing dung fuel preparation does not contain the right proportion of dung, rice husk, jute and other agricultural residues. Therefore, there is a need for modification in preparation of well-proportioned dung fuel in terms of dung and residue proportion. The dung fuel processing can be improved as follows,

- With the right proportion of 2 portion of dung, 1 portion of residue and 1 portion of *Santhi* or Bamboo stick

There is need for training packages and awareness programme for making better dung fuel.

Making dung briquette

Existing dung fuel processing techniques should be improved. There is possibility of making briquette from the dung by first washing the dung to remove harmful elements like chlorides and then using paper as binder to produce briquettes. After that, it needs to be pressed by using briquette press/die and dry properly.

8.1.3. Fuel Switching to Briquette

In the places where forest and agricultural residues are abundantly available, briquette production and improved stoves for that should be introduced. Pellet briquette could be a substitute to dung cake. But promotion of briquette should be accompanied by massive social marketing and behavioural changes activities through awareness creation to encourage its use.

8.2. Target Areas for Project Implementation

Out of 20 districts from Terai, 13 districts mainly from Central and Eastern Terai have dung user HHs in 5 digit (more than 15% of total HHs). So it is recommended to focus the project on those districts (Kapilbastu, Rupandehi, Nawalparasi, Parsa, Bara, Rautahat, Sarlahi, Mahottari, Dhanusa, Siraha, Saptari, Sunsari and Morang) as highlighted in Annex 4. There is possibility of achieving 100,000 improved stoves by year 2014 (in around 25% of dung users HHs.).

8.3. Best dissemination approach

Existing AEPC/ESAP project implementation model is recommended for disseminating the above improved cook stoves in Terai also. But there is need of few improvements as following:

- Working with the research organizations and investing on R&D. Further research and testing required on proposed models before going for large scale dissemination. It is recommended for 6 months research phase
- Need to activate DDC & DEEU/S in monitoring and quality assurance aspects. Need to build capacity of the DEEU/S staff accordingly.
- Need to work closely with FECOFUN and Public Land Management Groups (PLMGs) in Terai
- Working with micro-financing institutions to ensure access to credit
- Develop social marketing skills of implementing partners and stove promoters/masters
- Develop mechanism for ensuring after sales of services (repair & maintenance, monitoring etc.)

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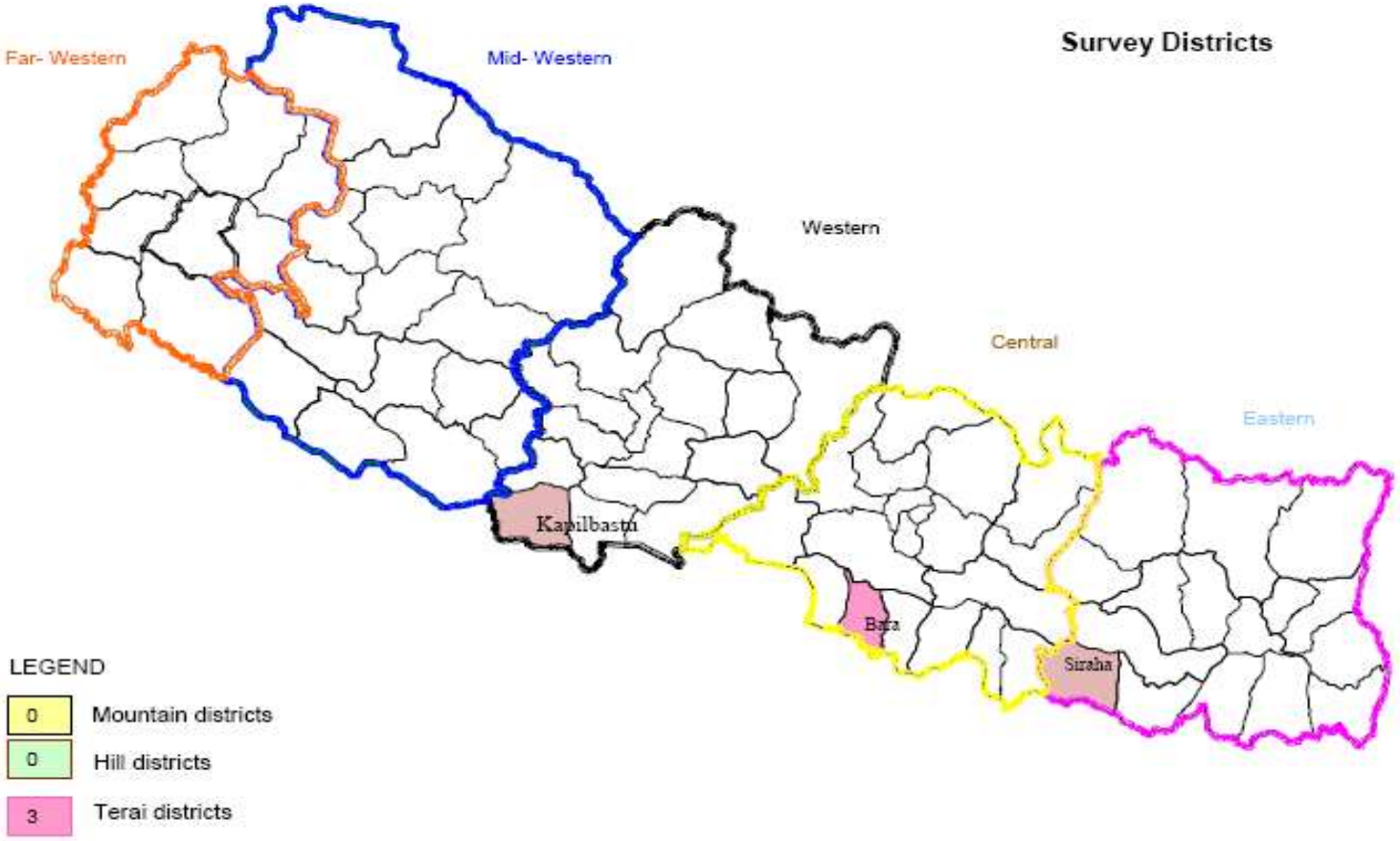
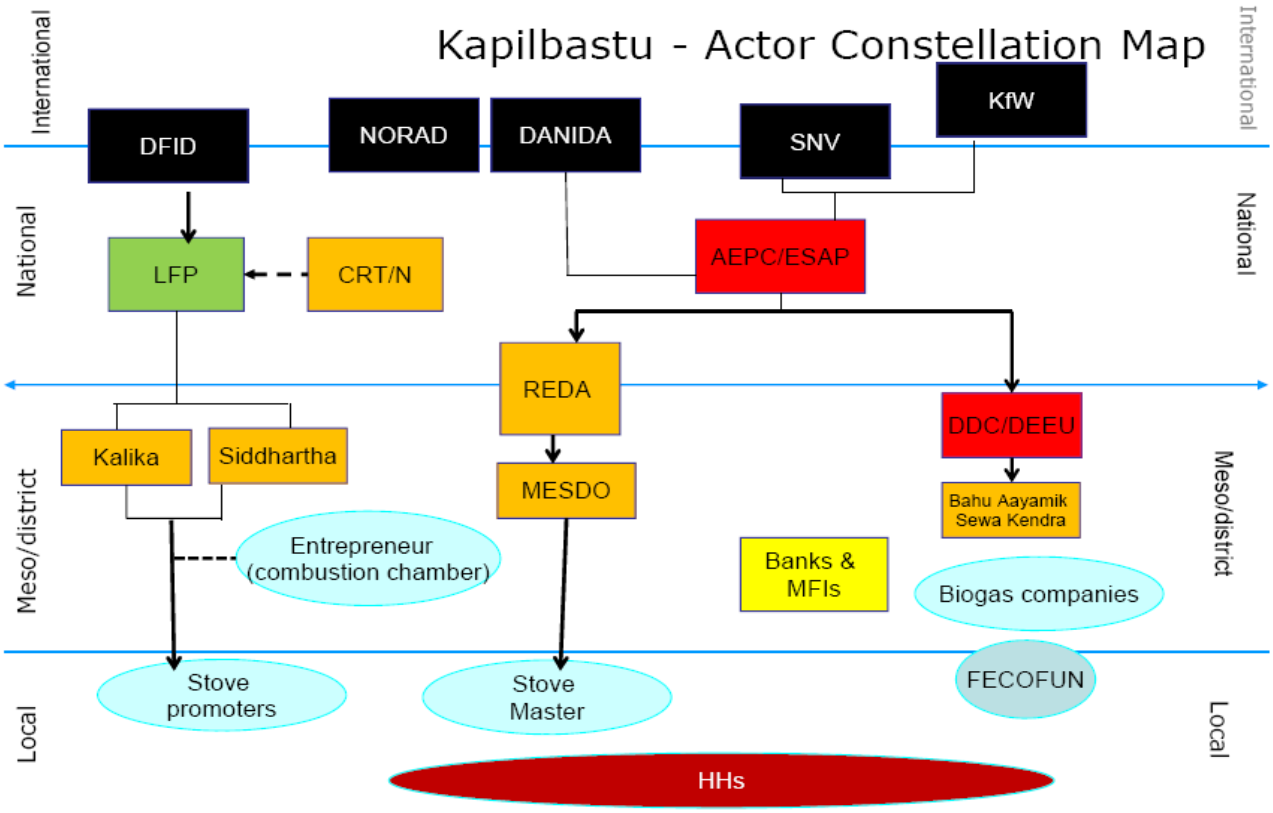
Annexes

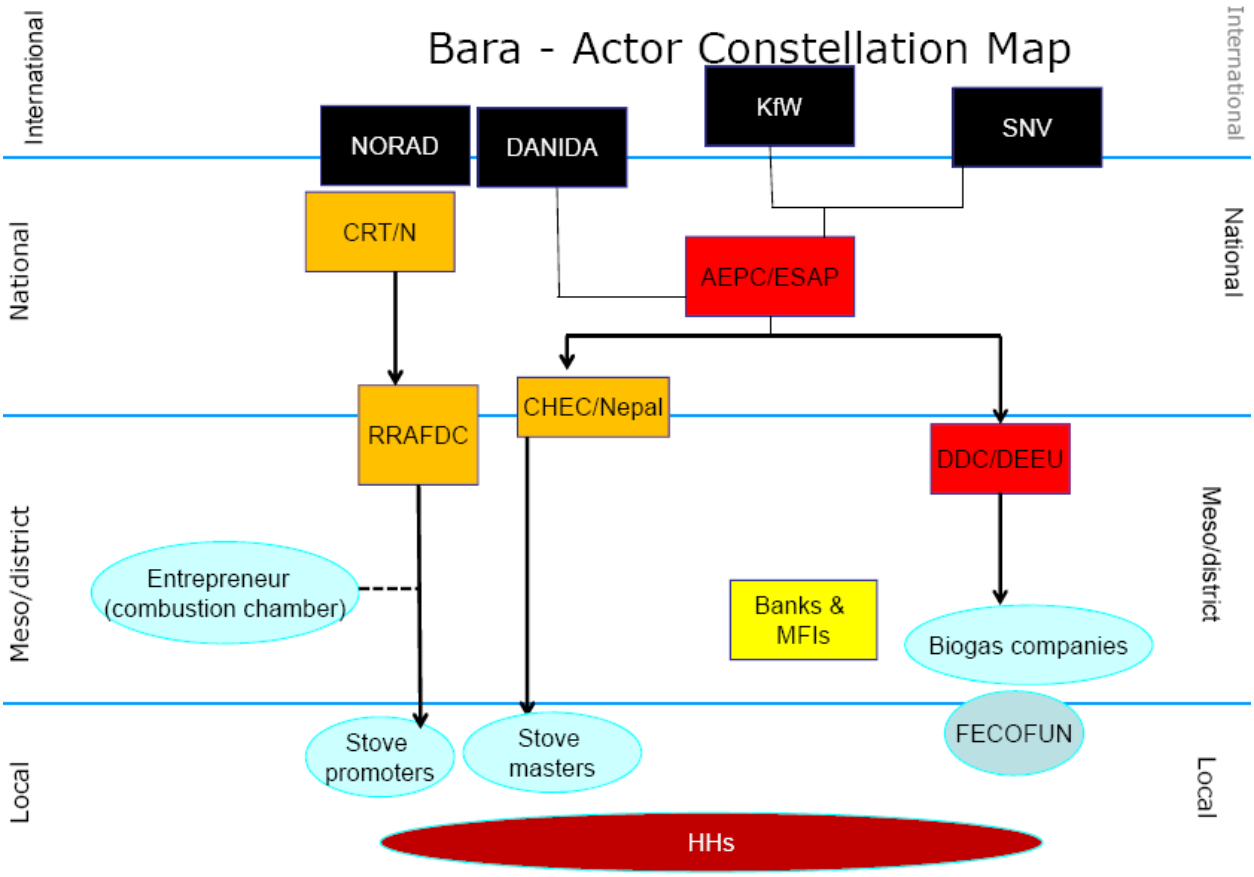
Annex 1: Survey Districts

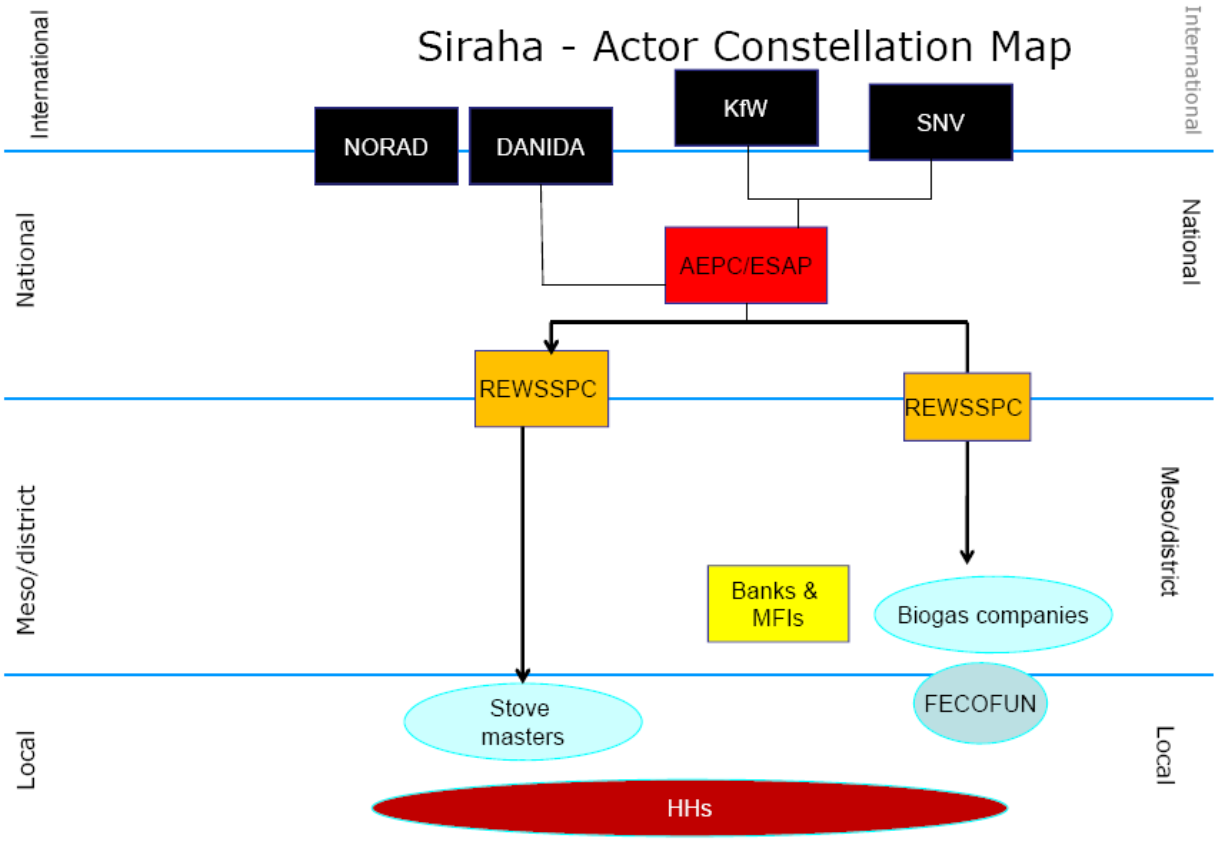


Annex 2: Actor Constellation Map



Note: As of Year 2010. Currently there is not LFP project.


Bara - Actor Constellation Map
International
National
Meso/district
Local
NORAD
DANIDA
KfW
SNV
CRT/N
AEPC/ESAP
RRAFDC
CHEC/Nepal
DDC/DEEU
Entrepreneur (combustion chamber)
Banks & MFIs
Biogas companies
Stove promoters
Stove masters
FECOFUN
HHs


Siraha - Actor Constellation Map
International
National
Meso/district
Local
NORAD
DANIDA
KfW
SNV
AEPC/ESAP
REWSSPC
REWSSPC
Banks & MFIs
Biogas companies
FECOFUN
Stove masters
HHs

Annex 3: Strengths and weakness analysis of various stoves

Type of stoves	Strength	Weakness	Remarks
Traditional mud stoves	• Made from local material • Affordable • Suit to their culture and cooking needs	• High smoke (air pollution generation due to inefficient combustion) • Time consuming • Less than 10% efficient ,consume much fuel materials • The open fire results in risk of accidents with children burn and/or household fire	• Not good for health and environment • Utensils and clothes are blackened by soot
Mud ICS (ESAP model)	• Affordable (Rs.300 – 500) • Good for wood burning • Efficiency up to 24% and 6 months to 1 year durable • High smoke reduction in the kitchen • Two pot-hole stove allows cooking with two pots leading to saving of cooking time and fuel • Can be build one and two pot holes	• Not suitable for dung • Due to small combustion chamber inefficient primary air flow; low combustion temperature increase; burn inefficiently. • High deposit of ash inside combustion chamber	• Not appropriate for dung fuel
Mud ICS with ceramic combustion chamber (CRT model)	• Comparative durable and easy to install (Can be in use for 3-4 years if properly maintained) • Higher efficiency (25-30%) of energy conversion with more safety • High smoke reduction in kitchen • Two pot-hole stove allows cooking with two pots leading to saving of cooking time and fuel • Used for heating water by attaching a back boiler to the side or around the chimney pipe • Made in different sizes and capacities to suit the family size and pot size • Affordable (Rs.500-600)	• Due to small combustion chamber inefficient primary air flow; low combustion temperature increase; burn inefficiently. • High deposit of ash inside combustion chamber • The baffle inside ICS has to be repaired frequently to maintain shape and size to make ICS operate efficiently	• Need modification in internal combustion and grate as well (as per the nature of dung fuel)

Dung stove (CWS design) (Still in testing phase)	• Durable (low maintenance requirement) • Designed particularly for wood and dung briquette • Attractive and portable	• Costly around NRs. 4000 (but it is relative not absolute issue) • Can't manufactured locally but can be assembled locally (need to develop market supply chain)	• Potential for large scale dissemination
Rocket stove (locally made with technical support from NGOs)	• Emits less smoke and requires less time in comparison to traditional cook stove • Requires less maintenance in comparison to other cook stove • Affordable	• according to users it consumes more fuel (burn efficiently after getting hot only)	• Need design modification
Briquette & briquette stove	• Proper use of Agricultural residues (waste)	• No demand • Not suite to local cooking habits • High air pollution (mainly CO)	• Can't replace dung fuel use
Rice husk stoves	• Affordable (Rs.300 – 1200 based on size and design) • Durable (low maintenance requirement) • Use of waste (husk)	• Highly polluting (IAP very high)	Need to replace it also

Annex 4: Target Areas for Project Implementation

*Map designed and printed at HMG Survey Department, National Geographic Information Infrastructure Project (NGIIP)

Annex 5: Recommended stoves, estimated costs and proposed dissemination approach

Stove/Intervention types	Cost (Rs.)*	Dissemination app.	Quantity	Organization
ICS - Two pothole	600	Subsidy	25,000	AEPC/ESAP
ICS-One pothole	500	Subsidy	10,000	AEPC/ESAP
ICS ceramic - Two pothole	900	Subsidy	35,000	AEPC/ESAP, CRT/N
Portable rocket stoves	1800	Revolving fund	20,000	AEPC/ESAP, CRTN
CWSN modified design (Prakti Model – Leo Stove)	4000	Revolving fund	5,000	CWSN
Smoke Hood (brick & GI sheet)	3000	Revolving fund	5,000	Practical Action

Annex 6: List of Workshop Participants and Contacted Persons

Table 1: List of District Workshop Participants in Kapilbastu District

SN	Name of Participants	Office & Designation	Contact Phone &Address
1	Rajan Kumar Pokharel	Communication Officer	DDC, Kapilbastu
2	Manoj K Thapa	DC-MESDO Nepal	Bangai-3, Kapilbastu
3	Santosh Kumar Acharya	RRESC/REDA-Butwal	9851112692
4	Sharada Panthi	Enumerator/PAN	9841078721
5	Manish Karki	Media Personal	9847062514
6	Sita Neupane	Bahuayamic Sewa Kendra Nepal, Jayanagar	9847384099
7	Nar Bdr Magar	Nawa Jagriti Community Forest Group	9847288727
8	Thagi Prasad Choudhary	National Biogas Company	9847045632
9	Samjhana Bhandari	Women and Child Office	76560641
10	Santosh Panthi	Officer, DEEU/DDC	9841642142
11	Bishnu Prasad Khanal	VDC, Secretary	9847107300
12	Krishna Prasad Gautam	Dubiya VDC	9847087926
13	Mani Ram Kunwar	Dhanamauli VDC	9847511668
14	Min Raj Belbase	Bhrikuti Samudaik Adhyan Kendra	9847047840, 076-691883
15	Surendra Raj Lamsal	Kalika Swabalamban Samajik Kendra	9847062505
16	Ramsebak Prasad Chaudhary	Barkulpur VDC	9747009085
17	Hari Prasad Ghimire	Office Assistant, DDC/DEEU	9847058671
18	Saraswati Paudel	Journalist	9847040530
19	Sakti Karki	AFA,DDC/DEEU	9847204099
20	Mani Prasad Gaire	Sajha News /Journalist	9857050694
21	Bishnu Maaya	Pairabi manch	
22	Rabin Paudel	Mesdo Nepal	9847062523
23	Indu Tharu	Social Mobilizer/ Hatausa VDC	
24	Bhagwati Regmi	'	
25	Bimala Neali	LSM/Mesdo	9847040894
26	Rumlal Pokharel	Mesdo Nepal	9847133328
27	Nawa Raj Sharma	Kopa-4	9847275488
28	Ramsaran Raidas	Secretary/NGO Federation	9847040758
29	Lachman Belbase	Mesdo Nepal	9857050970

30	Durga Singh Thapa	Secretary/Niglihawa VDC	9847040317
31	Bishnu Prasad Paudel	DDC	
32	Bom Bahadur Khanal	Municipality	
33	Minraj Belbase		
34	Suraj Sharma	Practical Action Nepal	
35	Min Bikram Malla	"	
36	Madan Thapaliya	"	

Table 2: List of District Workshop Participants in Bara District

SN	Name	Office/Designation	Contact phone
1	Keshab Bdr. Thapa	DDC/DEEU, Energy Officer	9841856219
2	Tap karki	Manaharwa -3 Badaharwa	9814228917
3	Khudus Miya	DFCC	9845162997
4	Bijay Kumar Chaudhary	DAO	9845128355
5	Akwal Miya	RRAFDC	9845035125
6	Shukh Praad Chaudhary	Civil Society	9845395207
7	Ramesh Prasad	Shah Agri Engineering	9845032939
8	Neuthu Shah	Municipality Bara	9855045224
9	Raj Kumar Shah	Check Nepal/District Coordinator	9845061915
10	Shyam Sundar Churasiya	District Forest Office	9845393273
11	Ram Pukar Mahato	Chatwa VDC Secretary	9807159650
12	Laxmi Shah	Bisram Pur VDC	9817279921
13	Ramananda Shah	Women and Children	9845430069
14	Nandalal Ram	NNDSWO	9814288662
15	Ram Prasad Chaudhary	Cooperative	9845193555
16	Amleshwor Mishra	District Healh Office	9855023639
17	Harinarayan Shah	RRAFDC	9845037609
18	Sandesh Singh	RRAFDC	9845313307
19	Pheku Prasad Chaudhary	CWSC	9807127453
20	Parwati Devi	Women Group	
21	Krishna Udash Khanal	Journalist /Kripa Danik	
22	Biraj Khanal	Journalist /Kripa Danik	
23	Renju Shah	Yekophone	9845034561

SN	Name	Office/Designation	Contact phone
24	Dawrika Prasad Gupta		
25	Naresh Kumar Rayabhar	Enumerator	9807180940
26	Begum Bahadur Kunwar	Enumerator	9841206194
27	Madan Tahapaliya	CRT/PAN	9804050842
28	Suraj Sharma	IAP Health Forum/Practical Action	9741014021

Table 3: List of District Workshop Participants – Siraha District

SN	Name	Offic/ Designation	
1	Ganga Prasad Yadav	District Forest Office	
2	Badri narayan Chaudhary	District Cooperative Fedration	
3	Dilip Kumar Lama	Fecofun	
4	Ramesh Adhikari	Secretary, Bishnupurkatti VDC	
5	Santosh Kuamr Bisunkhe	Dalit Janakalayan yuba Club	
6	Kiran Raya Danuwar	Nepal Watawaran tatha Krishi Bikash Kendra, Lahan	
7	Rajendra Prasad Chaudhary	REWSSP	
8	Pradip Singh	Reproductive health Network	
9	Jagannath Jha	Gramjoti Krishi Sahakari	
10	Umesh Nandan Chaudhary	Enumerator /REWSSPC	
11	Sandip Kumar Kantha	Programe Manager REWSSPC	
12	Madan Thapaliya	CRT/PAN	
13	Suraj Sharma	PAN	
14	Anil Kumar Chaudhary	REWSSPC	
15	Chandra Bhusan Chaudhary	Enumerator /REWSSPC	
16	Bishnu Dev Chaudhary	Agriculture Cooperative	
17	Rajesh Kumar Singh		
18	Akhilesh Kuamr	REWSSPC	

Table 4: List of Contacted Person

SN	Name of Contact Person	Organization & District	Contract No
1	Sandeep Kantha	REWSSPC-Siraha/Rautahat	9851120128
2	Akhilesh Kumar Karna	REWSSPC-Siraha/Rautahat	9803286648
3	Harinarayan Sah	RRAFDC, Kalaiya-Bara	98455037609
4	Umesh Kumar Gupta	CHECK Nepal-Birgunj	9845021428
5	Keshab Bdr. Thapa	DDC/DEEU-Bara	9841856219
6	Nandalal Ram	NNDSWO-Bara/Birgunj	9814288662
7	Santosh Panthi	DDC/DEEU-Kapilbastu	9841642142
8	Sakti Karki	DDC/DEEU	9847204099/ 076561071
9	Santosh Sharma	REDA-Butwal	9851112692
10	Manoj Thapa-	MESDO, Bangai, Kapilbastu	9857030837

SN	Name of Contact Person	Organization & District	Contract No
11	Saroj Khanal -President	MESDO, Bangai, Kapilbastu	9857030837
12	Madan Thapaliya	CRT/N	9804050842
13	Nawa Raj Dhakal	AEPC/ESAP	
14	Karuna Bajracharya	AEPC/ESAP	01-4427329
15	Rishi Ghimire	IDS	
16	Sheekanta Adhikari	IFP(LFP), Bhairahawa	
17	Sanukaji Maharjan	FOST	01-4361574