ENERGY INSIGHT

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People, Energy & Environment Development Association (PEEDA)
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From the Chairperson

The role of non-government organizations is indispensible for a country like Nepal. Initiatives taken by NGOs in all sectors including that in energy and environment have significantly contributed to the upliftment in living standard of rural people through just and right-based approach in promotion of energy systems.

PEEDA is an NGO dedicated to improve livelihoods of communities, particularly the poor, by collective utilization of RE resources, while ensuring due care for the environment. It mainly focuses on institutional development, promotion of cooperation to undertake projects, advocacy and targeted research. We believe that poverty will substantially be reduced through effective, socially responsible and environmentally sustainable RE development.

Since its establishment, PEEDA has been undertaking innovative initiatives esp. pertaining to hydropower development through initiation of PPHP concept and governance of two institutions – Hydro Lab P. Ltd. for hydraulic modeling and Hydro Consult Engg. Ltd. for engineering consultancy services. PEEDA is also undertaking developmental projects and carrying out research activities.

I am greatly delighted that PEEDA has been able to publish a publication that serves both promotion and knowledge sharing among wider stakeholders. I greatly hope that this publication would assist in increasing awareness on the sector. I would greatly like to acknowledge the efforts of the PEEDA management team in bringing out this annual publication. Lastly, I would also like to extend my sincere gratitude to the Executive Committee, members, development partners and all other stakeholders for their invaluable contributions to PEEDA.

Thank you!!!

Murali Prasad Sharma
Chairperson, PEEDA

From the Executive Director

RETs have long been considered to be the only savior to the energy deprived citizens of Nepal. Despite having humongous opportunities, we have failed miserably in tapping our resources. Yet, we have not lost hope and still, numerous projects and researches are being conducted to overcome the persisting energy crunch.

PEEDA has been conducting various energy and environment related activities and projects over the last 15 years. PEEDA has been exploring concepts and technologies that could impact lives both on shorter and longer terms. We are currently executing four projects and have been playing a significant role in the development of sustainable energy in Nepal.

After conducting numerous activities, we have taken this opportunity to disseminate information. It is also imperative to bring together other works on RE and environment so that a collaborative effort could be instigated. Hence, this yearly publication called “Energy Insight” has articles and research papers on various technologies as well as concept notes on different projects.

Being our first attempt at such an initiative, I do acknowledge that there might be plenty of shortcomings both with regards to the content or the concept as such. I sincerely do hope that your valuable comments, suggestions and timely advices would help us to put together a better publication in the years ahead.

I greatly appreciate the individual authors who voluntarily contributed by sharing their views and findings in this publication. Finally, I would also like to sincerely thank the Chairperson, the Executive Committee, my colleagues, partners and the publishers for their support in bringing out this publication.

Thank you!!!

Muhan Maskey
Executive Director, PEEDA

Table of Content

RENEWABLE ENERGY TECHNOLOGY FOR RURAL DEVELOPMENT

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Introduction

There are several organizations such as governmental, non-governmental, multilateral/bilateral, donor agencies, financing institutions, associations, manufacturing companies, installation companies and consulting firms involved in the development and dissemination of renewable energy technology (RET) in Nepal. Renewable energy technology is a synonym for new, renewable and non-conventional forms of energy i.e. technologies which use local energy resources (other than commercial fuels) and biomass fuel (firewood, agricultural residues and animal wastes) in traditional forms. The main sources of these alternatives are biomass, water, sun and air. These include biomass (especially biogas, improved cooking stove, bio-briquettes, gasifiers etc.), micro hydro, solar energy (both solar PV and solar thermal) and wind energy technology.

Development of Renewable Energy Technologies

The biomass fuel contributes an overwhelming share of the energy consumption in the rural areas. About 90% of the energy demand in the country is met by biomass of which about 78% come from fuel wood. Renewable energy contributes only about 1% of the total energy consumption in Nepal and about 56% of the people have access to electricity. This huge dependence on fuel wood has been a cause for depletion of forests and degradation of environment. Likewise, different types of improved cook stoves have been promoted in the country. Based on the study of biogas mapping in Nepal, technical potentiality of biogas is estimated at 1.2 million plants throughout the country. With more than 6,000 rivers and streams many with hydraulic heads and flow, Nepal is very rich in hydropower potential. Utilisation of solar energy began in the early seventies through the introduction of domestic solar water heaters. Solar photovoltaic systems (PVS), solar cookers and dryers are massively developed and disseminated all over the country nowadays. Wind is one of the less harnessed energy sources in Nepal. Various studies conducted in the past indicate that wind potential for power generation is favorable in some places such as Mustang and Palpa of the country. Hence, Nepal's potential for alternative energy is immense. As these are location specific, they need to be exploited/developed/promoted accordingly.

Biogas

Biogas is a mixture of different gases such as methane (50-65%), carbon dioxide (30-40%), hydrogen sulfide (less than 1%) and other gases such as nitrogen, hydrogen and carbon monoxide in traces. Biogas consists of water vapour, which needs to be removed through a device known as water drain. Biogas is flammable gas produced by microbes when organic materials are fermented in a certain range of temperature and moisture contents. It acidifies under airtight conditions. The main component of biogas is methane, which is represented as CH_4 symbolically. It is colourless, odourless and tasteless but due to the presence of other gases, it has slight smell of garlic or rotten eggs. The specific gravity of biogas is 0.86. A total of about 300,000 households biogas plants (fixed dome GGC 2047), about 200 institutional and about 60 community biogas plants have been installed in the country by 113 pre-qualified companies.

Improved Cook stove

Improved cooking stoves (ICSs) with efficiency of 18% to 28% have been developed in Nepal over some time. Research and development (R&D) have been carried out in these devices since the early eighties. As a result, different types of ICSs such as mud stove, metallic stove, institutional and rocket type stoves have been designed and developed. ICS consists of combustion chamber, baffle, pothole, flue exist hole, raised pothole, chimney pipe, grate, lug, soot cleaning hole, chimney hood, and primary and secondary holes.

A total of about 619,816 ICS have been installed in the country (July 2011) by pre-qualified companies. There are 32 pre-qualified companies for manufacturing and installation of metallic cook stoves.

Micro-hydro

Mini and micro-hydro technology have enormous potential to promote environmentally sound sustainable development in hilly region of Nepal. In the past, most of the turbines were installed solely for agro processing. However, these days, most of them are used for rural electrification.

Micro-hydro plant consists of civil and electro-mechanical components. Civil structure consists of intake, canal, desilting basin, forebay tank, support piers, anchor blocks and powerhouse. Similarly electrical components consist of generator, control panel, ballast heater, transmission distribution system, earthing, poles, stay sets, insulators and load limiting devices. Likewise, mechanical components of a micro-hydro scheme consists of penstock pipe, turbine, valve, drive system and expansion joints.

By the end of July 2011, 40 mini-hydro plants generating 14.95 MW, about 1,000 micro hydro generating 18.86 MW, 1,480 pico/peltric generating 3.18 MW and about 7,959 Improved Water Mills have been installed in the country. There are 78 companies prequalified for the installation of micro-hydro, and 61 consulting companies for the survey and design of micro-hydro ranging from 10 kW to 100 kW capacities. There are also 27 local partner organizations and kit manufacturers of Improved Water Mills.

Solar energy

Today, there are about 30 manufacturers of solar heaters in Nepal. The total installed capacity in the country is estimated at 10,000 sq meters of solar panels. Solar photovoltaic (PV) is not a new technology in Nepal. It is estimated that solar companies have installed more than 300,000 units of PV all over the country. Solar cookers and dryers were also developed and propagated some time back. The solar heater technology has not yet been proven appropriate/suitable for mountainous region. There are 43 companies pre-qualified for small solar home system, solar home systems, and institutional solar power systems including solar photovoltaic pumping systems.

Wind energy

Wind is still one of the unharnessed energy sources in Nepal. Its countrywide potential has not been assessed yet. Some studies have indicated that wind potential for power generation is favorable in Tansen of Palpa, Lomangthang of Mustang and Khumbu regions of Nepal. However, wind monitoring and mapping data are not available for many places.

Government Policies for RETs

The Government of Nepal has promulgated the Rural Energy Policy, 2006 to promote clean, reliable and appropriate energy sources as a means to reduce rural poverty and protect the environment. The policy aims to raise awareness on improved cook stoves, biogas as well as other biomass energy technologies such as briquettes, bio-fuel, biomass gasification, etc. to reduce indoor air pollution and fuel wood consumption. The policy also seeks to institutionalize the promotion of rural energy at the district level and mentions the provision of providing subsidies for promoting renewable energy technologies such as, micro-hydro, solar, biogas, briquette, bio-fuel and biomass gasification.

There are certain criteria to be fulfilled by companies for the subsidy and its delivery mechanism. This will be applicable to all household biogas plants, urban households biogas plants, institutional biogas plants, community biogas plants, commercial biogas plants and biogas production from solid wastes. Likewise, for biomass energy, the criteria to be fulfilled apply for metallic improved cook stove, institutional metallic cook stove, metallic rocket stove and metallic gasifiers. The subsidy will be provided to the household biogas plants from 2 to 8 cubic meter capacity only constructed by the qualified companies as per the technical standard prescribed by the Centre. The subsidies for the installation of RETs depends on the size of the plant as well as the place or location of the installation.

Under rural electrification, subsidy is provided for solar home systems, small solar home systems and institutional solar plants for pumping water. Likewise, subsidy is also provided for pico, IWM and micro hydro feasibility studies and their installations.

The following Table 1 shows the subsidy provided for micro-hydro feasibility studies depending on the size and remoteness of the places in the country.
Table 1: Subsidy for micro hydro feasibility study.

Locations	Financial support for detailed feasibility study of micro hydro (All amounts in NRs.)				
	Up to 5 kW	5 - 10 kW	10 – 50 kW	50 –100 kW	100- 1000kW
VDCs in A Category	50,000	90,000	225, 000	295,000	12,00,000
VDCs in B Category	40,000	80,000	200,000	275,000	11,00,000
VDCs in C Category	30,000	70,000	175,000	250,000	10,00, 000

Scaling Up and Challenges of the Sector

For up-scaling the renewable energy sector, there should be continuous financial support for both loan and subsidy. The subsidy policy and its delivery mechanism need to be improved based on its development as well as requirement. There should also be improved payment schedule to the companies with no procedural hurdles and there should be trained human resources in the company especially for survey and design of bigger schemes and grid connection. Here are given some way forwards for the sector.

- Integration of RETs with other development activities;
- Scale up with climate funding;
- Capacity building of private sector;
- Promote innovative financing mechanism;
- A successful south - south co-operation;

There are several challenges in renewable energy sectors. These include:

- Strong ownership of quality concept in the sector;
- Safeguarding the investment of the communities by increasing the confidence of the technology;
- Sustainability of the sector;
- Cost reduction without deteriorating the quality of the plant;
- Fulfillment of the target without subsidy and the successful operation of the system thereafter.

Conclusions and Recommendations

Biogas, micro-hydro and solar are the main sources of renewable energy technologies in Nepal. There are several organizations involved in the development and dissemination of the renewable energy technologies in the country. There are some opportunities for private sector in technology transfer as well as employment generation.

It is recommended that there should be good organizational development for the success of the programme. Likewise, there should be more focus on the enterprise development through end use applications especially for income generating activities for which the capacity of the private sector needs to be enhanced.

BIO-FUEL CONSOLIDATION PROJECT: A CASE OF OKHALDHUNGA, NEPAL

Shalabh Poudyal
Project Officer, PEEDA

Background

PEEDA, in partnership with Group of Helping Hands (SAHAS) Nepal, has been implementing Bio-fuel Consolidation Project in Okhaldhunga district from February 2008. The project aims to enable poor villagers to develop alternative ways of creating a livelihood or additional income by cultivating and marketing bio-fuels from inedible oil bearing seeds, particularly from the Jatropha plant. Seeds are harvested from existing Jatropha plants and the community is being encouraged to plant high yielding varieties of Jatropha curcas on unused and waste land. Jatropha oil can be used directly in cooking stoves or wick lamps which reduces consumption of fire wood or as fossil fuel replacement, which will create an alternative to fuel imports. Various end use products such as soap, briquette, compost, etc. are also envisioned to be produced from the Jatropha oil or its by products. The final component of the project is to create a local market and an infrastructure for small scale business for the sector. The project has been spread over three phases. First phase started in 2008 and continued till the end of 2009, second phase started in 2010 and continued till 2012 , and the third phase started from 2013 and will continue till 2015.

Fig.1: Jatropha planted along the side of road

Key Achievements of Phase I & Phase II

The first phase of the project implementation started in 2008 when cultivation of Jatropha Curcas was considered as an alternate solution for many of the world's energy supply problems. During this early time of Jatropha

Fig. 2: Jatropha seeds and kernel

development, it was thought Jatropha can be grown under unfavorable conditions, resisting long droughts and withstanding poor soils. However, recent years of intensive research brought up a more realistic picture. The "energy wonder plant" is now being approached more scientifically. The results of many investigations around the globe showed that Jatropha has a good potential to become a major bio-fuel resource, which can replace diesel fuel to a large extent especially if it is used as a blend. However, these opportunities are partly outweighed by number of challenges, which still have to be considered more closely. The knowledge about oil production from Jatropha has enormously increased, but there are still open questions, uncertainties and bottlenecks which have to be addressed in the future. Based on the project experiences, there have been some key achievements and findings, some of which are listed below:

- Jatropha has been successfully introduced as a possible future energy crop for rural regions to farmers and concerned stakeholders in the selected 7 VDCs in Okhaldhunga district.
- A research activity of the project (satellite based GIS Jatropha cultivation feasibility map of Okhaldhunga) showed that there is abundance of feasible land for Jatropha cultivation in the Project's region even for small plantations.
- Numerous trainings for farmers, community groups and expeller user group have been carried out. Farmer groups were trained in agricultural techniques such as plantation, pruning, seed harvesting, composting, intercropping, etc. This has enabled farmers to establish Jatropha nurseries on their own. On the other hand, the expeller user group was trained in technical and management skills.

- The Project has successfully established a processing unit in Manebanyhang VDC for expelling oil from the Jatropha seeds "Sundhara Oil Expeller" is used to expel oil from the dried seeds, afterwhich the oil will be cleaned and filtered and, stored in containers.
- Trials with Jatropha oil on the generator of the Okhaldhunga Community Hospital (OCH) was conducted successfully which showed the possibility of Jatropha oil replacing the conventional diesel fuel.
- Several seed collection centres have been established, which are buying seeds from within the project area as well as from outside.
- In Okhaldhunga, the project has already mobilized most of the relevant initiatives, organizations, governmental institutions, NGOs and INGOs as well as the private sector for the development of Jatropha based biofuel sector.
- In the previous project stages, Jatropha cultivation and livelihood development on local level, and advocacy and lobbying at the national level have been the major themes of the Project. In 2012, the project intensified R&D activities in the field of "technologies and marketing for the oil and its side products". Bio-fuel stoves, lamps, soaps and compost production as well as uses in generators have been a part of the researches conducted. Field trials, tests and trainings have helped to find and demonstrate the most adapted technologies and build abase for further investigations during the next project phase, mainly using locally available resources and capacities.

Fig. 3: Jatropha plantation in barren/steep land

Fig. 4: Running a generator at OCH using Jatropha oil

Jatropha Seeds Expelling Mill: A Successful Intervention

Fig. 5: Mr. Hira Kaji operating the expeller machine

Jatropha Seeds Expelling Mill which was established in the second phase of the project at Maneybhanjyang is a real success story. Farmers from 7 VDCs of Okhaldhunga visit the mill and sometimes from the neighbouring Khotang district as well. It has been expellingoil from Jatropha seeds as well as, mustard. As Jatropha seeds are seasonal, its usage has been extended to other oil bearing seeds as well. Furthermore due to potentiality of rendering added services within the premises as well as generating futher income, the mill operating committee has added other equipment for grinding and hulling through the mobilization of internal and other external resources.Till the mid of June, 2014, the mill has made a profit of Rs. 58,000. The operator of the mill Mr. Hira Kaji Rana Magar makes a steady income of around five thousand rupees per month which has helped him support his family better.

PEEDA's Activities during Phase III

The third phase of the project started from January 2013 and will be continued for three years. The main objective of bio-fuel phase III is to enable marginalized and poor rural communities in the 7 VDCs to have the capacity to establish a local supply chain for Jatropha bio-fuel based products and services to sustain at district level without competing with food-crop production and climate change mitigation efforts. Formation of sustainable local enterprises from the products derived from Jatropha oil and its by-products is of highest priority during this phase.

Ten Jatropha nurseries have already been established by farmers in different project VDCs that are being monitored and supervised by the local partner SAHAS Nepal. PEEDA has taken the onus of conducting research work on Jatropha soap, seed cake and briquettes so that the community in Okhaldhunga would be able start local enterprises out of them. Chemical testings of the aforementioned products have been done at Nepal Academy of Science and Technology (NAST), Centre for Energy & Environment Nepal (CEEN), Nepal Bureau of Standards & Metrology (NBSM) and Cemat Water Lab Pvt. Ltd.

A brief synopsis of the activities is listed below:

- On February, 2014, Jatropha seeds collected from 3 different VDCs were expelled in Maneybhanjyang. In average, oil content from the seeds was found to be 20%. The lower yield is due to the fact that the seeds were improperly stored for more than three months.
- In the chemical test conducted at NAST, Saponification Value of the Jatropha oil expelled at Okhaldhunga was found to be 156.4 which has paved way for high quality production of soaps to be sold by the community. Furthermore, the oil content of the Jatropha seed cake had also been measured. In average, it was found that the oil content in three samples of the seed cake from Thakle, Madhavpur and Toksel VDCs of Okhaldhunga was 8.5%.
- In the chemical test of locally manufactured Jatropha soap conducted at NBSM, parameters such as pH, moisture, total fatty matter, free caustic alkali and matter insoluble in alcohol have been measured. This is to ensure that the locally made soap is able to acquire the required quality standards from NBSM. A training on soap making was provided to the community at Okhaldhunga during June 2014 based on the re search findings as obtained.
- CEEN has been bestowed with the responsibility of manufacturing briquettes and pellets from the Jatropha seed cake. In addition to this, they will also be conducting physical and chemical tests such as calorific value, smoke index, density, moisture content, ash content, volatile matter and fixed carbon. This shall determine the overall feasibility of briquette production from Jatropha seed cake.

As PEEDA aims to create enterprises owned by the community and farmers from the end use products of Jatropha oil, market analysis is done for all feasible products. In addition to this, plantation is continued to be done in un-used and barren lands in Okhaldhunga so as to produce Jatropha seeds in abundant amount. The project has been able to generate tremendous interest among villagers that is evident from the extensive community participation. After the project completes in 2015, PEEDA envisions to create sustainable enterprises for the community with more than half managed by rural women, lobbying for the formulation of a concrete bio-fuel policy and replication of the project for enhanced bio-fuel production that can serve as a replacement for conventional diesel.

Lessons Learnt

The major lesson leant through the project for PEEDA is about ensuring sustainability and exit mechanisms. Optimal care and management for Jatropha for high yield is imperative but the cultivation of it in wasted and barren land without proper management will not be able to achieve over- all development goals. Since the project has longer gestation period, keeping ammunities motivated in the project is of fundamental importance if the project seeks to achieve desired results. Trainings and capacity building programs are imperative in order to keep the farmers interested and motivated for Jatropha cultivation. The problem of Jatropho based Micro-enterprise development helps to enhance the economic condition of the community. The project must opt for extensive cultivation in the waste and barren land to ensure ample seed supply and also safeguarding against food security issues. M&E visits have to be expedited more often in order to identify the field level issues that the farmers and the local partner are facing.

QUALITATIVE AND QUANTITATIVE ANALYSIS OF JATROPHA SEEDS PRODUCED IN NEPAL

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Introduction

Energy is an essential input for economic growth, social development and it contributes significantly to the growth rate of civilizations. Over the period of centuries, fossil fuel is the major energy source. Currently due to gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions, there is an urgent need to develop alternative energy resources, such as biodiesel fuel. Vegetable oil is a promising alternative because it has several advantages-it is renewable, environ-friendly and can be produced easily in rural areas, where there is an acute need for modern forms of energy. Therefore, in recent years several researches have been done to use vegetable oils as fuel in engines as biodiesel (Pramanik, 2003; Bozbas, 2005). Furthermore, vegetable oil-based products hold great potential for stimulating rural economic development because farmers would benefit from increased demand for vegetable oils. Various vegetable oils, including palm oil, soybean oil, sunflower oil, rapeseed oil, and canola oil have been used to produce biodiesel fuel and lubricants (Demirbas, 2003). Various researchers have shown that the Jatropha oil can become a major source of renewable energy and also become the boon for the development of developing country.

The promotion and development activities of Jatropha curcas as bio-fuel are done by various governments, non-government and private organization. Despite all positive aspects and activities done so far done in bio-fuel subsector in Nepal, there is a gap of identification in high yielding seeds for bio-fuel production. So in this context, there is urgent need of identifying the high yield Jatropha seed for plantation as the development activities in biodiesel sector has just started.

Research Methodology

Jatropha seeds required for the study were collected from fifteen different regions of Nepal. The collected Jatropha samples were expelled for Jatropha oil. Both mechanical extraction and solvent extraction methods were used to extract the oil from the Jatropha seeds. The acid value was also determined. Oil content, free fatty acid (FFA) and other physio-chemical properties of each sample were determined.

Financial Analysis of Commercial Plantation of Jatropha

Some of the assumptions and basic parameters adopted during the analysis are as follows:

- Plant Spacing: 2 m X 2 m.
- Plant Density: 2500 plants /ha.
- Yield Rate: 5 kg/tree.
- Survival Rate: 80 %.
- Jatropha seeds collection loss: 20%.
- Oil content: 30 %.
- Cultivating Jatropha Plant in at least 5 % of the uncultivated area and 5 % buffer area.

In this case, the potential area for Jatropha cultivation comes to about 70,740 ha throughout the country. Around 17,68,50,000 number of plants can be planted in 70,740 ha of uncultivated and buffer area. The total seeds production will be 8,84,250 MT. The total oil production will be 265,275 KL, which is about 40% of the High Speed Diesel (HSD) consumption in 2067/068 in Nepal. So, by planting only in 5% of the uncultivated area and 5% buffer area, huge amount of money can be saved and employment opportunities could also be created within the country. This saved money can be invested in other productive sectors such as hydropower development, road expansion etc. If Jatropha is cultivated in 10% of the uncultivated area and 20% of the buffer area, the HSD consumption in Nepal can be totally substituted by Jatropha oil.

Findings

Highest oil content of 51.7% has been found in the Jatropha seeds of Syntar, Makawanpur at an elevation of 600m which was plucked along the side of cultivated land and used as hedge. This was due to proper use of fertilizer, cutting and climatic condition. Likewise, lowest oil content of 25.2% was found in the seeds collected from Birbas, Gulmi where the Jatropha plant was being used as a hedge along the sides of the road. Low oil content could be attributed to lack of fertilizer, no cutting and adverse climatic condition. Overall, the average oil content was found to be 38%.

There was no significant relationship derived between oil content and elevation from sea level up to 1200 m but thereafter, oil content in Jatropha seed decreased with the increase in elevation. The oil content and acid value were found to be directly related with the storage duration. The oil content decreased with the increase in storage duration and the acid value increased with the increase in storage duration. The oil content of the Jatropha seeds of Syntar decreased from 51.7% to 35.5% and acid value increased from 9.51 to 15.36 mgKOH/g when it was stored for a period of one year and expelled.

In addition to this, the research also investigated the effect of storage period of Jatropha seeds on the Free Fatty Acid (FFA) content of the extracted oil. FFA content (%) which is one of the critical parameters in biodiesel production also increased from 9.51% to 18.1% for the sample of Syntar that was stored for one year. Furthermore, seed size and weight were two important characteristics for improving seedling productivity and reducing nursery cost through selection of quality seeds, apart from selecting and delineating provenances.

Recommendations

Commercial farming should be promoted which will not only give higher yield from seeds but also lower the cost of production. It will make Jatropha oil competitive among the consumers. Likewise, detailed study on plantation, seed collection technology and storage of Jatropha seeds have to be done. Lastly, government should implement strong policy for commercial use of Jatropha--oil.

DEVELOPING A CRITERIA CATALOGUE AND SATELLITE ATLAS FOR THE DETERMINATION OF OPTIMIZED LOCATIONS FOR JATROPHA CULTIVATION IN NEPAL'S HILLY REGIONS

Compiled & Edited By: Gaurav Dahal

Former Project Manager- Biofuel PEEDA

Introduction

Limited depositions of fossil fuels which has confined spatial distribution, and growing carbon dioxide emissions have contributed to global warming leading to recent climate change. This has dragged focus of the world to replace fossil fuels by renewable biofuels. Different feedstock have been used to produce liquid biofuels. In this context Jatropha curcas is a poisonous plant, easy to establish and do not compete with food cycle.

Jatropha curcas (L.) is a perennial plant that is classified under the family Euphorbiaceae. It is locally known as Sajivan. Jatropha curcas is sensitive to frost, and does not flourish above the frost line. In Nepal, the potential altitudinal limit for it has been delineated as between 100 and 1600m above sea level. And to secure that it does not compete with food cycle, there is practice to cultivate in marginal lands, waste lands, and cultivated or uncultivable lands.

Since last decade, this plant has received much attention for being a potential source of vegetable oil that is basically used for bio-diesel production which has been considered as alternative to fossil diesel. Besides these, practioners of Jatropha curcas cultivation view that the soil type also affects the production of seeds. Hence, these things will basically be considered in identifying the potential area of Jatropha curcas in study area.

Objectives/Methodology/Outcome

The objective of this study is to identify the Jatropha curcas potential cultivation area in Okhaldhunga district, Nepal following defined conditions.

Methodology

The research work mainly focused on following issues:

- Contacting/visiting all organizations and institutions in the Kathmandu valley relevant to the research subject (including governmental organizations like AEPC and NAST, research institutions, the private sector involved in Jatropha plantation, NGOs and INGOs)
- Undertaking shorter field visits, e.g. the Jatropha Research Center of Everest Biodiesel Company in Chumlingtar had been visited and a one-week pre-study field trip to the project region Okhaldhunga was undertaken.
- The main field visit to Okhaldhunga including the data/sample collection and survey was out from the end of November to December 2011 (a pre-field study was undertaken in June 2011).
- The preparation for the study included the purchase of GPS equipment, computer programmes (GIS) and mobile testing equipment, e.g. for soil testing the soil-testing lab ATC Pulchowk, Lalitpur had been selected. The equipment for taking the soil samples had been designed and locally manufactured with the help of metal workshops in Okhaldhunga.

Study Area

This study has identified the Jatropha cultivation potential area in the Okhaldhunga district. The district is located at Eastern part of Nepal and extend between 86^0 12' 17" to 86^0 41' 22"E and 270 8' 17" to 27^0 31' 32"N. On the basis of altitudinal range of the district, most of the areas have potential for Jatropha cultivation. Besides this, as the district belongs to hilly region of Nepal, there is high potential of finding marginal and waste lands that has been preferred for Jatropha cultivation and unsuitable for agricultural crops.

The district is connected with the Siddhicharan highway and local agro-roads have been extending to most VDCs, therefore collection and transport of Jatropha seeds or extracted oil could be relatively easy and economical viable (except during the monsoon season). These facts could create the opportunity of income generation of low for vulnerable and marginal groups with no employment or for underemployed community members. The district is resided by approximately 400,000 indigenous people (mainly Rai, Gurung and Sherpa communities) and most of them are living under the poverty line.

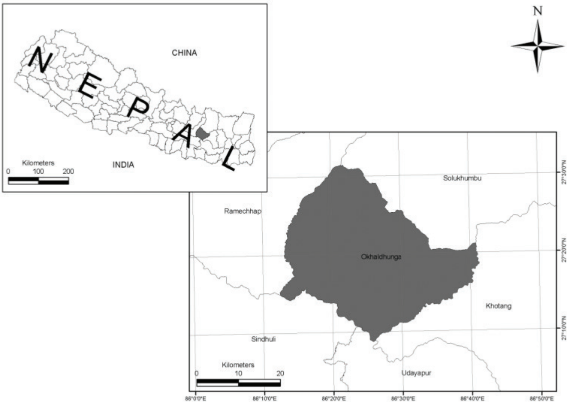


Fig 1: Study Area Okhaldhunga District

Data Collection

The required data that are used for designing the spatial maps had been requested from GON ministries as well as private sources. The following table illustrates the use of the different data in the right side column.

Table 1: Required Data and their Uses

S.N	Data	For
1	Elevation data	To find area under defined altitude
2	Slope	To find slope of study area
3	Aspect	To find suitable aspects in study area
4	Precipitation	To find precipitation regime in study area
5	Land cover	To find suitable land cover area
6	District Boundary	To delineate boundary
7	Hydrological (River)	To find locations of rivers

Methodology for Designing the Map

Methodological details are displayed in the chart 1 showed below . The study began with collection of data from different sources and then errors were fixed. A Triangulated Irregular Network (TIN) was created from contours. From the created TIN-Slope map, aspect map the Digital Elevation Model (DEM) had been prepared. This was done in a raster format. The land cover map and precipitation map were converted to raster maps too. All of them have a cell size of 20m x 20m. All the maps are then subjected to reclassification of the raster with the required weight for different types of fields. The detailed reclassification values and number of classes are listed in Table below. The numbers in the value field column indicate the comparative suitability of the class i.e. 0 means not suitable and as higher the value the better the class.

Aspect	Value
Flat	4
North	4
Northeast	3
Northwest	3
South	0
Southeast	1
Southwest	1
East	2
West	2

Precipitation	Value
Below 1200	2
1200 to 1400	3
1400 to 1600	4
1600 to 1800	4
1800 to 2000	4
Above 2000	3

Altitude	Value
Below 300	2
300 to 700	4
700 to 1000	4
1000 to 1300	3
1400 to 1800	1

Land use	Value
Cultivation	0
Forest	0
Shrub	3
Grass	2
Landslide	4
Sand/gravel	0
Fan	4

Above 1800	0
Slope	Value
0 - 10	4
10 -20	3
20 - 30	2
30 - 40	1
Above 40	0

Note: the numbers in value field has been developed with expert consultation and guidance.

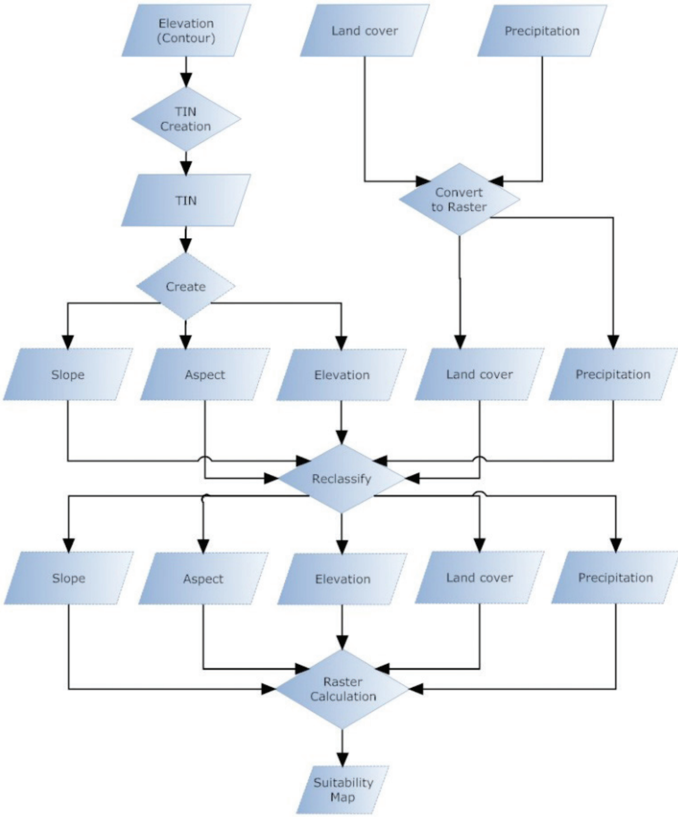


Chart 1: Flow Chart of Study Method

Results from the Map Design

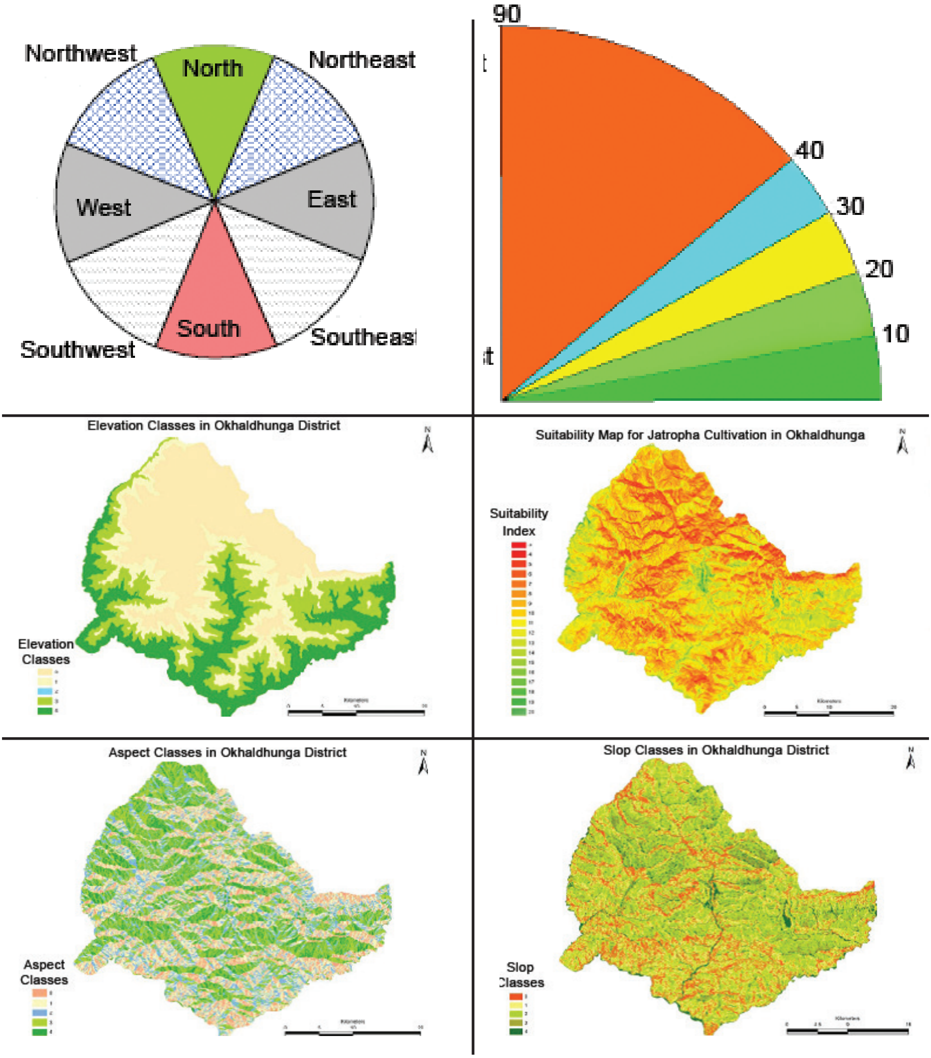
This study came up with a suitability map after the analysis and inclusion of all the maps. It has 18 classes with values from 3 to 20. The higher the suitability index value, the better is the location for Jatropha cultivation. The following Table summarizes the suitability value and their corresponding coverage in square meters and hectares.

This study has concluded that in total there are 18 classes of suitability index. And the most suitable index value covers about 122.36 Hectares of area. The map shows that Okhaldhunga district has a rather good potential for Jatropha cultivation locations, which could be used for employment generation and economic uplift of the local people.

Value	Area (in m²)	Area (in Ha)
3	110400	11.04
4	9774800	977.48
5	32799600	3279.96
6	57634800	5763.48
7	90229200	9022.92
8	132056800	13205.68
9	171000800	17100.08
10	168868400	16886.84
11	142098000	14209.8
12	112073600	11207.36
13	75099600	7509.96
14	41442000	4144.2
15	20224000	2022.4
16	12745200	1274.52
17	4217600	421.76
18	2305600	230.56
19	2197600	219.76
20	1223600	122.36
Total	1076101600	107610.16

The following figures display the Suitability Map for Cultivation in Okhaldhunga as well the under-laying maps for the relevant criteria. It can be integrated in the common and freely available Google-Earth programme and all the known facilities and tools of this programme can be used too. This makes the map easy and comfortable to display and present at amultiple occasions, e.g. from the farmer and community level upto international research, conference and policy level. It can help both, to create awareness among the community members as well as be used as a decision making tool for policy and management. The map has been designed for a relative simple replication also in other districts of Nepal.

After reclassification of the raster data, the raster calculation was performed to find the most suitable sites based on above criteria. The aspect and slope classes are as:



Figures: Jatropha Suitability Map and under-laying Criteria Maps

One important criteria was, so far, not considered in the map design described above: the soil conditions. Therefore an extensive soil sampling field tour has been carried out in the project region by the researcher. The 30 collected samples had been brought to Kathmandu and tested in the ATC Lab. The results of the analysis are described herewith;

According to the result of the soil analysis from various locations, the nutrients status has been found different in the various locations. The soil pH has been found between 5.30 to 8.30 which is acceptable for Jatropha plant. Under more acidic or alkaline condition, the plant growth may be limited. Similarly, determination of the soil texture has been found from sandy loam to silt loam, which is most suitable for Jatropha planting except the sample No. 21, which is clay loam. Actually, the most suitable soils for Jatropha plant are loam, sandy clay loam and silt loam. Among the soil nutrient determination results, nitrogen, phosphorus, potash and organic matter content are found to be low to medium.

The potassium status found is low to high. No doubt, Jatropha might survive at low soil nutrient contents, but in that case, growth and production will be limited.

Soil Sampling in the Target Area: Okhaldhunga District

According to the soil analysis result, nutrient content of those soils usually are not so optimum. Higher nutrient levels help to increase productivity. More organic matter content is also favorable for Jatropha growth especially in coarse soil. In brief, the following practices may be recommended to improve soil fertility and increase productivity in the study area.

- Time to time, Check soil fertility by soil analysis to determine the soil status from.
- Farmers' field trial should be conducted.
- Aware and education of the farmers for judicious use of fertilizers.
- Train the farmers about quality compost / FYM preparation from lo cally available organic waste and its management.
- Increase Integrated Plant Nutrient System (IPNS).

- Maintain the soil pH range towards neutral (6-7.5 pH) because all the essential nutrient elements are inavailable form in this range. In acidic soil, iron, manganese, zinc, copper and baron, these elements become highly soluble, which may cause toxic effect.
- Using more organic matter, the required macro and micro nutrients will be supplied.

A CASE STUDY ON BIO-FUEL STOVE TECHNOLOGY: JATROPHA AS A BIO-FUEL

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Introduction

In Nepal, the most well-known liquid cooking fuel is kerosene, composed of hydrocarbon molecules. Plant oils are tri-glycerol of fatty acids, with distinct chemical and physical properties, and have different combustion characteristics than those of kerosene. The viscosity of plant oils can be up to 30 times higher than that of kerosene. The flash point of plant oils ranges from 180 to 300°C, compared to 80°C for kerosene. This means, the operating risks of kerosene are much higher due to its easy inflammation. Tests found that the hydrocarbon emissions of the Protos plant oil cooker were 370 times lower than that of an open fire with comparable output.

The world is approaching an era where energy is increasingly essential. Unfortunately, few developing countries have been able to adjust their energy consumption and production in time. This inability to adapt is responsible for stagnation of certain forms of development, notably that of agriculture. The search for new and renewable energy sources becomes more and more urgent. Using vegetable oils as fuel substitutes is an interesting departure, in particular, if this consists in non-food oil crops. Jatropha curcas is one of them. Research has been done on this plant for over 40 years, particularly during the last world war. But it was abandoned at that time. Perhaps the moment has come to establish a small research program for this plant.

Methodology

The methodology of this study was developed by rigorous literature review. In the literature review part, study undertaken by various organizations and individual experts on Jatropha, Jatropha oil, appropriate technology development, bio fuel appliance and manufacturing process were reviewed. Being a research and technology development study, its methodology is based on outcome of design methods rather than usual studio designed method. The study process involved development of an appropriate design methodology supported by utilizing multiple methods like intervention trials and laboratory scale formulations. These methods were integrated with possible solution which was provided through modification and manufacturing of a product. The study regarding technologies for end use of Jatropha oil consists of formulations and investigation techniques to find out low technology suitability.

The data collection to develop technology and review the existing process and technology was done through secondary sources, especially on electronic communication and various literatures. But, the data to support recommendation of technology is obtained from primary sources i.e. test results and observations. The study was performed for the modifications of stove for the compatibility with pure Jatropha oil only. And the modification of kerosene- wick stove taken for the purpose of study was modified by the use of simple mechanical devices.

Technology

The cooking stove in general is classified into two main categories

- Vapor jet burner
- Wick burners

Due to its high viscosity, Jatropha oil has difficulty in cooking. Also, presence of other component forming coke and higher ignition temperature of Jatropha oil compared to petroleum make it difficult to ignite the fuel. Designs of stoves using the Jatropha seed are based on three different methods. The first uses the solid Jatropha seed kernels as fuel (the TLUD, UB 16 etc.). The second method uses pure Jatropha oil in modified kerosene stoves with a wick. The third method utilizes Jatropha oil, vaporized and sprayed under pressure into a specially designed stove, like the Protos stove developed by the German concern Bosch-Siemens. The main challenge of using Jatropha oil in cooking stoves is its high viscosity, which often leads to clogging of fuel pipe or burner nozzle. Although it is documented that Jatropha stoves have very low emission levels compared to wood stoves, it is not known yet if the smoke of Jatropha fuel is harmful because of its toxic compositions. Designs of stoves using Jatropha are based on three different methods

1. In first method, solid Jatropha seeds, kernels can be used.
2. In second method, Jatropha oil can be used in wick stove instead of kerosene.
3. In third method, in pressure stove Jatropha oil can be used as stove fuel.

Firstly UB16 has used Jatropha woody part, kernels and seed as fuel followed by Anderson's TLUD stove. Currently, the JI-KO is a successful leading stove for seed and kernels.

Results & Discussion

The modification of the existing kerosene wick stove was done for compatibility with Jatropha oil. The bio fuel consumption for a given wick and a given setting was about the same as for kerosene. The brightness/ color the flame for a given wick and a given setting was about the same as for kerosene.

The problem with adapting a kerosene stove to plant oils is due to varying viscosity than in terms of purity of the oil. Jatropha oil is too thick at room temperature to travel through wick, and it was difficult for the oil to cross 5 cm, rather than the 10 to 15 cm required to efficient burning. Once the problem was pointed out, the modification was made with wick length and with wick holder. As the wicks are not able to maintain oil supply in the same way, the oil burns at the upper end of the wick. Consequently the wicks catch fire and burn and the flame extinguish after a short time of burning.

The prototype wick stove is still in their nascent stage, even the feedback from some of the initial community acceptance done, confirmed from literature review, urges the demonstration is rather positive. It can be assumed for slow cooking purposes (preparing fodder for animal and traditional food i.e. Dhindo, Dal-Bhat, etc.) will be fulfilled by this stove. Before bringing this type of stove into use or disseminating it in any community for use, an emission test must be carried out (preferably following the UNFCC stove protocol).

If a public acceptance survey is positive and the emission tests are acceptable, the setting up of a small manufacturing unit might be considered. Since pure Jatropha oil has high viscosity and ignition temperature, it is difficult to use in normal kerosene stove. The vapor jet burner stove (Pressure Stove) for pure oil is still in development phase. Wick-burner kerosene stove can be used for Jatropha oil with modifications on oil transportation length and capillary. This does not produce any bad odor and also soot emissions are less than biomass stove which can be done by adjusting fuel to air ratio.

Conclusion

As Jatropha oil possesses various potential uses, it is regarded as the best option compared to petroleum oil. In case of Nepal, where 80% of energy need is fulfilled by biomass i.e. fuel wood, Jatropha plant can be a major source of biomass energy. Pure Jatropha oil can be used as a renewable source in the stoves to meet the required energy demand.

Besides the use of Jatropha seed for fuel, Jatropha possesses several potential uses. It can grow in harsh soil conditions and can be planted on bare and eroded land which reduces the potential risk of erosions. Likewise, the end products of Jatropha plant such as oil, residual biomass, seed kernels have other likely uses. Pure Jatropha oil can be used in the manufacture of commercial high value medicinal soap as Jatropha shows great anti-microbial property. The residual biomass remained after pressing of seed for oil obtained as seed cake can be used as direct compost in the field. Along with this, the seed cake can be used in vermin composting.

Although Jatropha contains phorbol ester as a toxic component, it can be used as compost. The calcium activates of both innate and adaptive immunity which is basically important in coelomocytes. The phorbol ester present in the seed cake of Jatropha can attenuate the increasing requirements of calcium ions in the body of earthworms. Similarly, the remaining biomass can be used as a source for briquetting. The dried biomass of Jatropha, along with seed kernels and seed cake when pressed with binding material can be used as briquette. Thus, Jatropha plant can be designated as a source for multi-purpose uses.

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Further R&D, optimization and prototype development of Jatropha based sustainable cooking technology for rural Nepal by enabling environment for technology dissemination and commercial development.

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Abstract

In Nepal, traditional biomass energy source supplies more than 87 per cent of energy needs. Two-thirds of total energy consumption of any kind is done by cooking and more than 75 per cent households use cook stoves fuelled by firewood. Especially, in rural areas, women and children are affected by the smoke and emissions from the traditional stoves making them vulnerable to different respiratory diseases and eye infections, and in some cases leading to premature deaths as well. If we are able to replace the cooking methodology with sustainable bio-fuel, it will help improve the lives of a large number of women who are in the frontline of smoke assault as well as reduce carbon emissions.

The NORAD supported Renewable Nepal program has supported this research project to develop an efficient Jatropha based cooking stove technology suitable for rural Nepal. The research project aims to strengthen and support the capacity of existing designs with locally available resources. The concepts for preliminary design and pre-modifications were drawn on the basis of the studies conducted on existing prototypes of bio fuel stoves. After a series of simulated tests and experiments, final prototype stoves using vapor jet technology and wick burners were developed.

This paper focuses on the methodologies that were adapted during the project period, modifications done on the existing prototypes, its subsequent results and the way forward.

Introduction

For rural communities in Nepal, wood is still the main energy source for cooking. They are dependent on firewood, which is time consuming to collect and are depleting at an alarming rate or expensive oil imports which are beyond their means. Steadily rising firewood consumption for cooking purposes results in deforestation of large forest areas which creates severe ecological, economical and sociological problems. Moreover, the emissions from open fires are extremely harmful to users. Therefore, utilization of locally available alternative cooking energies needs to be identified and promoted.

Depending upon economy level, people started replacing traditional kerosene stove by other commercial sources of energy like LPG gases, solar energy etc. while people with poor economic background are still bound to use the same even though they are forced to suffer the consequences of Indoor Air Pollution. The development and commercialization of the existing Jatropha based stove will not only save women from drudgery of collecting firewood and reduction in indoor air pollution but also make usages of locally available bio energy resources. To replace kerosene and diesel, Jatropha plants can be the best alternative. Jatropha plants also known as physic nut has seed which contains up to 40% oil in them. The seed can be crushed and processed to extract oil from them which can be used as energy source. Hilly regions of Nepal have proper tropical climate for the production of such plants. The Jatropha plants (sajivan) are inedible and their uses are limited just to make barriers, fencing in the rural areas. As a replacement of the conventional energy source, bio-fuel can be used. Local plant oils can be used as a substitute for kerosene oil and fuel wood. This research focused on the use of Jatropha oil as an alternative for kerosene in stoves.

Since 2007, PEEDA is working on Biofuel program in Okhaldunga, Nepal. The developmental goal of PEEDA's intervention is to see households within the target area be able to generate additional income through the cultivation of inedible oil bearing seeds. The seeds will be a sustainable energy resource and income, and thereby reduce their level of poverty. Additional goals are for the Okhaldhunga Community Hospital to reduce their operating costs and reliance on external diesel imports and for the overall environment of the target area to be improved. PEEDA also focuses on R&D activities in order to assess how to utilize the by-products of the oil production process. Depending on the results, the communities will be advised on how to use the by-products to open up further revenue streams. PEEDA already has a supporting mechanism for oil production with an expeller plant managed by the community in place. Further, the mechanism for engaging participatory community involvement with the new technological solution is in place.

Technology Development

Centre for Excellence in Production and Transportation of Electricity (CEPTE) in Kathmandu University carried out the research to study the atomization characteristics of the Jatropha oil in kerosene stoves. The study of the hybrid stove (Plant Oil stove) was done. The different composition of Jatropha and kerosene have been studied and tested in the local kerosene stoves. The kerosene was used at 5%, 15%, and 30%, with the crude Jatropha oil. Among all these, the 30% mix of kerosene burns without any complications. The test of the stove with trans-esterified Jatropha oil was also done. With the result of the tests and literature review, the new stove was designed and fabricated. Some modifications were also made in the stove burner.

As fuel was viscous, the pressure applied by normal pump system was not sufficient. Further R&D work in testing the atomization pressure of the fuel and apply pressure by other method like mini-hand pump needs to be studied further. This will help in making the technology more robust by finding the exact pressure needed to atomize the fuel thereby changing the pressure application method/design. Similarly, the problem of oil clogging in the burner after a period of time is another major problem in the existing model, there needs to be further R&D in order to devise a model where pre-heating will be sufficient for long time efficient burning.

There exists a Memorandum of Understanding (MoU) between Centre for Excellence in Production and Transportation of Electricity CEPTE/KU and Energy, Environment Research & Development Centre (EERDC) to formalize the acceptance by CEPTE/KU to handover the documents and findings of its Jatropha project to EERDC so that further research required in the project can be carried on by EERDC.

PEEDA has done some R&D in developing a 1.5 Liter Size Multi-wick stove, a barrel shaped stove that has its three support legs caging a flat cylindrical-shaped fuel vessel with the wick burner mechanism exposed. This multi-wick/'range wick' stove is aimed at low-income communities for domestic cooking use. This stove can be used for either indoor or outdoor cooking. The multi-wick mechanism allows for air flow to occur around its enclosed stilt barrel configuration. This has the effect of reducing heat transfer to the fuel vessel and through this reducing the potential fuel loss in the vessel through evaporation. The cooling effect on the stilt wick reduces the transfer of heat to the fuel vessel, and thus the fuel within the fuel vessel remains below the dangerous flashpoint temperature even after long periods of use. Closer to the top of the enclosed stilt areas become hot during stove use. The prototype wick stove is still in their nascent stage, there is need of further R&D especially regarding the effectiveness and efficiency of its usages when used with highly viscous Jatropha oil. Also there is need optimize the stove ignition process as substantial amount of coke is found to be formed in higher ignition temperature of Jatropha oil compared to kerosene. Before commercialization and disseminating it in community, emission tests (following the UNFCC stove protocol) and community pilot testing is also needed.

Design/Modification Factors

The modifications done on the previous design was based on the modification principles proposed by Whitney Veigas, suggests the four factors of a successful design as: "function, aesthetics, cost and technology".

Following steps have been undertaken during the design process:

- Problem identification
- Observation and testing
- Re-designing and testing
- Follow-up

Modified Wick Stove

Previous researches have shown wick stove as one of the best option for rural use of Jatropha oil. It is easily available in Nepal as well as accepted by the community. In Nepal, the presence of kerosene wick stove is decades old. It is based on a relatively simple and long proven technology and modifications for bio fuel usages in wick stoves are relatively simple.

Modifications

- Fuel is fed to the burner by gravity force
- Simple concept of capillarity is used for its design
- Burner consists of 10 cylindrical features to support wicks
- A valve to stop oil flow
- A perforated aluminium cap is installed around the wicks for optimum oxygen and to protect from wind blows.

Results

After modifications, the wick stove seems to be burning with better efficiency. The problem of the stove not being able to burn for a longer period of time (in case of previous model of wick stoves) has been solved with the inception of new design.

Modified Vapor Jet Stove

Due to its high viscosity, high atomization and ignition point, crude jatropha oil can't be used as a sole fuel for cooking purposes in pressure stoves. To aid these constraints, a dual fuel tank and dual nozzle system stove has been developed in which the use of kerosene is used as a preheating agent.

Modifications

After a series of experiments and tests, community demonstration and feedback collection, the final modification made to the prototype are as follows:

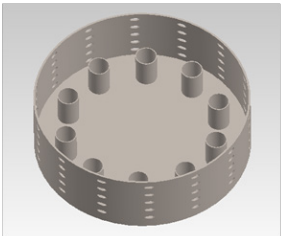

Fig 1: Burner assembly of modified wick stove

Fig 2: Modified Wick Stove (Design)

Fig 3: Modified Wick Stove (Final Product)

IWA Performance Metrics	Units	Average Values	
Operational Fuel Modality		Kerosene only	Dual mode
High Power Thermal Efficiency	%	34	37.6
Average PM Concentration	ug/m3	229	227
Average CO Concentration	ug/m3	2.6	2.2
Highest PM concentration	ug/m3	685	675
Highest CO concentration	ppm	3.9	3.4
	Standard Performance Measures		
Fuel Consumption Rate	g/s	0.96	0.916
Jatropha Fuel Consumption Rate	g/s	-	0.118
Kerosone Fuel Consumption Rate	g/s	0.96	0.87
Burning Rate	g/min	5.102	6.805
Time to Boil	min	20.1	16.2

- Outlet of circular windings in jatropha fuel pipe fitted with a nipple to concentrate the vapour stream which results in the ejection of flam mable jatropha vapour from the fuel pipe
- Dual fuel tank and dual nozzle system (one for kerosene and other for jatropha oil)
- Preheating the stove with kerosene

Results

The coiled fuel pipe design in the prototype has been beneficial in improving the fuel properties of Jatropha by utilizing the exhaust heat from the burner. The problem of tip being caught by fire while operating pressure stove is no longer after the installation of nipple in jatropha fuel pipe. Furthermore, the tests results of operating this stove under simulated conditions are as follows:

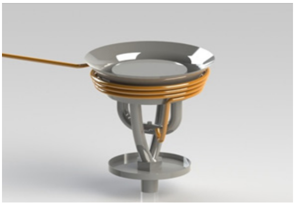

Fig 4: Burner Assembly of Vapor Jet Stove

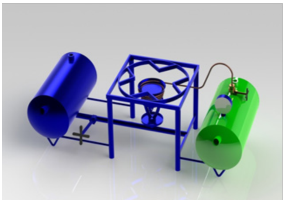

Fig 5: Modified Vapour Jet Stove (Design)

Fig 6: Modified Vapor Jet Stove (Final Product)

Conclusion

Utilization of plant oil cooking stove has numerous ecological, economical, and sociological benefits. Plant oils are a sustainable energy source ensuring sustainable cooking energy supply. Jatropha promises to be superior to other plant oils in Nepal as it has short gestation period, easy handling, high oil extraction and superior quality of bio-diesel. A number of plantation practices and engine test runs have been conducted across the world and also in Nepal, which have been successful to demonstrate that it is the best alternative to conventional fossil fuel. In this scenario, the use of Jatropha based bio fuel stoves in the rural areas for fulfilling energy requirement in Nepal has high possibilities and potentialities.

The primary challenge for the adoption of the stoves will be the assurance of a reliable fuel supply for the rural community. This challenge can be addressed through the establishment of production facilities located strategically near the field test areas with an abundance of wild variety of Jatropha in mid hilly regions of Nepal. Market opportunities would then exist for entrepreneurs to become involved in the production and distribution of stoves in similar geographical location throughout the country. PEEDA is working to develop its market development and marketing strategy, which includes required training, technical support, financing and marketing support. PEEDA has already purchased and placed an expeller unit in Okhaldhunga. PEEDA has already planted 60,000 high yielding variety of Jatropha and anticipates planting of 75,000 high yielding varieties by 2015. In order to ensure widespread access and adoption of these stoves, as well as the supply of related renewable energy fuel products, PEEDA has committed enterprises development activities in its project.

The field investigations and analyses undertaken by PEEDA depict the viability of stove for poor and low income group farmers in Nepal. It is found that the rural communities can greatly benefit from them. The wide ranges of benefits include socio-economic, financial and environmental gains. The technology also provides additional health and environmental benefits when compared with the traditional stoves in place. Thus, the use of Jatropha stove can be a meaningful alternative for rural communities in the long run.

Acknowledgement

The authors gratefully acknowledge the contributions of everyone involved during the project period especially Renewable Nepal programme for supporting this research project.

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CAN BARBECUE CHARCOAL PLAY A ROLE IN CLIMATE CHANGE MITIGATION STRATEGIES?

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From barbecue to climate change mitigation!

We are all familiar with charcoal for barbecue. According to recent FAO statistic (FAO, 2013), the world's wood charcoal production reached a new high of 51.3 megatons in 2012 with Africa being the largest producer, followed by South America and Asia. Most of the charcoal is being used by private households for cooking and other purposes as it is cheap and mostly the only source of thermal energy, especially in rural areas. However, even in developed nations, wood charcoal still represents an essential role in traditional cooking, e.g. South Korea. A large share of charcoal utilized in South Korea is imported from Thailand, after China being the second-largest exporting nation in Asia and ninth-largest in the world (FAO, 2013). This makes wood charcoal an important energy carrier in certain regions and it plays an important role in international trading.

Prior to the utilization of fossil fuels, charcoal was the most important feedstock for thermal energy besides fuelwood, as it has remarkable properties in comparison with wood. Firstly, it is relatively light and secondly, there are lower emission levels during combustion which is of particular importance in densely populated areas and indoor use. Later, it was powering the early phase of the industrial revolution which started in the 18th century in Great Britain and soon spread to Western Europe and the United States. However, wood charcoal was gradually substituted by fossil energy carriers like coal and later, oil and natural gas which ceased the significance as an energy carrier.

A revival of charcoal!

In the last two or three decades, the interest in wood charcoal increased again, especially in the scientific community, where it is often referred as "Biochar." Biochar represents pyrolized organic matter, similar to barbecue wood charcoal. However, in contrast to barbecue wood charcoal, it can be produced from any organic matter, regardless of its origin, and the production parameters may be exactly controlled. In a nutshell, pyrolysis is the process of biomass heating in absence of oxygen, while separating the volatile fractions from carbon. From an engineering point of view, the process of pyrolysis can be categorized according to its duration, represented by slow and fast pyrolysis, and the reactor setup, which can process the biomass in batches or on a continuous basis.

While slow pyrolysis is more comparable with traditional charcoal production and the volatiles are mainly found in the gaseous phase, the fast pyrolysis process aims at producing bio-oil which contains the volatiles in a liquid phase. Bio-oil may be used as a renewable energy carrier or as a feedstock material for further refining. The gaseous compounds are commonly directly used as a source for (renewable) energy. Although the synthetic gas may be rich in methane, it is difficult and costly to purify it which is a necessary step if it is fed into the existing natural gas grid. The solid product of the pyrolysis process is biochar, with distinct chemical and physical properties.

These properties, such as pH-value, surface area, decomposition resilience, cation exchange capacity (CEC) etc. are highly dependent on the actual pyrolysis settings (especially temperature and reaction time). For instance, it was shown that the pH-value of biochar derived from black locust may range from around 4 to 12, only as a factor of pyrolysis temperature (Lehmann, 2007).

As mentioned above, pyrolized organic matter is - depending on the pyrolysis settings - relatively stable against microbial decomposition as a consequence of its intrinsic recalcitrance, mainly due to aromatic carbon ring structures being an obstacle for microbial decomposition. The formation of organo-mineral compounds in soils, i.e. the bonding between clay minerals and char particles is another mechanism of long-term protection of carbon compounds against microbial decomposition. This recently raised attention as biochar may be used in carbon capture and storage (CCS) strategies, if it is used as a soil amendment. Probably one of the first scientific observations of stable pyrolized carbon in soils was in tropical South America where scientists found distinctive patches of soils with unusual high fertility considering the tropical environment.

It turned out that biochar is the main reason for the relative large amounts of carbon in these soils, coupled with high cation exchange capacities representing a buffer for essential plant nutrients. These soils are known as "Terra Preta" and were initially set-up by the Indios, who mixed organic waste with charcoal and incorporated this mixture in their agricultural soils, leading to a permanent improvement of the soil fertility and productivity. Although decomposition processes under tropical environment are usually rapid, these soils are still rich in organic matter, even after centuries.

This confirms that the knowledge about the ability of biochar to positively influence both chemical and physical soil properties is not new. The potentially high pH-value of biochar leads to a liming effect which is often desired in acidic soils. The porous structure of the char itself is capable of raising the cation exchange capacity as a consequence of a high surface area. In addition, pores may increase the soil water retention which is of critical importance on dry and sandy sites. They may also create a suitable habitat for soil microorganisms. In terms of climate change mitigation, it was shown that biochar reduces the release of greenhouse gases (Spokas and Reicosky, 2009) and as a consequence of increasing soil fertility, the secondary effect of biochar amendment is expressed by increased biomass growth rates with higher uptake of carbon dioxide from the atmosphere. Another important positive function is the ability of biochar to increase the efficiency of fertilizer use, as shown previously for nitrogen(Chan and Zhihong, 2009).

Open questions and outlook!

There are still a number of issues to be investigated, for instance, the long-term stability and behavior of biochar in soils, potential contaminations (especially of heavy metals) and the influence of different feedstocks and production settings on biochar properties. A recent workshop held in Vienna in April 2013 tried to pin down major knowledge gaps and current obstacles in using biochar as soil amendment in larger scales. The outcome suggests that there is more research needed in various disciplines, starting from management of sustainable biomass sources, optimal pyrolysis conditions and balance between biochar and energy yields during the pyrolysis, to best practices of soil amendment. The experts from more than ten nations agreed that it needs local strategies rather than generalized approaches in all steps of the biochar life cycle, in the areas of biomass availability, production facilities, market mechanisms, soil local properties and the resulting biochar properties to improve fertility and act as a stable long-term carbon stock. Therefore it needs interdisciplinary scientific efforts, including both natural and social sciences, in order to provide ecological, social and economic sound solutions.

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BIOGAS AS EFFICIENT SOURCE OF BIO-ENERGY

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Bio-energy is most widely used form of renewable energy in the world. It is estimated that it currently provides about 15% of the world's energy supply and approximately 35% in developing countries (Schlamadinger, 2004). Bio-energy plays an important role in reducing Green House Gases (GHGs) emission from the fossils fuels which is a primary cause of climate change by stocking the terrestrial carbon.

We know that people of rural areas of developing countries like Nepal are very much dependent upon biomass fuels such as energy crops, agricultural & forestry wastes, by-products and dried dung for their energy consumption. This use of energy is often related with many problems such as deforestation, land degradation, various health and social problems as well as emission of GHGs. Also, the demand of energy is increasing than its availability and this will lead to more dependency on the forest resource which ultimately causes deforestation. The ability of various bio-energy types to reduce GHGs emission varies widely and the areas where forests are cleared to make way for new energy crops, the emission could be even higher than that of fossil fuels. In this case, biogas can be used as an alternative for these fuels and can help solve many problems that are associated with biomass fuels.

Usually, biomass is used as a source of fuel by direct burning in dry form like cattle dung or wood to produce heat and by converting the biomass into more useful fuels. Then such improvised fuels can be used for heating purpose that helps a single household and community to become more or less self dependent in terms of energy. For example, wood can be converted into better fuel called charcoal and cattle dung can be converted into a much better fuel called biogas. These fuels are much more efficient than their parent bio-mass from which they are prepared.

Biogas and Rural Livelihood

Biogas, as an effective source of bio-energy production has substantial social and economic implications including income generation and employment opportunities in rural areas. These implications have to be considered in order to and social and rural development. Biogas as a clean source of energy has helped rural people in reducing the harmful indoor air pollution and reduction in the obstructive pulmonary diseases in children and women of the rural areas.

The use of firewood has many negative effects, both social and environmental. Mostly women and children collect the firewood and this can take several hours in a day leaving this group with less time for education, employment and recreation. The use of firewood and other forms of biomass as a cooking fuel is also directly related to exposures of the hazardous particles from the smoke that these fuels produce when burned (Gautam et al., 2009)

The firewood is generally collected by women and children and a bundle of firewood can weigh about 25- 30 kg. In order to collect it, an average distance of about 5 km has to be traversed. This arduous job can be time consuming and also lead to back, neck as well as other problems to them (Topa et al., 2004). Replacing biomass energy with biogas can help to solve many problems that are typically found with biomass fuels. Indoor pollution can be dramatically reduced as a result of using clean biogas stoves instead of burning firewood, straw and dung cakes. This would mean that a lot of the problems with hazardous smoke particles would be avoided (Li et al., 2005).

In addition to this, biogas can play an important role in deeming rural areas to become more gender equal. The fact is that women and children could save significant time each day simply by converting from traditional biomass use to biogas. The provision of enough time for education to children can have a big positive impact in the future.

Some of the main reasons that have contributed to the widespread use of biogas in Nepal are the problems associated with traditional use of biomass and lack of alternatives such as fossil fuels. Awareness about biogas technology and of what it can achieve has been widely spread amongst the population because such large part of Nepal is agriculturally based and the materials needed to build the biogas plants can be found locally.

The use of biogas as an energy source has proven itself to be an important strategy in solving the problems of energy usage in rural areas of developing countries. By using existing substrates like dung and other waste products to produce biogas, individual households can become more or less self sufficient in terms of energy. The biogas can be used as a clean cooking fuel without the effects of hazardous particles typically associated with firewood and can also be used to generate electricity or for heating (Bajgain and Shakya, 2005).

GHGs emission

As we know, when dung is naturally digested, methane gas is produced and released into the atmosphere. If instead these substrates are digested in a biogas plant, the methane gas (biogas) is collected that avoids it from releasing into the atmosphere. When the biogas is combusted, most of it is converted into carbon-dioxide (CO_2). Methane gas is twenty one times more detrimental to GHG emission than CO_2. So, biogas plants can be an effective means to reduce the emission of methane gas in the atmosphere. The net saving of GHGs by an average sized biogas plant has been estimated at 4.6 tons of CO_2 equivalents per year (Bajgain and Shakya, 2005) which contributes to saving of 12 million tons of CO_2 equivalent per year by the total plants built in the country that is about 260,000 units.

From the study, it is estimated that 1m^3 of biogas is equivalent to 3.5 kg of firewood and a family size biogas plant can produce about 2m^3 of gas/day (FAO, 1996). This means that it can save about 7 kg of firewood/day or 2.55 tons/yr. Current biogas plants installed in Nepal can save about 6,63,000 tons of firewood per year. This data indicates that the use of biogas as a source of alternative energy can play a significant role in the conservation of forest resources and mitigating the GHGs emission.

Challenges

The sector has potential to construct about 1.9 million biogas plants throughout Nepal (WECS, 2010) but so far, only 260,000 plants have been constructed. This is mainly due to the difficult landscape of the country and biogas market having very little scope in high hill and remote areas. Besides this, it is also expensive for ultra-poor and vulnerable families for one time investment. In order to facilitate this, government should increase the current subsidy rate for the ultra poor families and also to the people of remote areas in order to promote biogas and environmental protection. Emphasis upon cost reduction technology and pro-poor based subsidy policy for remote areas of the country can enhance the use of biogas significantly.

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PRO-POOR HYDROPOWER – A MECHANISM FOR LOCAL OWNERSHIP OF HYDROPOWER PROJECTS

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Background

In theory, Nepal has more than 6,000 rivers and rivulets potentially viable to produce as much as 83,000 MW of electricity. Unfortunately, for decades Nepalese have seen these figures on paper only and Nepal still reels from the lack of policy, infrastructure, commitment and attitude fundamental to exploiting this potential for the benefit of majority of the population. Despite this lack of progress, there have been considerable developments in the hydropower sector in Nepal, the majority of which have been supported by external funding from either donors or lenders.

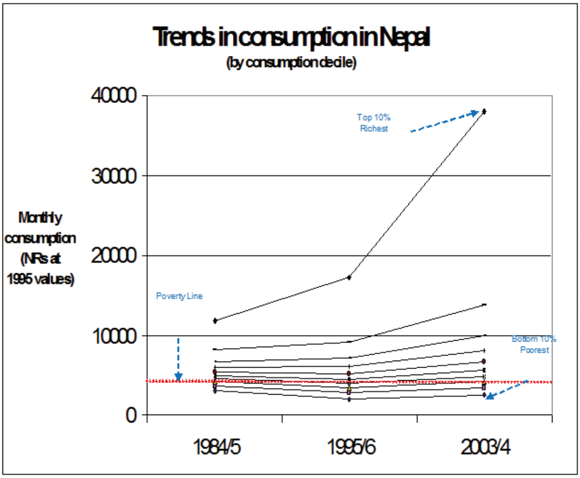

Figure 1: Trends in Consumption in Nepal (1984/85 to 2003/04)

In the last decade or so, the poverty indices have shown positive trends in numbers below the poverty line dropping more than 10% from 1996 to a decade later for instance. But, has the situation really improved for the general public and the needy? Figure 1 shows that the situation of the so called 'poorest of the poor' of the society has not improved when figures are examined over two decades. In fact, what becomes very clear is how the situation of the poor of Nepal has roughly stayed the same whilst at the same time the status of the wealthy has increased over threefold. The question remains – could the immense hydropower potential in the country reduce this poverty and how can this wealth be distributed more evenly between the rich and poor?

Hydropower Development in the Past

Bilateral donors and INGOs have a significant track record of promoting hydropower projects in Nepal. But, under the present modalities of investment, the interventions in hydropower development have not been able to benefit the poor (economically) – with the rich seemingly benefiting the most. When well designed and built, commercial power projects have proved to be very profitable. Nevertheless, during the process, and as a result of these projects, the poorer people living near these projects have enjoyed some social benefits - rural electrification, basic infrastructure (roads, water supplies, bridges etc), some employment, training, irrigation etc. Nepal as a whole has benefited with electricity generation, a number of institutions developed and capably working in the furtherance of more hydropower development. However, these projects would have still better met the needs of the poor and have been a means for poverty alleviation and breaking the vicious circle of development, if the poor actually gained more directly from the wealth generated from their rivers. This is the basic guiding principle behind the development of Pro-Poor Hydropower concept.

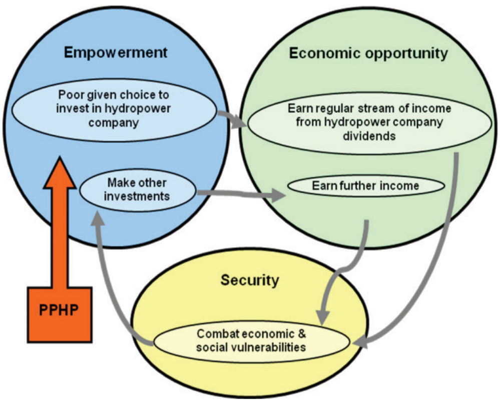

Figure 2: Basic Principle of PPHP Concept

Basic Concept

Pro-Poor Hydropower (PPHP) is a concept by which the rural poor of Nepal are facilitated into profitable ownership of their water resources. This is achieved through development of commercially profitable and socio-ecologically acceptable hydropower projects with the local poor gaining significant ownership of the projects. The PPHP concept is that the local poor sustainably and economically benefit from the development of local hydropower projects and particularly the profit generated by its commercial operation. Significant ownership is defined as ownership of shares which earn dividend that represents a sizable earning when compared to the household's other earning streams. Achieving this 'significant' ownership can be realized either through the local poor owning a majority of a small project ('pure' approach) or through the local poor owning a small part of a big project ('dilute' approach) - or a sliding scale in between.

In broader terms, Pro-Poor Hydropower concept includes two important development components integrated together. These are:

1. the development of a commercially profitable and socio-ecologically acceptable hydropower plant itself, and
2. mobilization of the local community particularly the poor and marginalised into the share ownership of the hydropower plant.

Project Goal & Key Outcomes

The direct project goal of PPHP is income generation through facilitating the rural poor of Nepal into the profitable ownership of their local water resources.

The key outcome of a successful PPHP project will be that a large part of a particular community – particularly the poor of the community – will have significant ownership in a profitable hydropower company that uses that community's river for hydropower generation. They will then receive regular and long-lasting cash income through dividends from their ownership. The community will also receive many spin-off benefits, such as having its awareness raised on various social and economic issues, training, jobs during construction, infrastructure, and some rural electrification (remembering that this is not the main purpose of the project) as well as skills to create small enterprises.

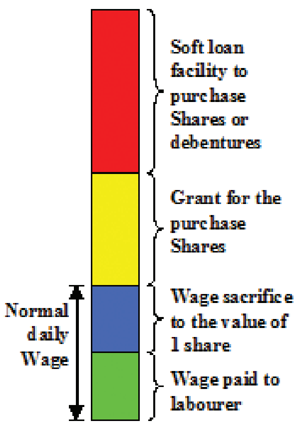

Figure 3: Mechanism by which the local poor earn shares

Facilitating Ownership of the Local Poor

Under the Pro-Poor Hydropower concept, local poor people are given the opportunity to invest in a hydropower company. The initial investment required for the rural poor to gain significant ownership in a hydropower project will be too high.

Generally, the local poor have nothing to invest except their own labour. Normally in hydropower projects, there is a labour component of around 10-20% to the total costs. The mechanism by which the local poor attain ownership is by building upon this labour component of the project's construction and operation. In PPHP, opportunities for the local poor to be employed on the project are maximised. Their labour is paid for in both cash and equity (shares) – see Figure 3. The labourer earns shares by sacrificing part of their wage.

This wage sacrifice can be then multiplied through a levering grant and/or soft loan facility. For each share that is earned through labour contribution, a certain amount of shares can be purchased through a grant (from donors). Another few shares can be purchased through a soft loan facility, which may be invested as a debenture in the project in order to give the local poor early return on at least part of their investment. The exact balance between the wage sacrifice, the grant and the soft loan will depend on the actual size of the local labour component in each project. The grant facility will likely not exceed 15% of the total hydropower project value.

The local non-poor (who will generally be unwilling to contribute labour) will also be facilitated to purchase shares in the project.

Ensuring Participation of the Local Poor

PPHP's greatest test will not be technical. It will be in actively involving the local community, particularly the poor and working with the community in managing and organizing their investment. It is always a developmental challenge to implement a new concept especially when it deals with relatively new ideas of sweat equity, wage sacrifice and shares. PPHP will work closely with the local community, both the poor and the non-poor, to raise awareness about the PPHP concept, and to mobilise them into groups. These are the essential parts of the community mobilisation process, and the community mobilisation process is the core to the success of testing the workability of PPHP concept. All the major decisions related to the investment by the local community including who shall be defined as poor, and hence be entitled to participate in the shares-for-labour, grant & loan scheme would be taken through consensus during the community mobilisation process. The poor, as defined by the community, will then receive the training they will need to contribute their labour input in the project. Through the community group formation, special emphasis will also be put on women's involvement and empowerment. As a target, at least 50% of the participants in the community groups should be women. As an inherent objective of the project, the local community will have capacity built to use their groups formed during implementation of PPHP to initiate and run other community development activities, based on their own needs.

Compliance to the Recent Development Trends

PPHP has undergone many long process of definition, design and refinement and this process will continue on for the entire pilot project period. Due attention and care has been given to the hydropower development issues and prevailing political, financial, socio-economic and natural environmental condition of the country. PPHP is in line with the recent developmental trends in Nepal.

- **Women's empowerment** – an integral component of the community mobilization process with formation of separate female groups and a target of at least 50% women representation in the management committee.
- **Social inclusion** – reaching out to all people in the community during community mobilization (awareness raising, group formation, skill training) and equal opportunity for participation in the PPHP project.
- **Local ownership** – the whole concept about facilitating local ownership of the local water resources
- **Capacity building** – local level capacity building of individuals and institutions for better participation in PPHP including skill training, financial support, technical advices, business development.
- **Conflict sensitivity** – transparent management, inclusiveness as well as individual and institutional empowerment key to conflict prevention.
- **Sustainability** – success of the hydropower project and institutional capacity building activities grants financial and developmental sustainability.
- **Environmental concerns** – hydropower considered a clean energy a n d furthermore, EIA and mitigation programs integral to the planning and

implementation of the hydropower project.

- **Reaching out to the poorest of the poor** – modality aimed at incorporating the poorest of the poor who cannot afford cash investment in the local hydropower project.

General Challenges of the PPHP

Implementing new concepts are not without its share of challenges that needs to be overcome for success. Some of the general challenges that need to be addressed and worked upon regarding the implementation of the PPHP concept are listed below:

- How to change the traditional mindset of rural people so that they understand share ownership and long term investment?
- How the poor will spend the income and how PPHP will be integrated with their overall development?
- How to increase the skills of the poor to be able to contribute skilled labour?
- How to build the capacity of the poor to invest cash and labour in the local hydropower company?
- How to manage the debentures and/or dividends?

Conclusion

The implementation of the PPHP concept is, no doubt, very challenging. However, the success of the PPHP concept will be win-win deal for both the local community as well as the commercial developer.

Benefits to the Local Poor:

- Regular income in the future
- Community mobilized – also for other development works
- Community empowered (women, peace-making, etc)
- Skills enhancement leading to long term employment opportunities

Benefits to the Hydropower Developer:

- Good working relations with the community
- Community has an incentive to keep the project running
- Contributing to the goal of poverty reduction
- Satisfaction in benefiting (not exploiting) the local poor

MANAGING COMMUNITY DEVELOPMENT PROJECT IN HYDRO POWER DEVELOPMENT IN NEPAL (A CASE OF KHIMTI HYDRO POWER PROJECT OF 60 MW)

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Introduction

In Nepal, private sector hydro power project developers have been encouraged only after the formulation of Hydro Power Development Policy (1992) and Electricity Act (1992). Himal Power Company (HPL) is one of the Independent Power Producer (IPP) companies registered in 1993 which has established Khimti Hydro Power Project (KHPP) of 60 MW at Dolakha and Ramechhap districts in 2000. Located at 1270 meter above sea level and 100 km east of the capital Kathmandu, this hydro power project is the first private sector promoted project under Build Own Operate and Transfer (BOOT) modality. The main purpose of this project is to generate electricity and supply to the national grid on a commercial basis based on the power purchase agreement (PPA) between Nepal Electricity Authority (NEA) and the Himal Power Limited (HPL). While constructing the project, the HPL has complied with 'effects mitigation' aspects and has been supporting community development activities in the surrounding areas as a part of Corporate Social Responsibility (CSR) since the beginning of the project construction.

As rural electrification is the prime concern of the rural communities at project affected and neighborhood areas, the HPL, first of all, constructed Jhankre Khola mini hydro power project of 630 kW from the water resources of local Jhankre Khola. This construction served multi purpose of providing electricity supply during construction of the main project of 60 MW and, rural electrification to the project affected 7500 rural households. This approach is the first ever practice in Nepal as locally installed mini hydro project not only saved huge liters of imported petroleum products like diesel, petrol and kerosene but also addressed the development need of rural people. Therefore, the concept of another development project is visualized in the name of 'Khimti Neighborhood Development Project (KiND)' to meet the increasing demand of electricity in the neighborhood rural areas including rural infrastructure development and institution development in the community.

Response of the Hydro Power Project to Community Development

Environmental Impact Assessment (EIA) is always prerequisite before launching any development projects and there are certain policies and guidelines to conduct EIA in large hydro power project development. In response to EIA study, the project parallel initiated community development activities in the project affected areas during the hydro power construction phase by establishing Khimti Community and Environment Unit (KCEU). The unit was assigned two principal functions - conduct community development activities and monitor the project impacts of mitigation measures implementation. Following were the major community development activities, carried out by the company through the Unit.

Non-formal Education: As literacy rate was the prime issue of the community, the project launched the non formal education programme for adults in coordination with District Education Office in three phases – basic course, follow up course and trunk library. Basic course duration was of 7 months and 923 participants successfully completed the course. However, follow up course duration was of extra 7 months including mathematical skills in addition to simple literacy class in basic course. A total of 619 participants successfully completed the course. 75 % of the total participants were women and after the completion of the courses, a concept of trunk library was introduced with educational material by forming of users' group and total 27 such trunk libraries were established.

Improvement in Educational Facilities: During the hydro power construction phase, the project supported to improve the educational facilities in two approaches : establishment of an English Medium Primary School in coordination with District Education Office in fully subsidized by the project at the rural market area namely 'Kirne Bazar' where the power house is also located and support to 7 primary schools and 1 high school for improvement of physical facilities such as school building, furniture, teaching material.

Health and Medical Services: Due to large workforce involved in the hydro power construction and nature of work, the company established a separate health clinic in the project site with provision of full time two medical doctors, health assistants, nurses and an ambulance services. This health clinic not only provided the health services to the project workers and staff but is providing the services to the local people as well.

Skill Development Training: Skill development training is pre-requisite before initiating any micro-enterprises in rural areas and the project conducted series of skill development trainings to 183 community members as needs of local situation out of which 152 were female participants.

Forest Conservation: As fire wood is prime source of energy for daily cooking in the rural areas, the fuel wood consumption automatically increases while involving thousands of project workers and staff in the hydro power project construction. It is additional pressure on local forest. Therefore, the power project promoted local forest conservation activities by establishing 12 community forestry users' groups in coordination with District Forest Office and by producing seedlings in local nurseries. During the project implementation 84,000 seedlings were planted in the areas of deforestation problem. Initial survey report on environmental monitoring indicated that the survival rate of the planted seedlings is about 65%.

Improvement in Agriculture: As agriculture is thestill predominant economic activity of rural economy, the project emphasized to improve the modern farming practices depending on the climatic conditions. The project had employed full time agricultural technicians to provide consultation to local farmers on improved seeds of various crops, use of fertilizers and farming technique. During the construction period of the project, 4600 farmers received such consultations and 30 farmers received kitchen gardening training and approximately 29000 vegetables seedlings and 10,900 fruit seedlings of various species were distributed to the local farmers which was definitely supportive to the agriculture productivity and raised awareness on vegetable and fruit farming.

Conclusion and Future Course of Action

Hydro power project itself is a clean source of energy and does not cause adverse impact on the environment. However, the large hydro power projects, constructed at rural hill areas, have produced significant local social, economic and environmental impacts during pre and post construction and operation, creating conflict with local people at the dam site and downstream, and at the neighborhood areas as a whole. Despite of good concerns with the Corporate Social Responsibility (CSR) issues, the large hydro power project developer faces conflicts with local people from the planning phase of the project life cycle to project completion and even in the project operation phase. Such conflicts not only increases the project cost to complete in time and quality but also hampers the smooth operation of the project in long term even after it completed in any cost. In the case of Nepal, electricity supply from the large hydro power project to scattered rural hilly areas is not financially viable due to high transmission and distribution cost to extend the grid to scattered settlements and low purchasing capacity of rural poor and the small hydro power project like mini and micro hydro power project is the best solution for rural electrification to the isolated communities which can be taken as an entry point for holistic rural development in a sustainable manner. Just electrification, of course, is not only the solution of sustainable development and there are various factors of social, economic and environmental issues in rural areas. Hence, if the proper management of development project taking the entry point of small scale hydro power project is introduced at the neighborhood areas of large hydro power project construction site, it not only enhances the sustainable rural livelihoods of the areas but also supports smooth operation of large hydro power project.

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LOW HEAD PICO HYDRO– A ROBUST RURAL RENEWABLE ENERGY TECHNOLOGY FOR REMOTE AREAS

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Background

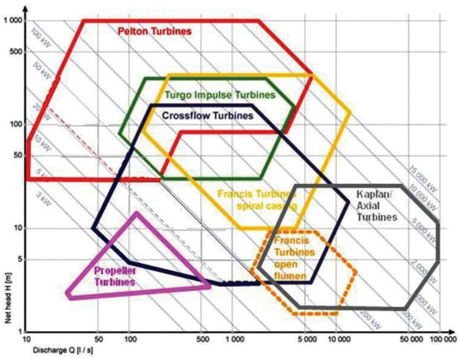
Many villages in Nepal have limited access to energy resources that could improve their livelihoods. They are dependent on either firewood, which is time consuming to collect and depleting at an alarming rate or expensive oil imports which are beyond their means. Electrical grid connection is available to only 32.7% of the population (ISRC, 2008). Its extension into remote rural locations is slow due to technical difficulties and high cost and low per capita electricity demand which all together work against economical viability of rural electrification. Social inclusion and the State's responsibility in providing electricity to all its citizens are the major thrusts for rural electrification. Some remote communities with suitable water resources are able to employ micro-hydro installations to produce power, but there are still a large number of communities that neither have the pre-conditions required for a micro hydro scheme (head and flow, investments, relatively dense population) nor are likely to be electrified through the national grid because of the cost involved.

Bridging the gap

Many villages do however have existing irrigation canals that extract reasonable quantities of water from nearby rivers to be supplied to their fields. Also, many hill communities use traditional water mills, known as 'ghattas' in Nepali, to grind rice and corn. These canals and water mills often pass near homes and can provide a small head to a pico-hydro plant. For this type of situation, propeller or cross flow type turbines that run on low head but use larger water volume can be suitable. These technologies would not compete with the irrigation channels and water mill sites, as the irrigation canals and water mills could be used during the day and the pico-hydro at night to cater to the lighting needs of the households and thereby optimizing the utilization of the water resources available.

The introduction of low head pico hydro power units into these communities will not only provide them with electricity, but it will also help to further open the doors for development. Small amount of power provided by existing pico units (high head peltric sets) has proved to be part of the solution to the energy imbalance, environmental degradation and a good source of income generation in the hills and mountains of Nepal. In most cases, these high head pico-hydro units use small volume of flow falling through a substantial height, usually more than 40m, to generate enough power for a small village. Unfortunately, many smaller villages do not have suitable sites for peltric type pico-hydro units.

Widening the use



PEEDA, 2009

Starting ten years ago, Nepal Hydro & Electric Ltd. (NHE), with the help of other partners, developed a low-head, high-flow, Pico propeller turbine unit. The unit underwent operational testing and was modified into a reliable, robust and efficient low-head Pico-hydropower unit. There were some research needs especially in electrical load controller which warrented to be addressed before launching these units commercially in the market.

Unfortunately, after manufacturing only 14 units, NHE decided that Pico hydropower units were no longer part of their core business plan and therefore stopped manufacturing them. PEEDA thus bought the technological rights from NHE with an aim to prevent this technology from dying inside the workshop.

Pico-hydro systems are often used in remote areas to supply electrical power to areas with no grid connection. They are usually intended for lighting applications. Self excited induction generators are commonly used due to their inexpensiveness and robustness. However, they are not able to start induction motors easily. It is often maintained that the generator must be rated a factor of five times larger than the motor load to ensure starting. Many Pico-hydro systems are of the size 200 W to 2 kW. This can be suitable for the lighting applications, but not at present for any industrial applications using motors e.g. electric drilling, wood sawing, sewing machine, etc. This project addresses this issue, and will design the controller system to operate electric machine with Pico-hydro system.

PEEDA, with its aim and objective, is always looking for the productive use of the small generated power at its maximum. To address the commercial utilization of energy generated from Pico hydro system, PEEDA recently has developed a new controller in the industrial collaboration with Kathmandu Energy and Power Group (KAPEG) under Renewable Nepal Programme. With the new excitation and control system added, new ELC is able to start the drill machine, television, computer and other electronic equipments that require high inrush current to operate. Thus, for the first time, Pico hydro systems with self excited induction generators can be used to operate income generating power tools and processing equipments.

Specification	PT1-Mk2	PT03-Mk2	PT5
Generator Output (kW)	1.2	0.3	5.0
Design Head (m)	3.5	2.32	7.6
Design Flow rate (l/s)	85	30.5	110
Output Voltage (V)	230	230	230
No. Phases	1	1	3

Table 1: Unit specification and component picture

This Pico hydro technology can electrify poor communities with green and reliable electrical energy. Despite the initial high cost per kW, the minimal cost required for running the scheme and great potential for it to open up new revenue streams, make the technology not only economically feasible, but also profitable for the poor communities of Nepal. The electrifying of people's homes will reduce their dependence on fossil fuels and traditional biomass, which in turn means that they will not have to spend what little money they have on fossil fuels and they will be able to reduce consuming the ever-depleting forest resources. Not having to depend on these fuel sources will also lessen the risk to health posed by indoor air pollution from these combustible fuels. As it is usually women who are required to collect firewood and then burn it for household uses, through the utilization of this technology, women will be removed from the drudgery and will be empowered to carry out other activities.

Addressing the high market demand

The feasibility study conducted by PEEDA showed that low-head Pico-hydropower system fills a gap in the Nepalese renewable energy market. The field investigations and analyses undertaken proved that investing in a low-head Pico-hydro scheme is a viable and attractive option for poor rural communities and can greatly benefit them. A figure of 2500 such sites are highly suitable for low head pico units. Wide ranges of benefits include socio-economic, financial and environmental gains. The low-head Pico-hydropower system also provides an opportunity to address the current rural/urban and regional energy access disparities in Nepal. The low-head Pico-hydropower system was shown by the study to offer one of the best means by which to supply quality, reliable and cost effective power to consumers in scattered and remote rural areas. Feedback from the beneficiaries of the NHE demonstration sites indicated an overall high level of satisfaction and acceptability of low-head Pico-hydropower systems. The study indicated that low-head Pico-hydropower units have a good market potential.

Fig1: Two Pico-hydro low head turbines in series in Gulmi

In a nutshell, the low-head Pico-hydropower units can assist poverty reduction and provide environmental sustainability. A community that installs a low-head Pico-hydro unit can have the facility of lighting and are also able to use the electricity to cook, thereby reducing the reliance on firewood. This improves health of the family, reduces drudgery, provides time for other income generating activities and decreases the number of trees that are cut down that ultimately helps the environment. The units can also be used for income generating activities such as tailoring, saw milling, grain milling, battery recharging and even charging laptop computers.

This gives many opportunities for communities to have alternatives to subsistence farming and can help reduce the poverty level of a community. As the units are small, they have minimal environmental impacts of their own, and so provide real opportunity for renewable and sustainable energy development in rural communities.

BARRIERS TO MICRO HYDRO ENERGY DEVELOPMENT IN BANGLADESH & WAY AHEAD

Md. Sayeed-Ur-Rahim Mahadi
Practical Action Bangladesh; FK Participant- PEEDA

Key Facts

Population	166,280,712 (July 2014 est.)
Area	147,570 km
Climate	Tropical; mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October)
Topography	Mostly flat alluvial plain (80%); terraces (8%) and hilly in southeast (12%)
Rain pattern	Average annual rainfall: 2,499 mm^2 Dry season: November to May. Rainy(Monsoon) season: June to October
Electricity - installed generating capacity	10.26 million KW (2013 est.)
Electricity - from fossil fuels	97.7% of total installed capacity (2013 est.)
Electricity - from hydroelectric plants	2.3% of total installed capacity (2013 est.)
Hydropower Potential	1897 MW
Hydropower Utilization	12.1% of total hydropower potential
Carbon dioxide emissions from consumption of energy:	58.81 million MT (2011 est.)

Source: (Central Intelligence Agency, 2012), (USAID-SARI/Energy Program Report, 2012)

Hydropower sector overview

Energy is one of the most critical economic, environmental and sustainable development issues concerning people worldwide. According to the World Energy Outlook 2012, 1.3 billion people still lack access to electricity. As 19% of the world's total electricity power is derived from large and small hydro power plants, it is playing an important role in the global energy mix.

Previously, electricity generation in Bangladesh was mono-fuel dependent due to apparent huge availability of indigenous natural gas. Presently, about 89.21% of generated power of Bangladesh comes from natural gas and the rest is from liquid fuel, coal and hydropower. The present share of electricity generation from large and micro hydroelectric plants is 2.5% of total installed capacity.

Though, in recent years, due to depleting existing gas reserves and non-exploration of new gas reserves, Government of Bangladesh has diversified the Power Generation Fuel Mix. Development of renewable energy is one of the important strategies adopted as part of Fuel Diversification Program.

The Government of Bangladesh approved its first Renewable Energy Policy on November 6, 2008, encouraging investment in this sector to generate electricity from renewable sources to meet an ever-growing demand. The main renewable energy sources are solar energy, wind energy, biomass, biogas and hydropower. In order to achieve the objectives of Renewable Energy Policy, the government has set a target of meeting 5% of the electricity demand by 2015 by utilizing renewable energy, and 10% by the year 2020 subsequently. So, hydropower can play an important role in the Power Generation Fuel Mix of Bangladesh due to decent availability of potential sites.

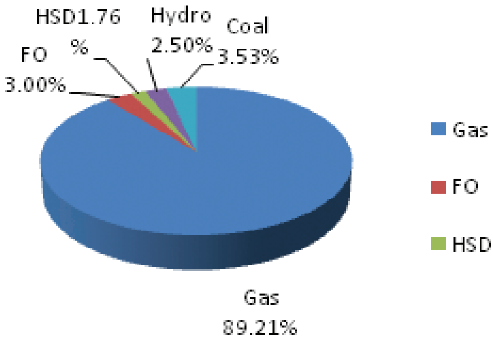


Figure: Power Generation Fuel Mix
[Source: Power Division, MoPEMR, Bangladesh]

According to the report of South Asia Regional Initiative for Energy Cooperation and Development (USAID-SARI/Energy Program Report), Bangladesh only utilizes 12.1% of its total hydropower potential. The current hydropower potential of Bangladesh is 1897 MW whereas the installed capacity is 230 MW. There are potentials in the Sangu and the Matamuhuri river basins (167 MW and Brahmaputra river basin (1,400 MW). Source: (USAID/SARI, 2012)

Barriers to small hydropower development

A range of obstacles exists in all the South Asian countries, such as the remote location of potential sites and the need for road access and long-distance transmission lines (e.g. Bangladesh, Nepal, Pakistan). Related to this is the ambiguity of grid extension, as it may not be economically feasible in rural areas where power demand is low (e.g. Nepal, Bhutan). Other specific barriers reported for each country were with regards to human resource capacity, technical knowledge and institutional capacity.

Some of the major barriers to small hydropower development in Bangladesh are:

1. High installation cost, inadequate hydrological data, the effects of climate change, deforestation and degradation of water catchment areas, and the limited local capacity and infrastructure to manufacture small hydro components combined impede development of small-scale hydropower in Bangladesh.
2. Installation of hydropower plants requires land acquisition. It is often delayed due to litigation, poor maintenance of land records, etc. Reservoir schemes could result in displacement of families.
3. Most of the untapped hydropower potential is located in the remote areas of the country for which roads will have to be constructed before work can commence.
4. Furthermore, power would have to be transmitted over long distances to load centres from these remote areas requiring construction of long transmission lines. Low load factor of hydropower reduces firm power due to strong rainfall seasonality and plants have low output during the dry season.
5. Administrative complexity and long waiting times delay small hydro power development. The process of getting clearance from the environment and forest agencies is cumbersome and involves input from many other agencies. Inter-State and Inter-Country water disputes have come in the way of developing projects.

6. Lack of field expertise having technical skills is one of the largest barrier impeding the development of small hydropower. To varying degrees, there is limited technical expertise for equipment manufacturing, construction, operation and maintenance.
7. Some climatic factors also limit the suitability of small hydropower development, such as irregular or seasonal rainfall, low flow and drying up of rivers during the dry season and a highly variable and arid climate.
8. Another barrier is the lack of investment from local and foreign investors and, private companies. Banks, in particular, are reluctant to lend the start-up capital upfront. Bank-lending to hydropower is low due to liquidity issues and due to the banking sector's slack of understanding of small hydropower and its benefits. Interest rates are too high and loan tenure is short, hindering private small hydropower development.

What can be done?

Small hydropower is one of the most suitable energy solutions for fostering inclusive sustainable development and industrialization. Much of the small hydropower potential of Bangladesh remains unused due to lack of reliable hydrological data, proper policy and planning. So, steps should be taken to remedy the situation through dissemination of reliable data that can inform policy development and energy planning, as well as guide investors in entering renewable energy markets.

Bangladesh should formulate a renewable energy master plan and a trust fund to support renewable technologies including small hydropower. Bangladesh government should promote for the up-scaling of small hydropower and renewable energy in the region through technical trainings, information exchange and identifying financing mechanisms. There should be proper financial mechanisms, improved institutional, regulatory and legal frameworks which will attract local entrepreneurs to invest in small hydropower development. There has not been any governmental policy on hydro-power, yet there are some internationally recognized mechanisms, which can create opportunity for developing nations to generate funds for implementing green projects in their country. Two of such mechanisms are CDM (Clean Development Mechanism) and

Carbon Finance, which provides monetary help for green projects.

Small hydropower potential sites need to be reassessed due to constantly changing hydrological and environmental conditions affecting the watershed. Potential non-conventional sites based on technical innovation need to be identified. New Business models for sustainable small hydropower development need to be developed and promoted to provide electricity in rural areas. Local capacities should be increased to conduct feasibility studies, improve local manufacturing capacity for construction, operation and maintenance of small hydropower plants. Hydro-power projects must be subjected to thorough environmental and social impact assessment in order to ensure balance in the eco-system.

Most countries use tax-based incentives for hydropower development. In Nepal, there are several incentives available, such as VAT exemption, custom duty reductions for imported small hydropower related machinery or equipment and income tax exemptions for the first 10 years from the date of plant commissioning, thereafter 50 per cent for the next five years.

Some other countries also have some similar facilities like value-added tax exemption (Uganda), subsidized value-added tax (China), direct subsidies (India, Rwanda) for hydropower investors, revised feed-in tariff (FIT) policy (Kenya, Madagascar, Mauritius and Rwanda), all import taxes exemption on equipment and machinery necessary for renewable energy production (Dominican Republic), concessions on leasing of land, exemption from electricity duty (India), purchase of electricity produced by private sector renewable energy plants at a tariff three times higher than those paid by the consumers (Iranian Government), direct sales contracts with the electricity distribution company, exemption from distribution and transmission costs for the first 10-year of commercial operation (Panama), sell their energy directly to the consumers via the grid at half price for grid use (Brazil), etc. Government of Bangladesh should implement such facilities, policies and strategies to promote hydro power development.

Renewable energy is seen as an opportunity to boost rural electrification (e.g. India, Afghanistan) and an option to be less dependent on imported fossil fuels (e.g. Pakistan). Bangladesh government should take necessary initiatives to adopt a hydropower policy like Bhutan, India and Nepal. Successful hydro power projects should be replicated in potential sites and steps should be taken to promote indigenous technologies for development of hydropower. Potential multi-purpose sites need to be identified. Some hydro power project sites may be set up for improvement of tourism, hydropower based irrigation, water supply system and provide power to local inhabitants. The electricity produced from these sites can play a vital role in facilitating the local farmers to have proper irrigation facility. Shrimp cultivation is one of the main sources of foreign revenue of Bangladesh. But, due to shortage of electricity, it has been very difficult to apply modern techniques of cultivation. Potential river sites with run-off MHP facility will enable the local farmer to apply semi-intensive and intensive method of cultivation.

There are enormous hydro potentials in neighboring countries viz. India, Nepal and Bhutan. With active and sincere co-operation of India, Nepal and Bhutan, it may be possible to develop the hydro potentials in Bangladesh. If these countries reach an agreement in terms of co-operation, expert services, investment, training, choice of technology and selection of equipment etc. then, it would be easier to implement hydro projects of these countries.

South-South and triangular cooperation among developing countries, developed countries and international organizations (including international banks) for technology-transfer, capacity building and financing should help to facilitate the transition from individual pilot small hydropower projects towards successful implementation of full-scale small hydropower programmes. Coordination, collaboration and knowledge sharing among regional and international organizations that include small-scale hydropower in their scope of work should continue and be expanded. Hydropower projects of Bangladesh, until recently, have been funded mainly by the Government. Now, many other organizations such as USAID, UN-Water and Practical Action Bangladesh have realized the benefits and are working for the hydropower development of Bangladesh.

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PEEDA AT A GLANCE

PEEDA is an NGO dedicated to improve livelihoods of communities, particularly the poor, by collective utilization of renewable energy resources, while ensuring due care for the environment. This is achieved by establishing institutions active in the renewable energy sector, promoting cooperation between relevant stakeholders to undertake development projects, advocating for policy & regulatory reforms and undertaking targeted research. The principle behind the activities of PEEDA is that the poor of Nepal, who live mainly in rural areas, should share in the benefits of Nepal's renewable energy resources, but this will not happen without dedicated and sustained effort. PEEDA is committed to the values of empowering individuals & communities to help themselves, non-discrimination, and maintaining good relationships.

News & Events

1. Bio-fuel Jatropha Concern Group Meeting

PEEDA, in collaboration with Alternative Energy Promotion Centre (AEPC) invited major stakeholders of Nepal's bio fuel sector for joining the "Bio fuel Jatropha Concern Group Meeting" which was held on March 26, 2014 at The Summit Hotel, Kupondole, Lalitpur. About forty bio-fuel experts and enthusiasts from the government, private sector, research institutions, universities, media and NGOs discussed ways in which the group could assist and provide technical backstopping to AEPC for the formulation of much needed policy to govern the bio-fuel sector.

Fig1: Jatropha Concern Group Meeting

2. FK Norway Exchange Participants at PEEDA

As part of the FK Norway Exchange Project, 2 participants from Practical Action, Bangladesh and 1 participant from Tarayana Foundation, Bhutan have joined PEEDA since May, 2014. They will be working at PEEDA for 1 year on various projects that may have due replicability in their home countries as well.

3. Demonstration of bio-fuel cook stoves

Fig 2: Bio-fuel stove demonstration

Wick stove and Pressure stove meant to be run on Jatropha oil were successfully demonstrated in 4 VDCs of Okhaldhunga district namely Thakle, Toksel, Madhavpur and Maneybhanjyang from May 9 to 12, 2014. Demonstration of bio fuel cook stove was carried out by showing the community how efficiently it could boil a kettle of water as compared to the firewood stove. This served as a part of Renewable Nepal project that PEEDA is currently executing.

4. Off grid hydro project in Bhutan

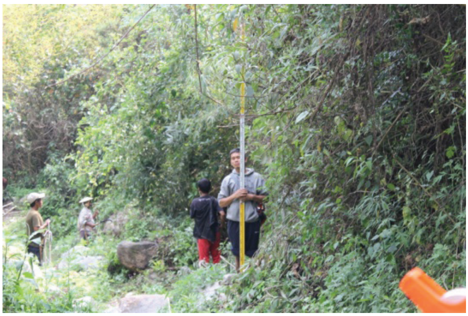

Fig 3: Field Survey in Bhutan

A joint technical team from Tarayana Foundation, Bhutan and PEEDA conducted couple of feasibility studies on off grid hydro project in Bhutan. The objective of this study was to electrify those remote villages who otherwise would not be electrified as these locations were proven to be expensive in order to be connected to the national electricity grid. One study was conducted in Phumzor village, inside the Jigme Singye Wangchuk National Park in Trongsa district in Central Bhutan. The technical feasibility study concluded the project as economically unsuitable. Another study was conducted in Dali village in Zhemgang district in Eastern Bhutan. Now, PEEDA and Tarayana Foundation are in the process of implementing Dali hydro project (17 kW unit) as the study found a technically suitable and economically feasible site to electrify Dali village.

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