Energy Gardens for Small-Scale Farmers in Nepal

Institutions, Species and Technology

Fieldwork Report

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Abbreviations and Acronyms

AEPC	Alternative Energy Promotion Centre
ANSAB	Asia Pacific Network for Sustainable Bio Resources
BGCI	Botanical Gardens Conservation International
CFUG/s	Community Forestry User Group/s
DFID	Department of International Development, UK Government
DFO	District Forest Office
DPR	Department of Plant Resources
ESON	Ethnobotanical Society of Nepal
ESRC	Economic and Social Research Council
FECOFUN	Federation of Community Forestry Users Nepal
FEDO	Feminist Dalit Organization
GHG	Green House Gas
GoN	Government of Nepal
I/NGOs	International/Non-Government Organizations
KATH	National Herbarium and Plant Laboratories
MSFP	Multi Stakeholder Forestry Programme
NAST	Nepal Academy of Science and Technology
NRs	Nepalese Rupees
PTA	Power Trade Agreement
RECAST	Research Centre for Applied Science and Technology, Tribhuvan University

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Executive Summary

Whilst access to clean energy is considered a fundamental to improve human welfare and protect environment, yet a significant proportion of people mostly in developing lack access to clean energy. Furthermore, efforts to generate clean energy through biofuel projects have attracted considerable controversy for displacing food production, land-grabbing, loss of biodiversity and greenhouse gas emissions. Creation of community-based biofuel project for small scale farmers using indigenous plant species in areas such as field bunds, waste land, community forests and fences provide a real opportunity to overcome some of the environmental and social concerns about biofuels and provide clean energy to rural communities in developing countries. Energy Gardens for Small-Scale Farmers in Nepal: Institutions, Species and Technology" is a scoping study funded by Department for International Development (DfID) and Economic and Social Research Council (ESRC) of the United Kingdom through ESRC-DFID Development Frontiers Research Fund - Grant reference: ES/K011812/1. This report brings together all the activities and outputs including fieldwork, workshops and advocacy work carried out as part of the Nepal Energy Gardens project.

The overarching objective of the project is to explore farmer and community use and perceptions of biomass and biofuel energy in Nepal in order to assess the potential for uptake of the energy garden approach. In doing so, the project reviews biofuel policies in Nepal, identifies potential indigenous plant species suitable for biofuel production, and provides an overview of suitable technologies for community based energy gardens projects in the country. Also, the project seeks to transfer knowledge through active engagement with our collaborators in India where energy gardens concept has been successfully applied. In doing so the project also facilitated deliberative dialogues between policy makers, scientists, development activists, donors and grassroots community representatives to identify ways to resolve existing issues and tensions pertaining to renewable energy sector.

The report highlights contemporary issues on renewable energy initiatives in Nepal with major focus on bioenergy. The workshop covered various aspects of renewable energy provisions in Nepal which included research approach, technology, past

initiatives in bioenergy sector and emerging issues, and tensions at program level (meso level). It is important to point out that the participants from rural communities (community forestry and local schools) raised some key issues related to the failure of bioenergy initiatives in rural villages. This study also identifies factors constrained community members in adopting bioenergy. The community members continue to face multitude of problems such as lack of compensation schemes in case of any losses in production, lack of quality seeds and technologies, inadequate promotion/awareness, market dominated production system, agency led initiatives, inadequate species selections, lack of buy back mechanism based on the market value, lack of realistic market strategy besides mass plantations, inadequate extension services, and lack of collaborative efforts between different agencies.

Nepal Energy Garden Project provides an alternative way of creating sustainable community based bioenergy provision for rural communities using previously unused lands, field bunds, and community forests for growing indigenous plant species for energy generation. Participation of multiple stakeholders enabled the project to start discussions at policy level to re-adjust/formulate relevant policies and programs with ultimate goals of reducing rural poverty and providing opportunity for diversifications of livelihoods amongst rural communities.

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PART ONE
Nepal Energy Gardens Project: Aims and Objectives

1.1 Introduction

Energy impinges all aspects of human societies - economic, social and geo-political and is therefore considered a fundamental input in economic activities, securing reasonable standard of living, promoting human health, enhancing technological innovation and achieving sustainable development (Birol, 2007; Hoogwijk, 2004; Rogner, 2000; Turkenburg, 2000). There is growing evidence that incidence of poverty is high in areas and communities where access to energy remains low, highlighting the importance of energy security for poverty reduction, livelihood sustenance and improving wellbeing (Srivastava and Rehman, 2006; Pachauri et al., 2004). However, more than 3 billion people, mostly from developing countries lack access to "adequate, affordable, reliable, high quality, safe and environmentally benign energy services to support economic and human development" (Masud et al., 2007). Many rural communities in developing countries have been experiencing an energy crisis. Extension of the national grid to many rural areas is difficult because of the geographical terrain and high cost. Lack of access to modern energy has meant that households and communities in developing countries rely on traditional fuels such as firewood, agricultural residues and animal dung cakes for cooking, heating and lighting. Inefficient burning of traditional fuels leads to indoor air pollution (IAP) with detrimental effects on human health causing eye infections, lunch cancer, bronchitis, chronic obstructive pulmonary disease (COPD) and acute lower respiratory infection (ALRI) (Bruce et al., 1998; Ezzati and Kammen, 2001; Smith et al., 2000). IAP ranks as the third major contributor to morbidity and mortality, only after malnutrition and unsafe water and sanitation (Kurmi et al., 2010) causing more than 1.5 million deaths, mostly amongst children and women across the developing world (Rehfuess and WHO, 2006) for which it is also called the “killer in the kitchen” (Bailis et al., 2009). In addition to respiratory and eye diseases, a dependency on firewood has other health implications as many women and children carry heavy bundles of firewood or wooden logs on their shoulders, head and back from forests to home and local markets causing muscular strain, head, neck and back pains. Women and young girls are particularly vulnerable as many they spend more time collecting fuel wood from the forests (Haile, 1991; Cecelski 1999, UNDP, 1997).

In many developing countries, access to education can be influenced by not only having access to educational resources such as books, stationary, schools and teachers, but also access to energy. Bhusal et al. (2007) argues that development interventions to electrify rural communities, such as in Humla district in Western Nepal, has the potential to double the district’s combined “education” HDI factor from 0.23 to 0.46 within a decade. Similarly, a growing body of literature has found direct and positive impacts of access to electricity on education (Andersson et al., 1999; Foley, 1992 & 2000) in many developing countries. Case studies from India (Sharma, 2005); Africa (Kirubi et al., 2009); the Philipines (Barnes et al., 2002); and Bangladesh and Vietnam (Wang, 2004) noted that rural electrification, either through biogas or photo-voltaic solar power, significantly contributed to lighting and thermal energy facilities in the schools, mainly in rural areas. Similarly, studies by Rajbhandari (2011) demonstrated that recurrent load shedding in Nepal has impacted all sectors: residential, commercial and education in Nepal making access to clean energy a major developmental challenge. As a result, many school children, especially girls, are kept out of school to assist in wood collection (Clancy et al., 2003) sometimes walking more than 20 kilometres daily, contributing to gender imbalance in schools (Rothchild, 2006). Furthermore, time saved from not having to go to the forest to collect firewood, and preparing dung for cooking and heating, can be used by reading and educational activities. Katuwal and Bohora (2009) reported that 11.5% of women in rural areas used the time saved due to availability of biogas plants in their houses for reading in the evening, particularly through adult education, which has contributed towards reducing adult illiteracy in Nepal. Because communities and household members, especially women, spend more time in provision of fuel for households, they lack sufficient time to be involved in income generating activities, adding to their level of poverty.

1.2 Energy situation in Nepal

Data on Nepal's energy demand and supply are still very sparse, partly because an overwhelmingly proportion of the Nepalese population rely heavily on the traditional sources of energy particularly solid wood, agricultural residues and animal dung for both for cooking, heating and lighting. The Energy Symposium Report 2010 prepared by the Water and Energy Commission Secretariat of the Government of Nepal is the only recent and most comprehensive assessment of country's energy status (WECS, 2010). The sources of energy in Nepal can broadly be categorised into three categories namely traditional, commercial and alternatives. The traditional sources of energy contribute 87% of energy generated in Nepal with 75% coming from burning solid fuelwood and 6% from animal dung. The proportion of energy generated through commercial sources remains very low, for example coal- 3%, petroleum products -9%); grid electricity -2% and alternative and renewables - 1%.

Nepal is considered one of the richest countries in water resources in the world, second to Brazil. It has 6000 perennial rivers with an average water runoff of 225 billion cubic meters and a huge potential for energy generation. Studies on Nepalese energy potential have estimated Nepal's theoretical hydropower potential of 83 GW, of which 42 GW is considered realisable (Pokhrel, 2003; Zahnd and Kimber, 2009). However, only 1% of Nepal's total potential hydropower has been used so far (Ale and Bade Shrestha, 2009). As a result, the National Electricity Authority (NEA) could meet only 77.45% of peak demand whilst remaining 22.55% was affected by load shedding. Almost 18% of demand was met by importing electricity from India (NEA, 2014). Nepal's inability to harness its hydropower has been attributed to a number of factors, such as lack of resources, both financial and technically; the Maoist led civil war (1996-2006) and prolonged political transition; and lack of political commitment and accountability (Udall, 1995; Gywali and Dixit, 2010; Ives, 2004).

Despite having huge potential for energy generation, Nepal suffers from a severe energy crisis with load shedding of sometimes up to 20 hours a day crippling economic, education, security and livelihoods. Efforts to reduce poverty and increase energy security through solar power, biogas and improved cook-stoves have gained some success, but they continue to face multiple challenges. Firstly, such interventions have had little consideration of socio-economic factors, which ultimately determine the social acceptability of technological interventions and the transaction costs of uptake. Secondly, distribution of such interventions has not been equitable, as available subsidies have been targeted mainly at accessible areas and for those who could afford the initial upfront costs. As a result many rural households and communities are still depend on traditional sources of fuels such as fuelwood, agricultural residues and animal dung for various household purposes including cooking, heating and lightening. These have resulted in a systematic exclusion of many households and communities living in remote areas from technological interventions and secure energy supply. A high dependency on fuelwood for energy not only adds pressure on local forest resources but inefficient burning of traditional sources of fuels causes detrimental impacts on human health due smoke inhalation and indoor air pollution. Not surprisingly, published statistics indicate that incidence of poverty is high in areas and communities where access to energy remains low, highlighting the importance of energy security for poverty reduction, livelihood sustenance and improving wellbeing.

Whilst some initiatives have taken towards implementing biofuels in Nepal, they have focused on single species, Jatropha, which is not native, overshadowing hundreds of other native oil-seed plant species. Furthermore, implementation of renewable and alternative sources of energy such as biofuels and biomass have attracted controversy for displacing food production, land-grabbing, loss of biodiversity and greenhouse gas emissions. Radical thinking and new approaches are required to tackle growing energy and income poverty amongst rural communities, whilst simultaneously protecting the environment and sustaining livelihoods. This requires application of pioneering theoretical and methodological approaches and collaboration of multiple disciplines to complement each other's expertise and engage stakeholders in new and novel streams of enquiry or practice including learning lessons and transferring policies and practices which have become successful to areas and communities.

Energy gardens for small-scale farmers in Nepal: Institutions, species and technology (Grant reference: ES/K011812/1) is a multidisciplinary research project funded through the ESRC-DFID Development Frontiers Research Fund. The project is a collaboration of both academics and practitioners including engineers, botanists, social scientists, institutional economists and development practitioners from Nepal, India and the United Kingdom working together to explore the possibilities of creating small scale biomass and biofuel production have an important role to play in sustainable energy provision for socio-economically disadvantaged rural communities in Nepal.

1.3 Aims and objectives

1.3.1 Aims

The main aim of this research project is to provide an innovative approach to the practise of energy management in small-scale farms through the creation of Energy Gardens, and overcoming environmental and social concerns about biofuels. In doing so, the project has built collaboration amongst various stakeholders including academic, policy makers and practitioners and end-user communities as a first step towards implementing 'Energy Gardens'. The project established links across disciplines that do not usually work together and across non-traditional partnerships by integrating research on the institutional economics of energy and technology transfer with the knowledge of botanists and engineers.

1.3.2 Objectives

The overarching objective of the project is to explore farmer and community use and perceptions of biomass and biofuel energy in Nepal in order to assess the potential for uptake of the energy garden approach.
The specific objectives of the project are:

a) To investigate the institutional economics of energy biomass and biofuel production from local to national and global scales.
b) To investigate social acceptability of Energy Gardens concept and technology transfer.
c) To assess the availability and identification of suitable plant species and under-utilised biomass which could be used for energy production.
d) To undertake a technical assessment of resources and conversion routes for identified biomass resources for energy production.
e) To devise socio-economic incentives and structures for community cooperation and building long-enduring institutions around energy production and technology uptake.
f) To dissemination and knowledge transfer amongst project partners.

1.4 Collaborating partners

The following organizations are the collaborating partners on the project

a) Asia Network for Sustainable Agriculture and Bioresources (ANSAB)

a. [http://www.ansab.org/]
b. ANSAB has practical experience of biomass and bioenergy implementation projects, especially on plant oils, bio-gas, bio-briquette and improved cooking stoves. ANSAB works on the concepts for scaling-up of the bio-briquette value chain and dissemination of renewable energy technologies in mountains areas of Nepal.

b) Ethnobotanical Society of Nepal (ESON)
   a. [http://www.eson.org.np/]
   b. ESON contributed on identification of potential indigenous Nepali plants for biomass and biofuel production in an energy garden.

c) Practical Action Nepal [http://practicalaction.org/wherewework_nepal]
   a. Practical Action Nepal has experience in the implementation of small-scale energy projects and advised the team on selection of communities for in-depth sampling. It also has been contributing to preparing a report on bioenergy use by small-scale farmers, including information on species used, amounts and technology.

d) Feminist Dalit Organisation (FEDO) [http://www.fedonepal.org]
   a. FEDO contributed towards a review on bioenergy use by the poor and marginalised members of the community, with emphasis on energy poverty, health impacts (e.g. indoor pollution); and how the energy garden concept can be effectively implemented so that the poorest of the poor can also receive benefits.

e) Botanic Gardens Conservation International (BGCI) [http://www.bgci.org/]
   a. The BGCI disseminated the energy garden concept through its international network of botanical gardens.

f) Hassan Biofuels Park [[http://biofuelpark.org/]

   a. Hassan Biofuels Park hosted a fact-finding mission to assess the potential for transfer of the Hassan project to Nepal, and continues to share its expertise with project partners for implementation of energy gardens in Nepal.

g) University of Leeds [http://www.leeds.ac.uk/]

   a. University of Leeds is providing a strategic leadership in the project through a joint efforts of the PI (Prof. Jon Lovett), Co-PI (Dr Andy Ross) and Research Fellow (Dr Bishnu Pariyar). All the research design, operation and analysis are carried out by the colleagues based at the University of Leeds. Prof. Lovett provided inputs on institutional economics, theory and practise, and integration of disciplines. Dr. Ross is providing help towards assessment of potential for underutilised indigenous biomass to conversion to a particular biofuel in light of technical possibilities. Dr. Pariyar conducted the field-based research including household survey, focus group discussions and key informant interviews and written up the reports.

1.5 Scope of the study

The term biofuels can be used to refer to a large number of different things. The scope of this project was limited to solid and liquid biofuels from non-edible crops that can be used by community as their energy source and as substitute for some conventional fossil fuels (kerosene, petrol and diesel) in residential, transportation and service sectors. It has identified the plant species based on their socio-economic impact and a review of the biofuel plant species available in Nepal is presented. Rules and regulations governing biofuels in Nepal are briefly reviewed. The report also highlights the technological possibilities for biomass energy for small farmers.

This report is structured in nine parts. Part I presents the problem statements and describes the approach taken by this project to enhance energy security including aims and objectives of the project and contribution of collaborating partners. General scope of the project is also presented in Part I. Part II presents the information on fieldwork sites, methods and activities undertaken as a first phase fieldwork of activities during fieldwork in Nepal. Part III presents information on the fact-finding visit undertaken by the project team to the Hassan Biofuel Park in Karnataka, India as a way of fostering south-south partnership and learning valuable policy lessons. Part IV presents the proceedings of the Nepal Energy Gardens Ambassadors' Workshop. Part V presents results of the household survey, which took place between 15th March and 10 April 2014. The household survey covers various aspects of community and household energy provisions, social capital and gender aspects. Part VI presents results of the plant survey carried out by ESON. Using case studies and fieldwork, and through primary and secondary sources it identifies potential indigenous plant species suitable for energy production. Part VII reports on the available technologies for biofuel production in light of the biomass available in Nepal. Part VIII presents the observations from the stage fieldwork in Nepal, which took place in October 2014. National and local institutions and rules and regulation pertinent to biomass and biofuel are reviewed in Part IX, which presents possibilities for implementing energy gardens in Nepal. The final part of report Part X presents the lessons learnt from the fieldwork in Nepal and outlines future directions for implementing energy gardens in Nepal.

PART TWO
First Phase of Fieldwork in Nepal

2.1 Project sites

The fieldwork for this research took place in three Village Development Committees namely Lakuri Danda (Dolakha), Khudi (Lamjung) and Hamsapur (Gorkha) in the mid-hills region of central and western Nepal. Lakuri Danda village is situated at an approx. 70 km east of Kathmandu on the way to Charikot, the district headquarters of Dolakha district, and has an area of 27.7 km^2. The Jiri Road runs through the village but some wards were almost 3 hours south of the highway. The total population of Lakuri Danda is 3713 with 1734 (46.7%) male and remaining 1979 (53.3%) females residing in 924 households. The population density is 135/km^2. Mude Bazaar is the local market place on the Jiri highway, which also served as a local market for the population of Lakuri Danda where people could buy daily essentials including batteries, kerosene and candles.

The village of Khudi was located at the northern part of Lamjung district, which is about 250 km west of Kathmandu, and further 45 km north of Besishahar, the district headquarters, and was served by a gravelled road. The area of Khudi village is 101.3 km^2. Khudi village has a population of 3401 with 1510 (44.4%) and remaining 1891 (55.6%) females living in 826 households. The population density of Khudi is only 34 person/km^2. A small market place called Khudi bazaar served as a shopping stop for the entire village where people buy essentials.

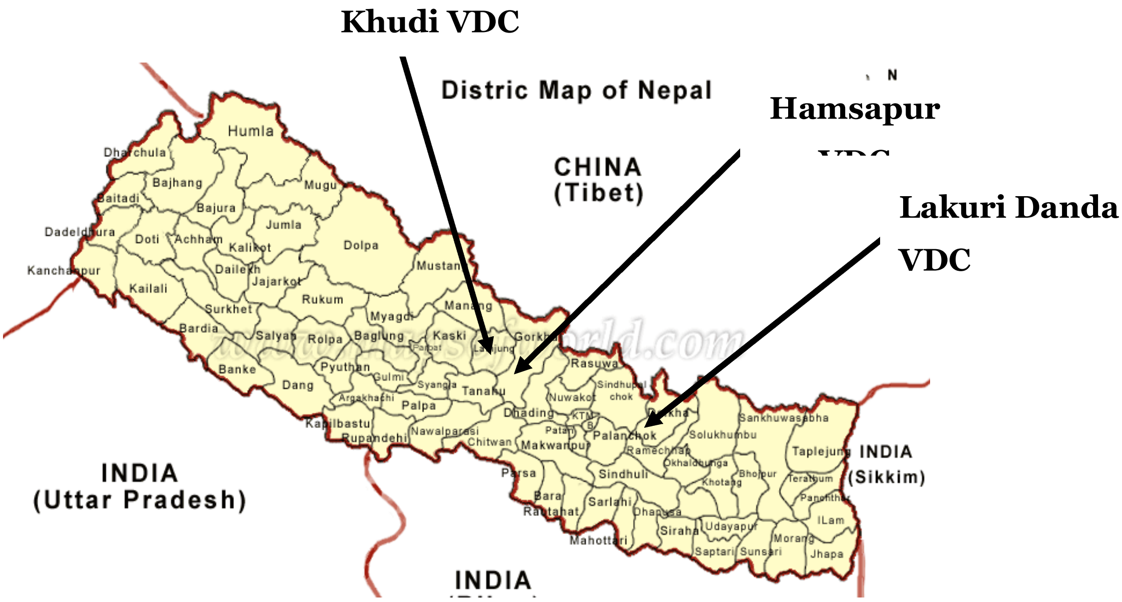

Figure 1: Map of Nepal showing location of project sites

The village of Hamsapur is located on the western side of Gorkha district, which is approx. 200 km west of Kathmandu. Hamsapur is served by seasonal road tracks where vehicles can only pass during the dry season. The total population of Hamsapur is 3658 with 1640 (44.8%) males and 2018 (55.2%) females. The area of Hamsapur is 17.6 km^2 and it has a population density of 208 person/km^2.

All three villages were typical rural villages with agriculture and animal husbandry as the main occupation. Many youths from all the villages were working abroad, mainly in the Middle East, and remittance was an important part of the economy both at household and community level. Demographically, the population of all the three villages was mixed, with majority being Tamang, Gurung and Brahmin/Chhertri as the major castes in Lakuri Danda, Khudi and Hamsapur villages respectively. A large number of Thami caste (an indigenous ethnic group) were also living in Lakuri Danda village. Farmers in Lakuri Danda grew mainly potato, maize and millet in pakho bari, and some farmers grew monsoon paddy in khetlands. The main crops grown in Khudi and Hamsapur were monsoon paddy in Khet land and winter wheat in khetland and maize, millet and potato in pakho bari.

The climatic conditions of the three districts were similar, but varied within the districts ranging from sub-tropical in southern parts, temperate and sub temperate (in mid-high hills) and tundra in the northern mountains. The VDCs were selected to have similar environmental conditions and altitude. Consequently the major vegetation types in all the VDCs were also similar. The main plant species were: *Schima wallichii, Alnus nepalensis, Pinus roxburghii*, *Symplocos pyrifolia*, *Shorea robusta, Rhododendron arboreum*, *Melia azederach*, *Mangifera indica, Maesa chisia, Ficus religiosa*, *Eurya acuminata, Dalbergia sisso, Buddleja asiatica*, *Ageratina adenophora*, *Gaultheria fragrantissima*, *Artemisia indica, Jatropha curcas, Brassica rapa*, *Helianthus annus* etc. The forest density in Khudi VDC was moderate but that of Lakuri Dada VDC and Hamsapur VDC was more dense and diverse.

2.2 Project planning

The project started in October 2013. Recruitment for PDRA did not take place until December 2013 due to a work permit issue for the named PDRA on the project. Initially the PDRA was employed on a part-time basis to carry out preparatory work for starting the project in Nepal. As a first task, the PDRA carried out a comprehensive literature review on energy consumption in Nepal. The literature review contributed to informing research design and planning of fieldwork. The literature review is being revised for submitting in a suitable international journal.

The part-time employment enabled the PDRA to liaise with the project partners in Nepal and India and plan for the project launch and fieldwork. A slight delay in the start of the project has meant that fieldwork had to be carried out immediately after the project launch in Kathmandu. The fieldwork preparation included tasks such as designing questionnaires, preparing a topic guide for key informant interviews and focus group discussions, recruiting field-based research assistants, site identification and completion of necessary paperwork. These tasks were carried out during the part-time employment by the PDRA. Since capacity building in the host country is one of the core components of the project, some Nepali final year undergraduate and post-graduates students were recruited, trained and subsequently employed as field-based research assistants for the duration of fieldwork.

2.3 Project launch

His Excellency Andrew Sparkes, the British Ambassador to Nepal, formally launched the Nepal Energy Garden Project on 2nd March 2014. Altogether more than 150 dignitaries attended the programme. A major TV station and newspapers covered the event. The participants included students from Budhanilkantha School - Centre of Excellence. Participants included all the project partners and the audience came from Tribhuvan University, Kathmandu University, Kanjirowa National High School (Kathmandu), Khwapa College, Padma Kanya College, Shanker Dev Campus and BBP College (Leeds, UK), Nepal Academy of Science and Technology (NAST), Society of Ex-Budhanilkantha Students and the Senior Management Team of Budhanilkantha School. The inaugural programme was organised as a day conference with papers presented by representatives from FEDO and Practical Action Nepal. Mr. Bhim B.K. presented FEDO’s work on discrimination against Dalits and their access to natural resources, including energy; whilst Ms. Samjhana Bista presented Practical Action Nepal’s work on rural energy in Nepal. Prof. Jon Lovett, Principal Investigator gave a talk on Massive Online Open Access Course (MOOC) and the Leeds MOOC ‘Fairness and Nature: When the Worlds Collide’, which features a debate on natural resource management in Nepal. There conference concluded with a lively question and answer session. As a result of the MOOC talk, many participants from Nepal enrolled on the course, which ran between 31st March and 13th April 2014. Participants in the MOOC showed a high level of engagement and there were some thought provoking discussions on issues such as climate change and access to natural resources such as land, water and energy amongst others.

Photo 1: His Excellency Andrew Sparkes, British Ambassador to Nepal during the conference

2.4 Fieldwork

2.4.1 Full team meeting

Following a successful project launch in Kathmandu, a full project team meeting was held at the meeting room in Budhanilknatha School. All the collaborating partners participated in the meeting.

Prof. Lovett presented the core idea of the project and mentioned that it is a short-term feasibility study to identify the potential for creating community-based Energy Gardens in rural Nepal to meet some of the fuel demands at households and community level. As such, the team agreed that the field sites need to be in areas where there is already some baseline information and good local contacts for permission and key informants. Practical Action has suitable field sites in many rural districts in mid-hills regions and the villages can be included as a study sites for Energy Gardens project. Initially, the team had proposed Gorkha district as the only site for fieldwork partly because of its elevation range. However, in order to control for altitude variations, it was agreed that the three villages, which are situated in comparable altitude (200-2500m) in Dolakha, Gorkha and Lamjung would be fieldwork sites.

Photo 2: Dr Bishnu Pariyar, with Research Assistants in Khudi VDC, Lamjung district, Nepal

Table 1: Participants of the first full project team meeting

SN	Name of Participants	Organisation
1	Prof. Jon Lovett	University of Leeds
2	Dr Bishnu Pariyar	University of Leeds
3	Prof. Krishna Shrestha	ESON
4	Dr. Bhishma Subedi	ANSAB
5	Mr. Pushpa Ghimire	ANSAB
6	Ms. Samjhana Bista	Practical Action Nepal
7	Mr. Bhim BK	FEDO

As per the decision of the first full project team meeting, the PDRA, Bishnu Pariyar had a follow up meeting with colleagues, namely Samjhana Bista; Vishwa Amatya and Min Malla from Practical Action Nepal participated. The meeting focused primarily on fieldwork logistics, including site selection, identifying local contacts and questionnaire design. During the meeting, it was decided that Min Malla would provide information on fieldwork related issues.

2.4.2 Questionnaire design

In order to carry out the household survey, a questionnaire was designed to gather information on household and communal provisioning and acquisition of energy in rural communities. Households and communities in rural Nepal rely on fuelwood for cooking, heating, boiling and preparing animal feed. In addition to cooking meals for household members, many, farmers also cook animal feed for their cattle. Animal feed also called “kudo” is a homemade concentrate feed made from a mixture of maize flour, rice bran, and some kitchen waste that has been boiled and salted. Households collect firewood mainly from local forests, which are mostly community managed. As such, rules governing community forests also guide residents’ access to forest products such as fuelwood, fodder, timber and herbs.

The questionnaire consisted of eight sections. Section 1 covered general aspects of household characteristics such as name of VDC, ward, settlement type, caste and home ownership. Section 2 covered demographic information including respondents’ age, gender, household size, education and time and money spent on acquiring fuels such as fuelwood, agricultural residues and biogas. Household landholdings, tenure and production systems were covered in Section 3, whilst Section 4 included information on household assets including livestock, bulbs, heaters fans and other assets which contributed to households’ energy consumption and general socio-economic status within the village settings. Section 5 was geared towards collecting information on households’ and community understanding and perceptions of biofuels. Section 6 was designed to obtain information on various aspects of rural energy provision such as energy consumption, energy sources, energy security/insecurity, energy consumption activities and households and community activities affected by energy insecurity.

Section 7 included some close ended questions designed to obtain information on household awareness and participation in communal activities such as participation in meetings for forest user groups, women's groups and local saving and credit associations. It also contained questions on the general level of social capital and level of trust amongst the villages. Section 8 included information on gender dynamics within the household and community for undertaking household and community related work. These questions were geared towards understanding the gender and power relations in the villages. The questionnaire was pre-tested in a randomly selected village outside the sample frame. The pre-testing helped the team to identify issues and refine/remove "difficult to answer" or irrelevant questions.

In addition to providing guidance and suggestions, Min Malla from Practical Action Nepal also contributed towards designing and finalising the questionnaire, fieldwork planning and introduced the PDRA to local contacts in the selected project sites.

Photo 3: Dr. Bishnu Pariyar, PDRA at Practical Action-Nepal in Kathmandu

2.4.3 Research methods

This study is based on formal and informal, secondary and primary sources. The main methods of data collection included i) household survey, ii) review of literature and records, iii) consultation and interviews with key experts at national level, iii) focus group discussions and iv) visit to Hassan Biofuel Park, India. Data and information were organized, processed and analysed with reference to two major components of the study - major biofuel plant species in Nepal; and potential for integration of biofuel species into farm and forest systems in Nepal. Important biofuel species have been identified and shortlisted based on socio-economic impact and industrial growth potential. Market demand and supply was examined to assess opportunities for expansion. The main indicators used for the assessment of socio-economic impact were income and employment generation potential.

Altogether 300 households were surveyed from three VDCs: Khudi (Lamjung), Lakuri Danda (Dolakha) and Hamsapur (Gorkha). A stratified random sampling method was used to sample the households. The sampling framework was designed with due consideration to local socio-economic and demographic factors. Households were divided on three categories - rich, middle and poor households using a wealth ranking exercise and the amount of landholding. Samples were drawn on proportional basis from different income groups, castes, gender and household sizes to make the sample representative for statistical analysis.

Altogether fifteen semi -structured interviews were held, with five interviews from each of the three case study villages. The participants of the key informant interviews were also drawn from different categories to reflect the socio-economic heterogeneity of the community including local leaders, businessmen, community members and local development experts who had considerable experience and wealth of information regarding important aspects of communities in the villages.

Similarly, fifteen focus group discussions with five from each of the three VDCs were held at different locations within the selected VDCs. The participants of the focus group discussions also represented existing socio-economic heterogeneities in the villages with participation from different landholding categories, castes, gender and local development experts to obtain views of different section of the community. The rationale for undertaking key informant interviews and focus group discussions was to gather qualitative information on farmers' perspectives on the status of the local forests, rules and regulation in the use of biomass and forest resources at local level, communal and social capital, and various issues pertinent to local development and how experience from those can be utilised for community-based biofuel projects such as energy gardens. Crucially, the data collected through key informant interviews will help to shed light on issues not captured in the household survey. The data collected through the key informant interviews addresses the institutional aspects of energy gardens i.e. the role of institutions in enabling households and communities to explore the opportunities offered by energy gardens. Expectation is that the data generated through the key informant interviews will be helpful for explaining differences in the level of fuel consumption, local fuel demand, supply and across all levels of heterogeneity considered for this research.

Many rural farmers had little or no understanding of climate change, food and energy security. Whilst they were aware of the need to secure their livelihoods, they had very little appreciation of their own vulnerability to the impacts of climate change. The villages were excited about the research taking place in their villages, they also had some suspicions about our activities and doubts about the possible benefits to households and communities. Whilst we felt the need to raise awareness about the issues such as climate change, energy security and need to make their livelihoods sustainable, we neither wanted to lecture the farmers like politicians nor teach them like an external consultants. This is because if we talk with them like politicians they will not simply believe us as politicians had broken many promises in the past. And, many consultants working from NGOs based in Kathmandu had carried out research in the area but rural farmers had not experienced tangible benefits from them.

Since the farmers were sceptical about external people advocating development in their villages, we needed a method of communication that would help build rapport and enable us to take on board villagers' views from the onset of the fieldwork. The team sang two rounds of Dohori songs with villagers from Khudi and Hamsapur villages. Dohori music is a type of Nepali folk song, in which participants are divided into two competing groups who engage in a rhythmic debate in the form of quick and witty songs. The villages were grouped on one side whilst the energy gardens team were on the other side. The villages asked questions in songs regarding biofuels, aims and objectives of project; and shared the difficulties they faced in energy provision in the rural villages. The Energy Gardens team then answered those questions in the form of songs. Local musical instruments such as Madal (drum), basuri (flute), jhyali (percussion instrument) were played. Both the villagers and the Energy Garden team members sang and danced for almost two hours in both Hamsapur and Khudi villages. The event took place in the evening around 8 p.m. after dinner to ensure maximum participation from the local villagers. The dohori sessions provided the villagers with the opportunity to learn about the impacts of climate change and how these will contribute their own vulnerability. The farmers also learned about their livelihoods, energy and food security and the nature and scope of the Energy Garden project. The following section presents an extract of the dohori songs between the villagers and Energy Garden fieldwork team.

गाउँले: टाढाबाट यहाँ सम्म आउनु भो, कस्तो खाले कार्यक्रमा ल्याउनु भो?
Villagers: You came from far flung place, we wonder what type of programme you have brought?

अनुसन्धानकर्ता: बिदेसी इन्धनमा नपरौ बन्धन, कार्यक्रम हो जैबिक इन्धन।
Researcher: let's not get shackled on foreign fuels, the progamme is called biofuels [Nepal Energy Gardens project]

गाउँले:धेरै भा'छ इन्धन खपत, कार्यक्रमको उद्देश्य के छ त?
Villagers: We have plenty of energy consumption, what are the aims and objectives of your project?

अनुसन्धानकर्ता: धुँवाले जिबन दुई दिनको खेल भो, निकाल्न त खोजेको तेल हो।
Researcher: The smoke [from fuelwood] has made life short, therefore, our aim is to produce some biofuels

गाउँले: पर्दैन त ति दाउरा बोक्नलाई?, बुढी आमा छोडलिन त खोक्नलाई ?
Villagers: So, we don't need to carry those fuelwoods, elderly mothers can't stop coughing [due to indoor air pollution]

अनुसन्धानकर्ता: रोग लाग्या छ आमा-बुवामा, घुल्नु पर्दा धुलो र धुँवामा ।
Researcher: Elderly mothers and fathers are suffering because they have to endure dust and smoke (dirt).

गाउँले: छोडि गये लाग्ला नि फेरि पाप, दु:ख देखाइ जगाइदेउ हाकिम सा'ब ।
Villagers: Don't leave us alone, you will regret, convey our problems to your boss and inspire your boss [to do something for the villagers]

अनुसन्धानकर्ता: यो गाउँको समस्या बुझ्ने छु, कायक्रम ल्याउन म धेरै जुध्ने छु।
Researcher: I absolutely understand the problems in the village, so I will try very hard to bring the programme.

Photo 4: Dohori in Hamsapur

Photo 5: Musical Instruments used in Dohori

2.4.4 Energy garden ambassadors

The project launch event was organised at Budhanilkantha School to minimise costs and engage with the students, who come from all the 75 districts of Nepal, so that they could participate in the project launch programme and learn about biofuels. There was a high level of enthusiasm from the students participating in the project launch workshop and strong interest from the students to get involved in the project. In response to this, senior students from Budhanilkantha School (Kathmandu), Kanjirowa National High School (Kathmandu) and Shree Shailaputri Higher Secondary School (Lamjung) have been nominated and trained as Energy Garden Ambassadors on a volunteer basis. The Energy Gardens Ambassador team have been actively involved in online discussions through social media sites such as Facebook. One of the important policy lessons learnt from the fieldwork was that there is a potential for Energy Gardens to be integrated within community forests. We are in contact with the Federation of Community Forests Users (FECOFUN) as to how best we can collaborate. A formal training workshop for the Ambassadors including representatives of the community foresters from rural Nepal was scheduled for October 2014 in Kathmandu. The Ambassadors team has a gender balance and represents students from both cities and villages. They are an integral part of project dissemination activities and will help to raise awareness about climate change, vulnerability, livelihoods and energy security. Through the activities of the ambassadors, the project will be able to create a lasting legacy and impact of the project will be realised in many rural villages in Nepal.

Photo 6: Energy Garden Ambassadors in Lamjung

Photo 7: Energy Garden Ambassadors in Kathmandu

2.5 Meeting with the Minister

In addition to forging long-term research collaboration with local NGOs, the project is also working closely with the Government of Nepal. Dr Bishnu Pariyar visited the Ministry of Agriculture Development at Singa Durbar, Kathmandu and a consultation meeting was held with Minister for Agriculture Rt. Hon. Hari Prasad Parajuli. Dr. Pariyar briefed the Minister on the Energy Gardens project and presented the first output of the project - a special edition of the BG Journal focusing on biofuels, in which the Nepal Energy Gardens project was a featured article. The Minister was delighted to hear about the project and promised to provide all the necessary Government support at Ministerial level for the possible implementation of Energy Gardens in Nepal.

Photo 8: Dr Bishnu Pariyar with Rt. Hon. Hari Parajuli, Minister of Agriculture in Nepal

PART THREE
South-South Collaboration

3.1 Purpose of the India visit

A key component of the proejct was to foster South-South collaboration for knowledge transfer. The PDRA, Dr Bishnu Pariyar led a five member delegation on a four day project visit to Hassan Biofuel Park and the University of Agricultural Sciences, both based in the southern Indian state of Karnataka from April 2-6, 2014. The main objective of the visit was to understand the production process of biofuel from seed to biodiesel; and how the local communities were successfully mobilised along the supply chain. The visit was a fact finding mission to understand the success story behind the biofuel project in Banglore, so that any successful implementation could also be replicated in Nepal. The following team members visited Hassan Biofuel Park in India.

a) Bishnu Pariyar (Team leader), University of Leeds
b) Kusang Yonjan Tamang, Practical Action Consulting
c) Sudarshan C Khanal, ANSAB
d) Punyawati Ramtel, FEDO
e) Laxmi Raj Joshi, ESON

Photo 9: Energy Garden Delegation in Hassan, India

The Hassan Biofuel Park, established at Madenuru, Hassan in an area of 50 acres belonging to the University of Agricultural Sciences Bangalore (UASB), and started functioning in 2007. The team was briefed on the project by Dr. Balakrishna Gowda, Professor at UASB and Project Coordinator of the Biofuel Park. The team also visited the nursery where seedlings of oilseed producing plants were grown, as well as the demonstration centre within the park. The demonstration centre produces oil and biodiesel from the oil and also acts as a collection and distribution centre for seeds and biodiesel.

The following section reports field observation and lessons learnt from the visit.

3.2 Some observations from the India visit

3.2.1 Criteria for plant species selection

The Hassan Biofuel Park was created with an overarching aim of helping rural communities to reduce their dependency on fossil fuels and encourage the use of biofuels produced from their own native plant species towards meeting some of their household energy demands. In Hassan Biofuel Park, selections of plant species are made in such a way that they provide multiple ecosystem goods and services to the communities. The entire biofuel project is based on the premise that household biofuel production should not affect the agricultural system, so that food security and sufficiency are not disturbed. In Hassan, the native plant species are mostly grown in farmlands for this purpose (more than 80% in Karnataka state). There are many benefits of choosing such species over the exotic species. For example, people can easily recognise these species and they are also culturally familiar with the multiple goods and services provided by such species. Moreover, native oil yielding plant species are well adapted to the prevailing environmental conditions of a particular region and will produce yield year round. Thus there is always a likelihood of earning people's trust and eagerness for adapting such species in their fields.

We observed that many oil yielding plant species were currently grown as biofuel plants in and around the Biofuel Park and collaborating communities. Seedlings and saplings are being produced in the Hassan Biofuel Park, and Research Center on Organic Farming, University of Agricultural Sciences, Bangalore, using techniques such as grafting. The entire mass propagation system does not rely on artificial chemical manures. Preferred native species in terms of oil yield are: *Aphanamixis polystachya* (Meliaceae); *Azadirachta indica* (Meliaceae); *Callophylum inophyllum; Madhuca indica* (Sapotaceae); *Mesua ferrea* (Clusiaceae); *Pongamia pinnata* (Fabaceae); *Sapindus* sp and *Eucalyptus* sp.. Similarly, exotic plant species preferred for oil extractions are: *Simarouba glauca* (Simaroubaceae).*Hevea braziliensis* –Rubber (Euphorbiaceae) and *Jatropha curcas* (Euphorbiaceae).

Photo 10: Ripen biofuel seeds in Hassan Biofuel Park, Kanataka, India

3.2.2 Production process

Only extraction of oil is currently possible at the community level because filtration of oil and refining the filtered oil into biodiesel are processes that require sophisticated equipment and technical expertise. The filtered oil is then chemically processed through transesterification to separate clycerin from the oil.

The oil extracted is used as biodiesel and glycerine is supplied to other industries such as pharmaceutical industries, soap industries, leather industries etc. which utilise them to make soaps and other cosmetic products. However, most of the villagers opt to only harvest the seed and sell the seeds to the collectors who then supply the seed to industrial level biodiesel extractors.

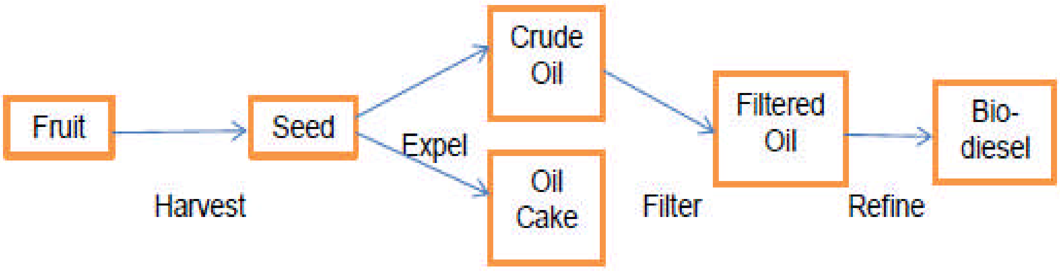

Figure 2: Production process for biofuel in Hassan, India

3.2.3 Production potential

Studies by Hassan Biofuel Park estimate that biodiesel can meet as much as 10-15% of the fuel requirement in the transportation sector and up to 80% of the requirement for household/rural energy needs in Karnataka state. Scientists in Bangalore arguing that this potential could also be achieved nationally. However, the biofuel projects in Karnataka, including the Hassan Biofuel Park, are primarily focused on fulfilling household fuel demand, including household cooking, heating, lighting, ground water pumping, operation of agricultural machinery etc.

The Biofuel Park distributes biofuel plants saplings free of charge to residents of Hassan District. However, a nominal price is set for farmers from outside Hassan District, which is around IRs. 18 per sapling. The outsider farmers do not have to pay upfront for the saplings, and can pay once they benefit from the plants grown in the field and can make use of technologies adopted in the biofuel park. Households with small landholdings and marginal farmers have planted a minimum of 5-6 biofuel plants in their farmlands, while those having larger landholding capacity have planted up to 100 and more plants. Altogether 467 villages have joined the biofuel program and each village on average is producing 3-4 tons of seeds per annum, of which 30% is used for production of crude biofuel (oil). Currently, in India petrol costs IRs. 50 per litre and it was reported that biofuel costs IRs. 2-3 per litre less than the industrial petroleum products.

3.2.4 Community involvement

The Biofuel Park has been able to mobilize communities in 2559 villages in Karnataka including Hassan district. Each villages formed a "Farmers' Association" comprised of 5 male lead farmers and 5 female farmers from the local women self-help groups.

Photo 11: Visiting team with villagers in Hassan, India

These Farmers Associations have a working model of collective growing, collecting, marketing, selling and value addition (oil pressing). The oil cakes (left over after expelling oil from the seeds) are used as animal feed, in bio-gas plants and as natural fertiliser.

The Biofuel Park advises villagers against planting the trees in agricultural land as biofuel should not be competing against food crops. The areas where farmers planted trees include areas along the border of their farms, field bunds and other non-agricultural lands. The community are aware that the oil-producing trees will not be their main source of income but will supplement their annual income by INR 150 -200 per tree.

3.2.5 Extension services

Value addition to biodiesel production is achieved through oil seed cakes, which are by-products of oil extraction, and used as agricultural fertilizers. Using small community based processing technologies can minimize transportation cost significantly. Hassan Biofuel Park and the University of Agricultural Sciences together have developed this type of technology. Demonstration models of processing units, including portable biofuel processing units, have been manufactured and piloted; and are being used in the community projects.

Photo 12: Pedal-powered biofuel processor in Hass

Photo 13: Oil being processed in Hassan, India

The challenges of meeting the needs of community extension services have been reduced through the introduction of cooperatives. The biofuel cooperatives are extensions of the dairy processing farmers' cooperatives.

3.2.6 Gender perspectives in the Biofuel Program

An inclusive approach is being practiced in Hassan for the community based biofuel production and extension services. There is a provision that each community based biofuel production cooperative should have at least 50% woman participants. Proactive gender inclusion in biofuel co-operatives is to bring the disadvantages faced by women, and their heavy reliance on natural resources in general and agriculture in particular, into the cooperative decision making process.

Photo 14: Local woman working in the Biofuel Park nursery, Hassan, India

3.3 Lessons learnt from the visit to Hassan

The following lessons were learnt from the visit to Hassan Biofuel Park:

a) While selecting species for biofuel production, the focus should be on indigenous species having multiple benefits. Indigenous species are known to people, they are adapted to the local environmental conditions and provide multiple benefits to the communities.

b) Marginal lands and terrace edges are the suitable sites for plantations of biofuel plant species in order to maintain agricultural productivity. Biofuel plants may also help to increase agricultural productivity by providing manure, shade and protection for agricultural crops.

c) Any biofuel production programme should first focus on meeting community household oil demand. Once households are energy sufficient, efforts can be made to develop entrepreneurship.

d) Local communities should be effectively mobilized in order to gain local ownership on biofuel production and entrepreneurship.

e) Building local cooperatives with the equal participation of marginalized communities including women, indigenous communities etc. adds value to any biofuel programs.

f) Establish a research/demonstration centre, which can provide scientific information, seedlings and extension services to the public.

g) Establish potential community-led, as well as scientific, technological interventions.

PART FOUR
Bio-Energy in Nepal: Opportunities and Challenges

4.1 Background

This part of the report presents the proceedings of the Nepal Energy Gardens Ambassadors' Workshop and brings together the activities carried out during the workshop held on October 10, 2014 at SAP-Falcha House, Kathmandu. The workshop was jointly organized by the collaborators of the Nepal Energy Garden Project with support and cooperation from the Federation of Community Forestry Users Nepal (FECOFUN), Community Forestry User Groups (CFUGs), government agencies, development activists, rural farmers, students and media representatives. The workshop brought together policy makers, practitioners and rural villagers in a common platform to share and learn from each other's experiences, and come up with a shared vision for bioenergy development in Nepal. Discussions were held on various themes of renewable energy, such as current energy consumption in Nepal and contribution of bioenergy, technology, gender, and social inclusion in bioenergy initiatives. The major focus of the workshop was to discuss the possibility of establishing Energy Gardens in Nepal with the core vision of reducing energy poverty, improving livelihoods and improve environment.

The overarching objective of the Nepal Energy Garden Ambassadors' Workshop was to disseminate the findings of scoping study carried out in Nepal by the project collaborators and to provide training to the Nepal Energy Garden Ambassadors to achieve societal impact of the project through early uptake. The other objectives were to identify the most promising ways of achieving energy security in rural communities of Nepal and identifying ways of establishing Energy Gardens in the country. The workshop also facilitated deliberative dialogues between policy makers, scientists, development activists, donors and grassroots community representatives to identify ways to resolve existing issues and tensions pertaining to renewable energy sector. The workshop brought together findings of different activities such as sharing of field experiences, inputs from group exercises, thematic presentations, question and answer sessions and interactive discussions amongst others.

This workshop proceedings are divided into four sections. Section one presents background information highlighting objectives of the workshop while section two presents the workshop approach. In section three technical sessions (I - II) and group discussion are presented.

The workshop was a useful event for discussing contemporary issues on renewable energy initiatives in Nepal, with a major focus on bioenergy. It covered various aspects of the renewable energy sector in Nepal, which included research approach, technology, past initiatives in this field and emerging issues, and tensions at program level (meso level). The participants from rural communities (community forestry and local schools) raised some key issues related to the failure of bioenergy initiatives in rural villages. They pointed out that community members continue to face multitude of problems such as lack of compensation schemes in case of any losses in production, lack of quality seeds and technologies, inadequate promotion/awareness, market dominated production system, agency led initiatives, inadequate species selection, lack of buy back mechanism based on the market value, lack of realistic market strategy besides mass plantations, inadequate extension services, and lack of collaborative efforts between different agencies.

Similarly, the workshop helped the Nepal Energy Garden Project to find ways in which the Energy Garden concept can be successfully implemented in rural communities and incorporate genuine voices of grassroots communities within the project. The shared vision among the participants will ultimately help to readjust/formulate relevant policies and programs with the ultimate goal of reducing rural poverty and providing opportunity for diversification of livelihoods amongst rural communities.

The workshop was an effort to disseminate the findings of scoping studies held in Nepal by the project collaborators and to train Nepal Energy Garden Ambassadors as a way to build capacity and achieve societal impacts. It brought together the rural farmers/community forestry users, planners and policy makers, development activists, academicians and other stakeholders in a common platform to identify the most promising ways of energy security in rural communities of Nepal and identifying the most promising ways to establish Energy Gardens in Nepal. Participants came from various districts in Nepal including Dhading, Gorkha, Lamjung and Dolakha districts where the first phase of fieldwork took place. The programme was covered by major Television stations including Kantipur Television, Image Channel, Nepal Television and Mountain Television and some newspaper outlets. It was also covered by BBC-Nepali Services.

4.2 Workshop approach

The workshop followed a communicative deliberative approach. Major activities included oral presentations by the key invitees, thematic presentations by the project collaborators and key invitees, interactive discussions amongst the participants (questions and answer series), and inputs from group exercises. Demonstration models of biofuel production and posters on key aspects of biofuels were also presented.

Photo 15: Key invitees to the workshop

The workshop was divided into three sessions. In the inauguration session the invitees shared important aspects of renewable energy sources in Nepal and various policy options for of making efforts stronger and wider to overcome the energy crisis in Nepal.

Photo 16: Workshop participants

A series of thematic presentations were made by project collaborators and other invited agency representatives during the formal session of the workshop. The major themes of this session were technologies, species, social inclusion in Energy Gardens and the possibility of integrating Energy Gardens in existing forestry and agricultural farming systems. The participants from rural villages were given an opportunity to share their understandings on grassroots bioenergy issues and the ways to resolve these challenges.

In technical sessions II, participants were divided into three groups - a) Plant species selection for Energy Garden; b) Indigenous vs. modern technology for energy production, and c) Role of CFUGs and indigenous communities in Energy Garden. Participants in each group made valuable contributions on these themes.

Photo: 17 Group discussion (A)

Photo 18: Group discussion (B)

There were a number of stimulating demonstrations from NAST on plant based biofuel production and from RECAST on gasification processes. The activities were designed to facilitate discussions amongst the participants and provide them with an opportunity to raise the grass roots issues and challenges to establishment of Energy Gardens. The group discussions also focused on the past initiatives of rural energy projects and major causes of failure of such programs.

Figure 3: Knowledge sharing approach of the workshop

4.3 Inauguration session

Dr. Bishnu Pariyar made a welcome speech addressing the invitees. He highlighted aims and objectives of the workshop as to discuss the issues of energy security in Nepal in general and the initiative towards establishing energy gardens in particular.

Later, Ms. Radha Gyawali (Chief Guest-minister of Energy, Government of Nepal), formally inaugurated the workshop by lighting a biofuel lamp (*Diyo)*. All other guests also lighted biofuel lamps in their respective places. All the *diyos* lit were fed by Nepalese indigenous oils.

Photo 19: His Excellency Andrew Sparkes, British Ambassador to Nepal

4.4 Key speakers at the inaugural session

4.4.1 Mr. Ram Prasad Dhital, Alternative Energy Promotion Center (AEPC)

Mr. Dhital is the Executive Director of AEPC. A brief synopsis of his speech is given below:

Almost 85-86% of total energy demand in Nepal comes from traditional fuel sources and the consumption pattern is significantly higher than the potential for sustainable yield. About 2% of total energy comes from hydro electricity and only 1% from other renewable sources, and rest from traditional sources as biomass. Annually, GoN spends around 120 billion NRs just to buy electricity (around 14-15% of total demand) from India. Thus the government feels the importance of renewable energy. An ambitious plan is set by GoN to make each household smokeless and energy secure by 2017 and there is a challenge to upscale our activities to make this a reality.

a) The technologies of renewable energy like that of biofuel production are very costly and the government's capacity for technological intervention is very weak.
b) Government representatives are still weak in planning.
c) Monitoring and evaluation system of government agencies, I/NGO is weak.
d) Modality of subsidy is not clear, for example how long will the subsidy go for? Whom to subsidize more and less?

To overcome these barriers we felt the importance of collaborative efforts with the academic institutions mainly to enhance our capacity. Furthermore, AEPC is planning to reduce the costs of renewable energy schemes while adapting any other models of implementations besides subsidy.
Mr. Dhital suggested that the organizers inform policy makers about their findings via policy papers and shared his belief that, planners will listen and apply in their program models. He also suggested conducting a pilot study of the energy gardens concept in Nepal, so that his organization will help replicating any successful model to larger portions of the communities.

4.4.2 Prof. Dr. Bal Krishna Gowda, Hassan Biofuel Park, India

Prof. Bal Krishna Gowda is the co-ordinator of Hassan Biofuel Park in southern India. The major focus of Prof. Gowda was to share the success story of the Biofuel Park concept and how this novel concept could help Nepalese communities to tackle growing energy demands.

Prof Gowda added that Biofuel Park is a small thinking/ a very simple humble concept in India to make our villagers self-sufficient in energy. The energy that is mostly produced from indigenous oil yielding plant species has been used for centuries and continues to sustain our villages. Biofuel energy of this type has better quality than that of fossil fuel energy and there are many side benefits too; as they can be easily produced in the villages with little technological and financial inputs.

Because all the energy required for household use is produced in the villages locally, we call our villages 'energy smart villages'. The entire process is very simple; all the energy produced is produced in the villages without involvement of any corporate body. In every single village, households are not only an integral part of the Biofuel Park, they also contribute towards it. The defining feature of the Biofuel Park is that there is no pollution and the waste produced is virtually zero. The by-products and residual wastes of the biofuel production process are returned back to soil for nutrient recycling and this helps in agricultural production. The Nepal Energy Garden can replicate this success story in Nepal because the country is rich in ethno ecological knowledge. Nepal has more than 100 species of naturally growing energy yielding plant species with high potential for energy productions. Prof. Gowda shared his belief that Nepal can reduce its dependency and investments in fossil energy in the next 5-10 years if the country takes real initiatives for Energy Gardens.

4.4.3 Dr. Swarnim Wagle, Member, National Planning Commission Nepal

Dr. Wagle shared national perspectives on renewable energy. He started with the scenario of national energy production and potential, and ended with the government initiatives to scale up renewable energy potentials.

Despite significant potential for renewable energy production, Nepal is still heavily reliant on fossil fuel. For example we are only able to utilize 2% (800 MW) of total hydro potentials (about 40,000 MW of economically viable hydro energy potential out of 83000 MW). About 705 MW of hydro electricity is produced from larger hydropower projects, whereas about 26 MW produced from micro hydro projects, 10 MW from solar and only 0.04 MW from biogas. Besides this potential, we are still at the stage of under utilization and under exploitation of energy resources, and thus there exists challenges to scale up renewable energy resources. The National Planning Commission thus took up an initiative in the renewable energy sector and interventions are contained in the current budget.

Dr. Wagle also shared some points to consider for scaling up these resources:

a) Political instability: After 2002, we are able to add just 90 MW electricity and not a single transmission line was added in this period.

b) Capacity of the private sector could not be enhanced as expected despite some good policy provisions-only one third of contributions are made by the private sector.

c) Structural weaknesses of Nepal Electricity Authority (NEA) mostly due to political instability.

d) A small market as compared to India, thus big investors are not interested at all.

e) Historical distrust with any understandings made between Nepal and India.

Despite of these hurdles Dr. Wagle shared plenty of hopes. Many power development activities and policy adjustments/improvements are being made, showing a good future for Nepal's energy sector. For example, Power Trade

Agreement (PTA), risk guarantees with Indian investors and thus private sectors are consequently feeling secure in making investments in power sector.

4.4.4 His Excellency Andrew Sparks, British Ambassador to Nepal

His Excellency Andrew Sparks, the British Ambassador to Nepal shared the UK Governments' support to GoN regarding renewable energy interventions.

His Excellency argued that the investment in and promotion of renewable energy is the key to Nepal's development. From early 1999 DFID has supported government of Nepal in the renewable energy sector. The UK government has contributed around 2 million pounds in the last two years. This year, the UK government joined hands with the GoN in supporting the ambitious initiative - Clean Cooking and lighting solutions for all by 2017. The benefit of our support in the renewable energy sector will help to reduce poverty in rural areas by increasing access to clean energy and will also help to reduce greenhouse gas emissions and thus contribute to the whole green agenda.

The concept of energy gardens is still developing in Nepal but given that around 85% of country's energy needs are still met by traditional biomass based energy sources, this indicates scale of the benefits from implementation of the concept. The UK's forestry program is already engaging with small farmers and community forest user groups (CFUGs) for promoting bio briquettes to energy enterprises. The enterprises are on the initial stage of development but the initial results are encouraging. People have found production technology simple. Bio briquettes have also advantages for forest management because only those plant species, which are invasive, are used in making briquettes.

This background clearly indicates the opportunity for biofuel productions in Nepal contributing positively to poor people's energy security and environmental conservation. The project needs to focus on smokeless stoves technology. Obviously, gas produced from biomass is less smoky compared to direct burning of biomass itself. This needs to be focused in the villages.

His Excellency encouraged Nepal Energy Garden Ambassadors' to take initiatives and make this concept a reality. He also advised to focus on environmental conservation by reducing pollutions as well as to generate revenue. Lastly, he showed his interest to continue with the initiative by much bigger investments of UK Government in the future.

4.4.5 Dr. Sabita Thapa, DFID (Climate and Environment Advisor)

Dr. Thapa shared information about DFID support for the promotion and development of renewable energy sector in Nepal.

The UK government has committed support to GoN to help achieve the goals of its ambitious initiative on providing energy security to the poor people in Nepal. It has already been working in this field through the agencies like AEPC and Multi Stakeholder Forestry Programme (MSFP). Through these two interventions, DFID spends around 7 million pounds each year in Nepal to provide support to the people on livelihoods and energy security.

The MSFP is in the third year of its implementation, and has been supporting quite a bit on renewable energy sector. We have helped to establish biochar productions plants in Nawalparasi and Parbat districts. These are mainly for increasing agricultural productivity and also contributing towards reducing carbon footprint by reducing greenhouse gas emission. We have also recently engaged in managing community wastelands, whereby communities are thinking of piloting biofuel production. The MSFP also supports projects to establish bio briquette factories. From all these initiatives we have seen many benefits to poor communities especially because it helps to create jobs and incomes for them.

Having all these benefits, we are moving passively on the biofuel production area because Nepal still does not have clear policy guidelines on biofuel production. Without any clear policy framework we are unable to provide any huge support for these initiatives where the fertile lands could still be used for biofuel production, but by principle it should actually be done in wastelands only.

We are now waiting for the outputs of Nepal Energy Garden project because it will be important for us to frame our future support in Nepal and help to determine whether, if or how we can provide more support in this area. We will be banking on the research like this to increase our support but not ready to provide huge support at this stage of policy vacuum.

4.4.6 Yam Bahadur Thapa, Director General, Department of Plant Resources (DPR)

Mr. Thapa urged the needs of collaborative efforts of different agencies working for the sake of developing renewable energy sector with entirely different working approaches. He pointed out some key actions including research activities conducted by many agencies could contribute towards adopting a radical approach. He also suggested project partners to be aware of rural communities for better management of natural resources, the ultimate source of bioenergy.

4.4.7 Honorable Jiban Bahadur Shahi (Constitution Assembly representative from Karnali)

Honorable Mr. Shahi highlighted five major development needs of Nepal (roads, electricity, communication, forests and market) to reduce the current trend of rural poverty and huge gaps in living standards of urban and rural communities. Expressing about his thought on the needs of bioenergy he explained the traditional rural cooking technique of three pillars open cooking stove, which are now become extinct and kept in museums in many other countries. With this example the major reflection of his argument was "natural resources are not being utilised in holistic approach in Nepal, the key weakness are concerned with planning and leaderships.

Mr. Shahi said that every corner of the country should be able to access fruits of development if we really want to make meaningful results from our initiatives like biofuels. One must consider that inaccessibility is the main cause of poverty because it makes people survive coping with high commodity costs, travel costs and many other dimensions of livelihoods.

4.4.8 Honorable Radha Gyawali (Minister of Energy, GoN)

Biofuel is relatively a new terminology to Nepal. Despite of huge investments in forestry sector the possible ways of livelihoods diversification (including biofuels) through forests are not explored well in Nepal. With series of discussions with the concerned stakeholders in ministry we came to realise that the problems are associated with the ways of planning and policy processes.

Currently, only 66 % Nepalese have access to electricity and this population is still suffering from severe power crisis. With this reality we now realised the importance of alternative energy sources like solar, wind, biofuels, biochar etc. We have initiated series of discussions with concerned stakeholders including FECOFUN, and found great potentials for biofuels in Nepal, and thus we are on the course of preparing required policies.

Gaps in policies are the major causes of failure in development of the renewable energy sector. For example, the Ministry of Environment has a mandate to look after project below 1 MW, Ministry of Energy have the same mandate for 1-500 MW projects and beyond that is the mandate of Investment Board. We have realised that AEPC has not been able to contribute much in this sector due to these policy provisions. GoN thus is applying a reliable model of alternative energy promotion and Ministry of Energy is also given a mandate to execute biofuel projects. With this provision Ministry of Energy now has taken initiatives on solar, biomass and other reliable energy sources. A major problem associated with biofuel energy projects is lack of market. Therefore, some provisions are being made to feed produced bioenergy in national grids.

A major focus of Honorable Gwayali is to enhance the cooperation with government agencies to increase the societal impacts of renewable energy projects. GoN agencies also become aware of existing problems and approaches to solve them if collaborative efforts make existence.

She also mentioned that Nepal is unable to produce enough energy using its resources partly because of political instability over the years. Now, with the model of federalism and rapid decentralisation, government is on the course of rapid development. We should think of geographical diversity as our assets not as problem.

Lastly, she expressed her thankfulness to the organisers with hopes of contributions in bioenergy sector of Nepal and its contributions in livelihoods, and minimising impacts of climate change. She also requested his Excellency British Ambassador to find out the possibilities of high-level academic exchange and human resource development programs under UK Aid schemes.

4.4.9 Sudarsan Khanal (ANSAB)

Mr. Khanal welcomed participants and guests on behalf of ANSAB (a collaborating organisation of Energy Gardens Project in Nepal). He also expressed his commitment to contribute further in the project on behalf of ANSAB.

4.4.9 Prof. Dr. Krishna Kumar Shrestha (ESON)

Honorable Minister of Energy Mrs. Radha Gyawali, Member of Parliament, Member of National Planning Commission, Honorable British Ambassador, Representative of DFID, distinguished guests in the dias, Ladies and Gentlemen,

I am delighted to welcome our distinguished guests and the workshop participants for attending the Nepal Energy Garden Ambassadors' workshop, which is jointly organized by University of Leeds, ANSAB, ESON, FEDO and Practical Action Nepal, and supported by DFID UK. Thanks to our colleagues from Hassan Biofuel Park, Karnataka and ICRAF, New Delhi, India for attending this important workshop.

It is my pleasure to recall the inaugural meeting of the project entitled "**Nepal Energy Garden: Institutions, species and Technologies**", held on March 2, 2014 at the Budanilkantha Higher Secondary School, Budanilkantha, Kathmandu. The main objective of the project is to encourage small-scale local farmers by using native indigenous plant species to grow in field edges, waste and marginalized areas, which are fast growing and high yielding for biofuel production. Thanks to the indigenous ethnic communities, dalits, women and underprivileged people for their enthusiasm to use underutilized biomass including weeds, invasive species for biochar and biofuel production.

The ongoing project is executing in three districts of Central Nepal namely, Dolakha, Gorkha and Lamjung. The research team includes geographers, sociologists, botanists and engineers from the UK, Nepal and India. Thanks to the colleagues of project collaborating partners, especially Dr. Bishnu Pariyar, Post Doc Fellow at the University of Leeds, for visiting the project sites, compiling necessary information on the energy situation, and exploring potential sources for local fuel production. One of our students is undertaking Master's dissertation on the exploration of potential biofuel plants in six VDCs of Dhading District, to compliment the on-going Nepal Energy Garden Project.

It is also a matter of great satisfaction that the authorities of Nepal Energy Promotion Centre, Department of Plant Resources (Ministry of Forests & Soil Conservation), Nepal Academy of Science & Technology (NAST) and Research Centre for Applied Science & Technology (RECAST), Tribhuvan University and ICRAF (India) for showing their interest to join hands in the next phase of the project. Thanks to the Minister of Energy for her assurance to support the Nepal Energy garden project.

Finally, I am delighted to extend my sincere thanks to our collaborators Prof. Jon Lovett and two researchers from University of Leeds for their active collaboration and support to enhance the project activities. Similarly, thanks are also due to our collaborators ANSAB, ESON, Practical Action Nepal and FEDO as well as Hassan Biofuel Park, India for their cooperation and support to organize this event.

I am also pleased to extend my thanks to Mr. Laxmi Raj Joshi, ESON member and Consultant for his laborious effort to conduct research activities and preparation of the project report. Our MSc. student Volunteers namely Bishnu Rijal, Rajani Awal, Laxmi Bhandari, Bidya Maya Shrestha, Devendra Pandey and Shreejana Raut for their contribution in making the workshop a great success. Finally, I acknowledge the colleagues of Falcha House, Babarmahal for providing good service and warm hospitality in organizing the workshop.

Photo 20: Workshop participants

4.5 Technical session I

This session of the workshop was devoted to the thematic presentations by some invited key speakers and project partners. The selected themes were of diverse issues and interest but directly related with energy gardens project bringing together some success stories for successful implementation of biofuel projects in

Nepal. Participants from different districts were also given opportunity to share grassroots issues and their aspirations from Energy Garden concept in Nepal.

4.5.1 Energy Gardens for small-scale farmers in Nepal

Dr. Bishnu Pariyar from the University of Leeds started with the scenario of energy consumption in Nepal, as significant proportions (more than 87%) of country's energy consumption comes from traditional biomass. However, despite having a huge potential renewable energy sources shares below 1% of total energy consumptions in Nepal. The current fuel supply chain looks more centralized, have high transport costs and greater ecological and carbon footprints. There is also a huge disparity of energy availability and consumption in rural and urban areas. There are some bright sides too as significant achievements have been made in recent years for the promotion and use of improved cooking stoves.

Whilst biofuels are viable and perhaps part of the ultimate solution to overcome looming energy crisis in Nepal, there are some controversies too. Some people believe that promotion of biofuels also causes environmental degradation, loss of biodiversity, GHG emissions and collapse in agriculture production. However, the benefits of biofuels clearly outweigh these believes.

Energy Gardens would be the ultimate solutions to uplift rural poverty and to create fuel self-sufficiency in rural areas because:

a) The energy garden concept helps keeping agricultural productivity intact, *i.e.* it never competes with the food crops. The energy plantings are recommended only in the boundaries, shades, field bunds, footpaths and local roads.
b) The entire concept is inclusive, *i.e.* participation of all community groups assured.

c) Creates opportunities for employment and income generation thereby reducing rural poverty.

d) Highly community centric-all the decisions and actions are made by the communities and in favour of communities.

Dr. Pariyar briefly mentioned the purpose of taking initiatives of Nepal Energy Garden concept including collaborations and strengths of each participating organisations. He also made a review of partner organisations' scoping research activities conducted in different parts of Nepal. The major highlights were the key methodologies, community participation during such studies, and the institutional and species scoping.

4.5.2 Smart agroforestry systems: bioenergy and livelihoods

Dr Babita Bohra and Dr Navin Sharma represented World Agro-Forestry Centre –ICRAF, New Delhi, India and first highlighted the background of ICRAF as an international organisation particularly working in south Asia (Nepal, Bhutan, Pakistan, Afghanistan, India). ICRAF hosts a global program on biofuel with the core mission and vision of improvement of livelihoods. It promotes biofuel energy without disturbing the existing agricultural integrity and promotes biofuel plantation on field edges and barren lands.

Current status of bioenergy:

a) Looking at the global energy scenario, the share of renewable energy is minimal as compared to the fossil fuels, and woody biomass contributes significant portion of it. Currently, energy from biological sources makes up only 10% of global use, although it has been estimated that bioenergy has the potential to provide 50% of global energy by 2050 from all resources.

b) Trees currently provide only the most basic energy services for poor people, viz. cooking, warmth and some rudimentary lighting, though they have the potential to provide all of the forms of energy needed to drive development.

Woody biomass can easily be used in gasification systems that provide fuel to drive machinery and generate electricity.

c) These systems are cost-effective and already widely used in both developed and developing countries. They can be effective at large scales.

d) Trees have a major potential to provide liquid biofuels, both biodiesel and ethanol, and will become more important as techniques for converting the lignin and cellulose of trees directly into ethanol.

Our core strategy is increase in farm production, livelihood enhancement and long-term environmental sustainability. For an agrarian country like ours, Biofuel plantations have multiple benefits. Farmers can meet the demand of fodder, fuelwood, energy and many other benefits from a single biofuel species. We do not mean to compete with agriculture in this regards, rather we choose crop-bonds and barren lands thereby keeping agricultural productivity intact.

Recently in India in collaboration with HASSAN Biofuel Park in Karnataka, we are working with the two villages to make them completely energy smart. Our efforts are to help communities to make them self-sufficient in energy through biofuels. Providing sources of income through increased market accessibility, capacity development and development of feedstock are the key strategies developed there. For feedstock range of plant species have been chosen and distributed to the farmers for year round energy productivity. A single biofuel species has range of benefits as the whole value-chain includes range of products like biomass-fuel wood, biogas, oil, oil cake, feedstock and fertiliser. Biofuel initiatives are gender friendly too. As most of the male members are engaged in outdoor income generating activities we encourage and develop capacity of women on whole value chain of biofuels from collection to selling.

Key Policy Challenges:

a) At the global level, the potential of wood-based energy must be taken into account in policy debates such as Sustainable Development Goals. At national level, wood-based fuels must be considered positively in national energy policy debates so wood as a renewable form of energy can play its proper role among other sources of energy in available energy mixes.

b) Many policies around the world are perverse in terms of encouraging the use of wood. Forests policies often prevent farmers from growing, cutting down and selling trees.

c) Charcoal is usually only barely legal in developing countries, preventing the establishment of a properly regulated industry. Instead, it becomes a rent-seeking enterprise, with much of its value accruing to corrupt officials and even terrorist groups. Need exists for official recognition of charcoal production and marketing by national energy policies. Energy policies for many countries in Africa tend to put more emphasis on commercial energy, biomass based energy often gets missed out.

d) Lack of coherence: For instance, although energy policy in Kenya favours development and promotion of improved charcoal cook stoves and sustainable farm forestry for fuelwood, charcoal making remains illegal in the country.

It is not always necessary to measure poverty based on the physical assets we have, the way we consume and harvest energy is also a cause of poverty. The way of energy consumption in Nepal is always a traditional type with heavy dependence in biomass energy and contribution of renewable energy sources far less than we expect.

e) Community engagements: community development initiatives including capacity building in farm forestry methods, charcoal-making and stove fabrication, charcoal trade and entrepreneurship to be realised.

f) Land tenure: land tenure policy in many countries in sub-Saharan Africa need to be streamlined. Land tenure is a key source of conflicts. But when a household has rights over a given land area, it can confidently develop it further through activities including modern farm forestry methods.

4.5.3 Bioenergy for developing countries

James Hammerton (School of Chemical and Process Engineering, Energy Research Institute, University of Leeds) introduced the existing human resources and facilities, and research activity overview of the University of Leeds pertaining to bioenegy development. The key research activities at Leeds as introduced by him are biofuels combustion, thermochemical conversion, development of biomass feedstock supply chain, processing and storage, anaerobic digestion and pollution. A major emphasis with biofuels research is in transport sector as production of biodiesel, biofuel engine testing, and development of future fuels form microalgae and from waste.

Mr. Hammerton also highlighted some of the key challenges of adaptation of technology to developing countries as remoteness, seasonal variation, cost, reliability and lack of expertise, and key solutions as flexible multi-fuel engines, selection of optimal conversion process, simple conversion routes, utilisation of waste streams and integration with other renewable energy sources.

4.5.4 Scope of biofuels to mitigate the fuel crisis of the country

Rabindra Dhakal, Dr. Eng. (Nepal Academy of Science and Technology-NAST)
Dr. Dhakal first shared some of the key research initiatives undertaken by NAST to minimise the power crisis in Nepal and then briefly highlighted power crisis

overview of Nepal, and two ways to resolve it- a) to continue importing petroleum products as needed, or b) to produce bioenergy from our own efforts. As Nepal harbours great possibility of energy productions, the second option looks more realistic and sustainable. Dr. Dhakal then shared findings of primary research experiments conducted by NAST in this regard.

A major focus of this presentation was to show the possibility of *Jatropha* plantations in Nepal for the sake of industrial production of biodiesel. As there exists significant proportions of degraded, fallow lands, *Jatropha* plantations may help keeping environmental integrity while benefiting community to strengthen their livelihoods through biodiesel productions. Dr. Dhakal also suggested rural communities initiate Jatropha plantations even in the agricultural lands because biodiesel values more than the subsistence agriculture practices. However, a major debate with this approach can be raised. What if entire agriculture system fails and the rural communities have to struggle with booming food prices?

4.5.5 Biomass gasification system for rural electrification

Prof. Dr. Krishna Raj Shrestha (RECAST) presented on the biomass gasification facility and ongoing research activities at RECAST with support from University Grants Commission Nepal. Later he introduced the principle sources of biomass in Nepal including leaf, litter, wood, algal biomass etc. The principle sources of these biomasses are the forests, industrial wastes, agricultural by-products, animal dung and household wastes. Currently, around 80% of total energy consumption in Nepal is met by biomass and there is very less contribution by renewable energy sources. Thus major technological inputs like biomass gasification systems would benefit rural communities to cope with increasing energy crisis and poverty.

The Research Centre for Applied Science and Technology (RECAST) of Tribhuvan University has been doing adaptive research on biomass gasification for electricity generation with the support of University Grants Commission (UGC), Nepal. The objective of the project was to fabricate the gasification system with the capacity of generating 10 kW electricity and testing its performance in the lab. A downdraft biomass gasifier, a cyclone separator, tar filter was designed and fabricated in RECAST workshop. The system was tested by operating 20 H.P diesel engine generator set by using charcoal as biomass material. The experiment was conducted by applying different loads. At dual fuel mode, 51 percent of the diesel was replaced by producer gas in the system at 6 kW load. The efficiency of the gasifier was 84 percent whereas the overall efficiency of the system was found to be 16 percent.

The Gasification Plant was successfully demonstrated by operating a diesel engine generator at the Workshop. Demonstration of the Gasification Plant was witnessed by Honorable Radha Gyawali, Minister of Energy, Government of Nepal who inaugurated the workshop as the Chief Guest. She took a keen interest in the electricity generation system. Along with the Chief Guest, other VVIPs, such as His Excellency the Ambassador of Great Britain to Nepal, Hon'ble Member of National Planning Commission Dr. Swarnim Wagle, Executive Director of AEPC, Mr. Ram Prasad Dhital also witnessed the demonstration.

Small scale biomass power generation is potentially attractive strategy for sustainable electricity supply in Tarai as well as hilly regions of Nepal where micro-hydro power plants are not feasible. Biomass derived power could contribute to Tarai development in a number of ways. In addition to direct employment in fuel gathering, delivery and power plant operation, the economically competitive electricity that could be produced by such systems could draw other employment and income generating activities in the Tarai region, especially energy intensive industries that offer well paid jobs. It can also be used for direct heating applications like process heating for industrial boilers or for drying of cash crops like tea, large cardamom and ginger etc. The cost of the gasification system varies according to the capacity of the power plant. For small scale decentralized power generation, the design of the plant with a capacity of 5 kW, 10 kW or 20 kW are available.

4.5.6 Bioenergy technologies and Practical Action experiences in Nepal

Roshan Manandhar (Practical Action Nepal) highlighted some key technological interventions on biofuels made by Practical Action Nepal and other energy projects in Nepal. The major biofuel production processes he mentioned were the thermochemical, biochemical and agrochemical technologies. Electricity production from biomass is made easier by the help the Internal Combustion Engine. He also showed a demonstration model of biogas electrification project and biochar project in Nepal. Later he briefly mentioned the clean cooking technologies promotion interventions piloted in different parts of Nepal by Practical Action as the Smoke hood, Score-1-stove, Score-2-stove, Anagi stove, Mud ICS, and Rocket stove.

4.5.7 Integration of biofuel plant species into farm and forest systems in Nepal

Sudarshan Khanal (Research, Planning and Communication Manager, ANSAB)

Mr. Khanal highlighted some of the key strategies for integrating biofuel plant species into farms and forest systems in Nepal.

He started with the background information on forest based biomass products in Nepal, as about 65% of households in Nepal still rely on forest for the collection of their fuel wood, of which the community managed forests accounts for 44% households and private forests account for 24% households.

There are existing community based briquette enterprises in many parts of Nepal. The community forests on the other hand are the prime sources of raw materials for bioenergy productions as briquette and pellets. The species having potential of both solid and liquid biofuel and those found in different physiographic regions of Nepal were also presented.

Integration of these species into farm and forest systems in Nepal requires a) assessment and prioritization of commercially important biofuel species, and b) introduction of biofuel species into existing community forestry system and farming System.

4.5.8 Potential plant species for biofuel production in Nepal

Laxmi Raj Joshi (Consultant, ESON) started with the current biofuel initiatives in Nepal and later highlighted some important research insights and learning for initiation of Energy Gardens in Nepal. He also shared the success story of HASSAN Biofuel Park, Karnataka, India as a model of rural energy project, led by communities and for the sake of benefiting communities.

The current biofuel initiatives in Nepal are limited in their scope to the stage of piloting. For example, the majority of such initiatives are limited to the development of some stationary diesel engines, cooking stoves and lamps, and limited supply of oil cake fertilisers in local market and in India. The whole bioenergy initiatives on the other hand undermined the immense potential of many indigenous plant species and based on the single species concept (i.e *Jatropha*). Failure of *Jatropha* based enterprises is a well-documented issue in Nepal. In the meantime, major earlier attempts in biofuel energy did not value community and household entrepreneurship and leadership.

i) Which species?

Selection of suitable energy yielding plant species is the prerequisite of any success in this field. Based on our scoping study, the following are the key suggestions:

a) Species origin: The selected species must be of native / indigenous in origin, known by and being used by the people from centuries.
b) Quantification of crude oil value: The more crude oil value, the best will be the result.
c) Quality assurance: The best quality oil/solid biomass content.

Mr. Joshi also highlighted some of the best plant species in Nepal for the production of indigenous oil, fuelwood and charcoal and draw attention of participants on the key learning based on the scoping study conducted by ESON.

ii) Key learning

a) While selecting suitable biofuel plant species, the focus should be on the indigenous species having multiple benefits.
b) Marginal lands and terrace edges are the most ideal sites of plantations.
c) The primary and most basic focus of any biofuel projects should be meeting household energy demands.
d) Local communities and institutions should be effectively mobilized and strengthened in order to achieve local ownership.
e) The best business model of community biofuel initiatives is through local cooperatives where participation of marginalised and poor community is equally valued.
f) Valuing sustainability: i) economic viability, ii) social suitability and iii) environmental durability.

4.5.9 Equity and social inclusion approach in promoting Energy Gardens in Nepal

Anshu Singh Manab (Program Officer, FEDO) expressed that the entire message of the presentation was to make planners and policy makers aware about valuing effective participation of minorities (including Dalit women) in bioenergy initiatives.

Biomass and Bio-fuels are gender friendly because they seek less labour effort and save time, and they have less health hazards due to smoke. However, most emerging ICS projects are limited to their scope, as consideration of disadvantaged people, in particular of Dalit women, is limited. Many studies suggested that Dalit women in Asia are more vulnerable to Indoor Air Pollution.

i) Energy Gardens and social inclusion:

The following issues of inclusion need to be considered during the planning of Energy Gardens in Nepal:

a) Dalit women have no access to capital and services.
b) Lack of advocacy for strengthening the voices of Dalits and other marginalised communities.
c) No policy provision for Dalits/Dalit women/ poor to increase access to decision making levels.
d) It seems difficult for women and Dalits to reach key positions in the Users' Committees (chair, secretary or treasurer).

ii) Recommendations based on FEDO's interventions on renewable energy in Nepal in collaboration with AEPC

a) Awareness generation for rural poor women, men and the Dalit and/or marginalized groups about the promotion of renewable/alternative energy technology.

b) Policies, strategies and periodic plans should be introduced through the perspectives of gender equity and social inclusion to commence the budget and programs for renewable energy promotion.

iii) Moderated discussion

In this session participants were asked to raise their queries/suggestions in response to the thematic presentations as presented above and the presenters were requested to respond.

Giri Bahadur Basyal (CFUG member) raised questions to Dr. Rabindra Dhakal:

We came to know that around 1.9 million hectare land area in Nepal is barren but we don't know how to make it productive? Had you make aware the policy makers and politicians in this regard?

Dr Dhakal replied that **o**ur effort is to make the barren, exposed, degraded and fallow lands productive. If we are able to utilise these land masses, the land becomes productive, gives energy and will help to tackle rural poverty. Thus we encourage farmers/villagers/CFUGs for mass plantations of energy giving plant species in the road edges, forest boundaries and other highly exposed land masses. Our research initiatives in NAST and beyond are thus focused to make this a reality. Based on GIS mapping we have generated high quality data and shared to planning commission and other government agencies, political leaders and relevant stakeholders. We have also replicated our research initiatives throughout the country and trying to aware communities in this regard.

I am happy because I came to know that Nepal has immense possibilities of energy productions. Wherever you touch (warmth of sun, flowing water, forest products, algal biomass) we find energy there. However the management of these resources is always a sky high challenge and dream of grass roots communities. I thus want to share my hopes for the effective implementation of Energy Garden concept and get helped.

-Sita K.C., CFUG member, Dolakha

Lamjung farmer representative-CFUG member

The farmer representative thanked the Nepal Energy Garden Project team for bringing out new energy possibilities in rural Nepali communities in the name of Energy Gardens. At this time, when strong muscles and brains have been migrating for foreign jobs, this concept may help in uplifting rural livelihoods and minimizing the current trend of migration. In the meantime he also suggested that the team help to overcome the existing socio-political barriers and make this a reality on the ground. As a CFUG member he committed to mobilising the communities at the time of implementation.

iv) Female participant- Sita K.C. CFUG member, Dolakha

Sharing her individual reflections on the benefits of Energy Gardens in rural communities Ms. K.C. mentioned the multiple benefits of energy producing indigenous plant species such as fruit for oil production, fodder for animals, wood for construction purposes and many others. She added: as a grassroots community member we are well aware of the research findings presented here, but if we look at the other side of coin, the implementing side is always very poor and limited with the scarce resources and support. In this regard, it is really opportune for the poor villagers, the forestry members, to share our beliefs directly with the policy makers, the researchers and the politicians.
She thus raised her queries to Mr. Rabindra Dhakal in response to his earlier presentation as:

Q1. How will you make community aware and make sure that they will implement the programs on grassroots communities and will be benefitted?

The first and by far the most important thing is to make communities aware of what resources community have and how the effective management of these resources benefit communities. FECOFUN has already started such initiatives in many rural settlements of the country, then why don't you join hands with FECOFUN and other likeminded organizations/groups and aware communities?

CFUGs based on Dolakha district have initiated biofuel productions since last 5 years with the support and commitments of external agency. At the time of earlier plantations, the commitment was to provide funds to CFUGs and villagers, also that the then planted Jatropha seeds will start fruiting within 3 years of plantations. But now, five years passed already, with not flowering and fruiting.

Although the alternative energy projects are said to contribute rural poverty, the ground reality is totally different. We, as a rural underprivileged farmers look at the sustainability part of any initiatives. If we found a guaranteed path of compensations for the mass loss of this type we are

Q2. Who takes the guarantee of benefits? Who pays compensation for the losses?

A private company requested villagers to initiate plantations with the hopes of good income. Farmers planted prescribed species as much as possible (in their kitchen gardens, farm lands, fallow lands, and community forests). What results after all this was really frustrating, a) farmers made desirable production but the buyers did not show their interest, b) Suggested plant species did not give desirable quantity or failed to produce as expected. Now with no provisions of adequate compensation schemes, local communities are compelled to a greater loss.

A researcher asks the villagers to plant biofuel species following the research findings, an inverter and a development activist asks them for maximal productions but nobody cares for their losses.

v) Sunmaya Nepali, Kaski-FECOFUN Secretary and local CFUG Chairperson:

After the success story of *Jatropha* oil used to run vehicles in Palpa district, FECOFUN Kaski also initiated local bio briquettes production by mobilising local CFUGs with support of external agencies. DFO Kaski supported 25000 *Jatropha* saplings which were distributed to CFUG members. However in absence of adequate market strategy, community forestry members couldn't realise the benefits. With this case some serious questions arise:

a) Isn't it necessary to prepare a workable market strategy besides mass plantations?
b) What is the overall benefit to the villagers?
c) Where to sell produced goods?
d) How to strengthen communities to make them capable of producing oil?

vi) Elderly lady:

She suggested looking at the implementing side of the research findings presented earlier in this session and advised scientists to work in collaboration with the grassroots communities. The special message for the Energy Garden Project was to try piloting implementation projects in at least a selected VDC in a district.

We did plantation but never got benefitted, we participated in different trainings at times again not benefitted, and then what are the benefit of our research and trainings? It is shameless that we never reflect ourselves.

Key question: How do you guarantee that the market will buy our products? If you cannot guarantee the market, then is it worth listening you?

vii) Concluding remarks:

Dr. Bishnu Pariyar *(University of Leeds)*

Listening to the villagers, I came to conclude that the current initiatives on biofuel production are not sustainable and it's really frustrating to show big dreams to the villagers unless we establish a sound buy back mechanism based on the market value, as already practiced in India and several other countries. Through the Energy Gardens initiatives in Nepal we are also trying to develop such mechanisms. The only goal of Energy Garden concept in Nepal is to benefit rural farmers and thus we need to overcome all these existing challenges.

Dr. Rabindra Dhakal (NAST)

We are not talking all that what we feel, we only talk things based on our research findings and all those activities meant for benefitting rural communities. We are also aware that government agencies and policy makers to listen genuine voices of grassroots communities, and make use of research findings.

Besides it being the prime responsibility of government, farmers should also take initiatives to find appropriate markets. Farmer's cooperatives and groups should work together to sell their goods. Petroleum products with appropriate proportions of biodiesel are widely used in transportation in many countries (around 75% of total). Our policy makers seldom look at these success stories, however we should not limit our efforts.

4.6 Technical session II-group work

4.6.1 Session Chair: Ganesh Karki (Chairperson, FECOFUN)

The third part of the workshop was dedicated to a group learning exercise for the Energy Garden Ambassadors'. Participants were divided into three groups to work collaboratively on various aspects of the energy garden project including identification of suitable indigenous plant species for energy generation, suitable technology for rural villages; and social inclusion and role of FECOFUN in implementing the Energy Garden project in the villages. Later, presentations on the key issues of discussions made by each group were presented by the respective group leaders.


Photo 21: Group exercises

4.6.2 Presentation on identification of suitable indigenous plant species for energy generation

This group made a list of 53 indigenous/native plant species with vernacular (Nepali) names that could be used for energy production and most of them are being used for producing oils and solid biomass for many generations. Prior to group work, Prof. Balkrishna Gowda and Prof. K. T. Prasanna (both from University of Agricultural Sciences, Banglore and Hassan Biofuel Park, Karnataka, India) suggested the participants to make a list of plant species based on the following criteria:

a) The selected plant species must be indigenous / native in origin and local communities easily recognise them.
b) Selected species should have multiple benefits.
c) The selections should be based on a mix of species that will give farmers production year round (multiple species for year round yields).
d) The list should include species suitable for different bio-climates.

The group was divided into few small groups based on the participants' home district. A list of plant species prepared by each group was compiled to prepare an integrated list of potential plant species.

The result clearly shows potential for promotion of Energy Gardens in Nepal. The list of plant species is provided in Annex 3.

Photo 22: Participants presenting their views

4.6.3 Ssocial inclusion and FECOFUN for energy gardens

Key reflections:

a) FECOFUN will help to ensure the participation of woman and

Major Issues at CFUGs levels:

- **Disparity on availability of natural resources**
- **Influence of political parties**
- **Lack of commitments**
- **Illiteracy, extreme poverty**

marginalised communities. The organisation will play crucial roles in making mandatory policy provisions for the meaningful participation of such communities and strengthen them.

b) It will help aware communities to participate in the program.

c) It will help building capacity of CFUG members with a special emphasis on disadvantaged groups.

4.6.4 Concluding remarks by Mr. Ganesh Karki

Mr. Karki expressed his vote of thanks to the organizers for making them aware of the scope of Energy Gardens in Nepal and potential roles of CFUG to make this concept a reality. Mr. Karki added, the development of technology is an important part of the word ‘progressive’. Every single country achieved economic development with the use of technology. Nepal has a good status in the global scenario, however the management side is always poor. If we look at the management side seriously, then Energy Gardens will soon be a reality. Finally, he made assurances to the organisers that FECOFUN would always collaborate and cooperate with the project implementers.

Finally, on behalf of organisers Dr. Bishnu Pariyar expressed his gratitude to the participants and shared hopes that the outputs of the workshop will help guide Energy Gardens to another step of success.

4.6.5 Conclusions and recommendations of the workshop

The Nepal Energy Garden Ambassadors’ Workshop served as a foundation for pro-poor based biofuel projects in Nepal by creating a space for grassroots voices in the policy and programme cycles. The main function of the workshop was to facilitate deliberative dialogues between key stakeholders on different aspects of renewable energy projects in Nepal, with a major emphasis on biofuels and Energy Gardens.

The Energy Gardens concept emerges as a novel concept for fulfilling the energy needs of rural poor communities in Nepal. Other past initiatives have also had the similar goals. The majority of such efforts were focused on the production of biodiesel from *Jatropha*. Other initiatives included production of bio briquettes, biochar and oil cakes. Under different schemes rural farmers were encouraged to produce biofuels through plantations of *Jatopha* species; however the results were not encouraging. There were many causes of this failure, some important ones being:

a) Policy challenges: Lack of compensation schemes in case of any losses in production, failure of market etc., no clear policy provisions explaining the types of land areas suitable for biofuel plantations.
b) Lack of quality seeds and technologies: Communities do not have access to good seeds, underlying technologies are out of reach to the rural communities.
c) Inadequate promotion/awareness.
d) Market dominated production system: alternative energy projects not focused to meet household/community energy needs.
e) Agency led initiatives: the roles and responsibilities/benefits of communities are not encouraged.
f) Inadequate species selections: based on a single exotic species concept and potential of native plant species ignored.
g) Lack of buy back mechanism based on the market value.
h) Lack of realistic market strategy besides mass plantations.
i) Inadequate extension services.

j) Lack of collaborative efforts between different agencies with the shared vision of developing a biofuels sector.
k) Lack of dialogues between different stakeholders.

Despite of these challenges there are opportunities as well. Recent technological developments and increasing bilateral and multilateral cooperation have widened the horizons of bioenergy production in Nepali rural communities. Recent interventions and investments on alternative energy sectors like solar energy, bio-briquettes, improved cooking stoves, biomass gasification etc. are encouraging. Similar efforts are being made on technological aspects too. In recent years, the mandatory provisions of the Nepal Government for representation of underprivileged groups in development courses has also widen the horizons of participatory development practices in Nepal.

It is noteworthy that the villagers made a draft list of native plant species with potential for biofuel production and many other services (fodder, fuelwood, timber etc.). These are the same plant species that play a role in daily life in rural villages and provide a number of ecosystem services. The Energy Garden concept in Nepal is expected to bring a paradigm shift in alternative energy, with projects led by the communities, for the sake of benefitting communities with improved access to market, technology and services. If a family and community became energy secure, then they will ultimately add value to national energy production and thereby the economy.

4.6.6 Notes on project partners visit to National Herbarium

The staff of KATH, Kathmandu organized a facilitation program for the Indian partners of Nepal Energy Garden Project for Prof. Balkrishna Gowda and Prof. K.T Prasanna of University of Agricultural Sciences, Bangalore, India. The program started with a visit to the National Herbarium. Mr Sanjeev Rai (Chief at KATH) briefly described the research activities conducted by KATH, including the e-floras project, biotechnological and dendrochronological research, anatomical studies, herbarium studies and extension services.

Later a formal facilitation and discussion program was organized at the KATH premises. Mr Rai briefly described the purpose of both professors' visit to Nepal and the workshop held the day before. He also expressed his interest for the possibilities of future collaborations (academic and research exchange) with University of Agriculture Science, Bangalore and active roles of DPR as a research institution in the Energy Garden concept in Nepal.

Later, Prof. Gowda mentioned the brief history behind the success of biofuel garden concept in Karnataka, India as a novel concept engaging both local and scientific communities. Prof. Gowda said that the success of energy garden concept in India could be important in the Nepalese context too. The diversity of indigenous biofuel plant species in different physiographic regions of Nepal means there are high chances of initiating similar concepts and programs.

Prof. Gowda also mentioned that he would be happy to welcome a few Nepalese scholars in his institution with scholarship schemes. A new call for 2015 will be opened shortly and he will inform the officials of KATH for their interest in this regard. He also mentioned that his institution will be happy to help establish the Energy Garden Concept in Nepal and will provide research and extension support, such as identifying potential indigenous plant species, quantifying the crude oil content, technology transfer and so on. KATH has a great capacity to recognize plant species that from different physiographic regions of Nepal suitable for establishing Energy Gardens. Future initiatives in the Nepal Energy Garden Project must value their role as a leading collaborator. Prof. Prassana added that the Energy Garden concept in Nepal will soon be a reality if we (the government officials/scientists) make real contributions. He also expressed his interest for academic and research collaboration between both institutions and would like to welcome Nepali scholars in his institution.

Mr. Laxmi Raj Joshi (Consultant, ESON) also reflected on his research experience with the Nepal Energy Garden Project. He shared the initial results from ESON's scoping study and fact finding visits to Hassan.
Later, Mr. Ramesh Basnet (Under Secretary at DPR) expressed his institutional and personal interests to be an integral part of Nepal Energy Garden Project.
The program ended with the formal facilitation to both professors by Mr. Rai and his colleagues. The team then visited Godavari Botanical Garden where they observed the resources and extension programs of the Garden.

PART FIVE:

Preliminary Results of the Household Survey

5. Preliminary results

This section of the report to presents preliminary results from the household survey carried out as the first part of fieldwork in Nepal.

5.1 Sample

A total of 300 households were surveyed, with 295 valid responses used in the final analysis as 5 questionnaires were discarded for being incomplete. The incomplete questionnaires resulted from two factors. Firstly, although almost all the participants were generally eager to answer the survey questionnaire, a small proportion of respondents did not have sufficient information to answer some of the questions partly because of individual memory failure, or the inaccurate recall of past events as well as from memory distortions. Secondly, a proportion of the household survey was conducted by five research assistants and a number of questionnaires returned were not fully completed.

Among the valid 295 households considered for analysis, more than half, 51.3%, of the sampled households were small landholders, 23.1% were medium and 25.6% larger landholders. This is characteristic of agriculture in the mid-hills of Nepal, where landholdings are small and often fragmented. Livelihoods are agriculture based and cultivation is often subsistence. Although some large landholdings exist, commercial farming is rarely practiced, instead the farmers with large landholdings allow farmers with smallholdings to cultivate their lands on a crop-sharing basis.

Dalit castes comprised 14.2% of households surveyed in the three selected villages, while 30.2% belonged to higher caste Brahmins and Chhetri. The remaining 55.8% belonged to Janajati castes. Although Janajati caste groups appear to be over represented in the sample, it is because two of the villages surveyed, namely Lakuri Danda and Khudi villages, had a higher proportion of Tamang/ Newar and Gurung respectively and the sample reflects the population from which the sample was taken using proportional stratification.

As expected, high proportions (54.2%) of households were headed by men, while women headed the remaining 45.8% of households. Generally, household members followed traditional family roles with women undertaking household activities and men involved in non-household activities including irrigation issues. The proportion of female headed households is considered higher than normal and the possible explanation is that many men from the villages are away in foreign employment, many of them working as labourers in India and Middle-eastern countries. The data indicated that more female-headed households are common within Dalits as females headed 50% of the households. The proportion of female-headed households within Janajati and higher Brahmin/Chherti castes remains 48.2% and 39.3 % respectively. A low access to landholding and generally higher level of poverty are factors likely to contribute to more Dalits and Janajati men seeking foreign employment compared to higher castes Brahmins/Chhetri.

Households were categorised into two categories: smaller households and larger households, based on number of family members in the household and livestock holdings in their possession. Household size will determine fuel consumption in the households. The majority (84.2 %) were small households and the remaining 15.9% were larger households. During the PRA process, time taken for preparing food was given as being twice the time taken for preparing animal feed. Therefore, a weighting factor of 0.5 was assigned to livestock holdings for determining its contribution towards the household size based on combined residents and livestock. The average size of the family was 5.41 people whilst the average number of animal holding was 5.5. After correction for livestock holding, the size of the household was 8.1 units.

Samples were also drawn from different wealth categories viz. poor, middle and richer households. After adjusting for income from landholding, the proportion of richer households was 38.6% whilst 11.2 % households belonged to the middle income group. A higher proportion of households were poorer households (50.2%). This is the characteristic of many rural households in Nepal. A majority of the sampled households engaged in agricultural practices (78%). A household with someone working abroad and sending remittance (27.6%) has become a major source of household income. Nonetheless, even though farmers reported alternative sources of employment such as business (8.8%), service sector (8.8%), wage labour (1.7%) and traditional ethnic job (1.7%), they still retain their agricultural practices reflecting the dominance of the sector in rural households.

5 .2 Household assets

Household assets play an important role in sustaining livelihoods and improving well-being of local farmers in rural Nepal. The primary assets of the households in the rural villages were landholding and livestock, which they mostly depended on for their livelihood. There are three types of landholdings the rural farmers have access to for crop cultivation and grass fields. Firstly, low lying productive Khet land with access to irrigation water. Khet lands are considered more valuable than other types of landholdings due to its productivity and access to irrigation facilities. Secondly, upland Pakho bari, with no access to irrigation water. These landholdings were less fertile than Khet land and mostly used for rainfed cultivation such as upland paddy (ghaiya dhan), maize, millet and potato. Thirdly, households also have access to khar bari (grass lands), which are not usually cultivated due to their rugged terrain and low productivity. These landholdings had wild grasses (used for thatch roofs) and shrubs and trees for fodder and fuelwood. Many respondents mentioned that these lands could be used for cultivating biofuel crops if the project is launched in the villages.

The number of livestock and landholdings in the three case study villages are presented in Table 2. It is very common for rural households to have livestock as a source of manure for agricultural purposes and for diary products such as milk, ghee and butter. Chickens were kept for meat whilst goats were used for meat and manure.

Table 2: Household assets in case study villages

Assets	Lakuri-Boch	Khudi	Hamsapur	Overall
Livestock holding				
Goat	2.7 (2.59)	4.01 (7.83)	3.0 (2.56)	1.18 (1.25)
Chicken	3.6 (15.03)	3.01 (6.0)	4.02 (19.9)	3.23 (4.92)
Cow	0.55 (.93)	1.67 (5.1)	1.0 (1.04)	3.57 (14.94)
Buffalo	1.0 (1.0)	1.1 (1.67)	1.4 (0.93)	1.12 (1.24)
Landholding in Ropani				
Khet Land	1.63 (3.31)	3.7 (5.09)	9.26 (16.16)	4.93 (10.56)
Pakho Bari	9.21 (12.93)	2.68 (3.24)	2.67 (4.0)	4.89 (8.65)
Khar Bari	2.33 (4.97)	1.29 (3.45)	3.09 (5.59	2.26 (4.82)

Buffaloes and cows were reared for manure and diary products. It was observed that richer households were more likely to have buffaloes, as they were considered more expensive than other livestock.

Overall, higher castes (Brahmin/Chhetri) had access to more productive Khet land (9.42 ropani) compared to ethnic group or Janajati (3.2 ropani) and Dalits (1.0 ropani). The ethnic groups had access to more Pakho bari (6.01 ropani) compared to brahmin/Chhetri (4.38 ropani) and Dalits (1.6 ropani). In general, Dalits had access to considerably less landholdings than both Brahmins/Chhetri and Janajati. Similarly, Bramin/Chherti also had considerably higher amount of grass land (4.3 ropani) compared to Janajati (1.6 ropani) and Dalits (0.67 ropani).

Disparity in gender-based land distribution was endemic in the villages. On average, male-headed households had access to higher amount of all three types of landholding (Khet: 6.87 ropani, Pakho: 5.87 ropani, Khar bari: 3.12 ropani) compared to female-headed households (Khet: 2.75 ropani, pakho: 3.73 ropani, Kharbari: 1.24 ropani). Disparities in access to landholding in gender and caste reflects historical disadvantages, as women did not have inheritance rights and Dalits continue to face socio-economic marginalisation, including untouchability.

In addition to landholdings and livestock, households had access to other amenities of daily use such as heaters, water filter, cookers, radios, television sets, motorcycles, LPG cylinders and mixtures and grinders. The number and types of household amenities also determine energy demands in the households. Table 3 presents different types of amenities reported by the respondents.

The proportion assets in households depended on their socio-economic status. Some assets such as motorcycles are considered expensive for rural households in Nepal. Only 6.8% households had motorcycles. Although there is a high need for assets such as mixture/grinders, water filter and, fan and heaters by rural farmers, only a small proportion of households had those assets. In Nepal, modern means of communication such as mobile phones and television has been increasing in recent years. This is reflected in the case study villages as a high proportion of households reported

Table 3: Household amenities in case study villages

Household Amenities	Per cent (N)
Fan/heater	4.4 (13)
Water filter	7.5 (22)
Cookers	65.4 (193)
Radio	60.3 (178)
Mobile Phone	93.9 (277)
Television	57.3 (169)
LPG	26.8 (79)
Mixture/Grinder	3.1 (9)
Motor Cycle	6.8 (20)
40 Watts Electricity Bulb	3.2 (295)
60 Watts Electricity Bulb	2.2 (295)
100 Watts Electricity Bulb	0.4 (295)
Total Electricity Bulbs	5.3 (295)

having access to mobile phones (93.9%) and television (57.3%). Similarly, the proportion of households using radio and cookers was 60.3% and 65.4% respectively. Although a higher proportion of households had access to cookers, mostly they were pressure cookers rather than electric rice cookers, which do not require electricity to operate. 26.8% of households reported to have used LPG for cooking, and this is considered to reflect an increasing trend. The most commonly used light bulbs were 40 watts and 60 watts. On average, households had 5.3 bulbs in use with the average number of electric bulbs being 3.1 and 2.1 for 40 watts and 60 watts respectively. The average number of 100 watt electric bulbs in sample households was low at 0.4.

5.3 Household energy scenario

5.3.1 Extent of energy insecurity

Nepal continues to suffer from frequent and often prolonged power cuts affecting both industrial and residential sectors. Communities and households in both rural and urban areas experience load shedding as the National Electricity Authority (NEA) has implemented scheduled load shedding to reduce the load on the National Grid. Although villages were connected to main power lines, they still suffer frequent power cuts. Table 4 shows the number of hours the villages are out of electricity in a week as reported by the respondents. Since the case study villages are typical rural locations, the respondents needed electricity mainly during evenings and nights primarily for light, cooking and children to study. The villages did not have any industries apart from a very few small scale home based handlooms, carpentry and ironwork. Respondents reported that they are suffering tremendously due to the lack of electricity at the time when they needed it the most i.e. evenings and nights.

Table 4: Number of hours without electricity in the night in a week

VDC (N)	Hours of nights/evenings without electricity (S.D.)
Lakuri/Boch (98)	22.73 (18.96)
Khudi (93)	25.18 (20.19)
Hamsapur (97)	28.72 (29.49)
Total (288)	25.54 (23.43)

Respondents in Lakuri Danda reported that on average they had to endure almost 23 hours per week of power-cuts during the evenings and nights, whilst the villagers in Khudi and Hamsapur faced almost 25 and 29 hours a week of evenings and nights without electricity. Table 5 presents the level to which households reported their various activities affected due to the power cuts.

Table 5: Impact of power-cuts on different household activities

Activities	Degree household activities are affected					
	Highly	Moderately	Slightly	Neutral	Not at all	NA
Education (N=293)	45.4 % (134)	20.0% (59)	20.0% (59)	5.4% (16)	9.2 % (27)	-
Lighting (N=293)	47.4 % (139)	24.6 % (72)	23.5% (69)	2.0 % (6)	2.4 % (7)	-
Cooking (N=293)	41.6 % (122)	20.1 % (59)	29.4% (86)	1.4 % (4)	7.5 % (22)	-
Heating (N=285)	23.2 % (66)	29.1 % (83)	19.6% (56)	11.2 % (32)	13.3% (38)	3.5% (10)
Communication/ Entertainment(N=290)	19.0 % (55)	33.4 % (97)	26.2% (76)	10.0% (29)	6.9 % (20)	4.5% (13)
Business/Industries (N=284)	10.6 % (30)	15.8 % (45)	14.1% (40)	21.5 % (61)	21.1 % (60)	16.9% (48)

Frequent and prolonged power cuts have meant that normal activities such as lighting, cooking, heating, entertainment (TV/radio) and children's education were affected. A significant proportion of respondents were affected by power cuts in all the aspects of their daily lives (children education - 85.5%, cooking - 91.1%, heating - 72%, entertainment - 78.6% and business and industries – 40.5%). It should be noted that the business and industries were small-scale home-based handlooms, carpentry and ironwork. Because of frequent power-cuts many households and community members found it difficult to meet some of the energy demands and had to rely on kerosene lamps and candles for lighting.

The level of frustration could be easily be observed amongt the villagers as one villagers called Shyam Shrestha "Swopnil" whom the team interacted with presented a poem to the fieldwork team leader, Dr Bishnu Pariyar, summarising the extent of energy crisis in the country:

Electricity, Give Me a Divorce

- Shyam Shrestha "Swopnil"

I sleep, he wakes up, and I wake up he sleeps;
I wake up early in the morning, he goes out early too;
I come home in the evening, he goes out in the evening;
Neither he comes when I am not there nor I come when he is there
What an awful hide and seek we are playing!

I invite him to the mud huts in the villages;
It aims for the VIP Quarters;
I want it to do some work;
It orders generators and inverters do the work;
What sort of relationship is it having with the generators and inverters?

Hey Electricity, I have learnt to live without you;
And, perhaps you have also learnt to live without me too;
Now, I am asking you for a divorce;
He tells me "Go Nepal Electricity Authority (NEA)";
I go to see him at the NEA
He tells me "See you at mid-night darling"
I ask for divorce paper;
He says "Not yet, I just want to spend ONLY a couple of hours with you!"

5.3.2 Household fuel consumption

All the three rural villages were located close to the local forests. Households relied on forests for fuelwood, timber, fodder, herbs and berries etc. Households use a combination of different fuels with mix of local and imported fuels as presented in Table 6. A high proportion of respondents relied on fuel wood and agricultural resides for household purposes such as cooking, heating, boiling and making tea/coffee and lighting.

Table 6: Reported reliance on different types of fuels in study villages

Source of Fuel in Year	Reliance on Fuels in study areas (N)		
	High	**Medium**	**Low**
Kerosene	23.4 (69)	25.8 (76)	50.8 (150)
Firewood	77.5 (227)	15.4 (45)	7.1 (21)
Agricultural Residues	33.7 (99)	46.9 (138)	19.4 (57)
LPG	18.4 (54)	29.6 (87)	52 (153)
Electricity	29.2 (86)	25.8 (76)	44.4 (131)
Charcoal	15.6 (46)	64.1 (189)	20.3 (60)
Candles	69.2 (204)	25.4 (75)	5.4 (16)

Households mostly used firewood and agricultural for cooking related tasks such as cooking food, animal feed, making tea, boiling water and brewing local alcohol called Raksi, and for meeting fuel demands for heating. Table 6 also presents the availability/reliability of different types of fuels used by the households in the project sites. Generally, households reported high to medium reliability for fuelwood and agricultural residues, whilst kerosene, LPG and electricity were reported to be low in availability and reliability. Candles were quite readily available in the local shops/markets as demands for them were high because of frequent power cuts. The average price of LPG and kerosene was NRs. 1500/cylinder and NRs. 145/litre respectively. Both LPG and kerosene were reported to be very expensive for rural households. Some villagers reported that local traders are thought to hide LPG and kerosene to create artificial shortages to increase their prices. The rural location of the villages means that during the monsoon seasons the roads are not suitable for transport vehicles and products such as the LPG, wax candles and kerosene have to be carried by local porters and mules/donkeys.

Table 7: Household socio-economic heterogeneities and amount of fuel consumed and time allocated for fuel provision in the study villages

	Fuelwood From Forest		Agricultural Residues		Gas in Cylinder/year	Kerosene in Litre/year	Electricity in Unit/month	Charcoal in KG/year	Candle Packets/year
Categories	Bhari/year	Time in Hour/week	Bhari/week	Time in Hour/week					
Male	110.80 (81.87)	13.77 (71.18)	9.7 (33.21)	2.51 (2.93)	2.3 (12.88)	9.78 (14.19)	27.37 (35.88)	28.42 (82.24)	17.39 (60.60)
Female	85.71 (62.50)	11.77 (7.73)	5.1 (9.61)	1.9 (2.65)	1.34 (2.81)	8.1 (12.73)	25.04 (24.29)	26.72 (75.97)	14.56 (24.91)
Large	108.19 (73.22)	14.73 (6.95)	14.87 (57.71)	2.48 (2.51)	.70 (2.170	10.73 (12.68)	20.82 (7.43)	25.23 (66.99)	17.94 (39.03)
Small	97.53 (74.79)	12.49 (7.56)	6.26 (11.24)	2.19 (2.88)	2.09 (10.49)	8.72 (13.69)	27.35 (33.68)	28.09 (81.53)	15.73 (49.08)
Poor	106. (75.27)	13.45 (8.28)	8.68 (34.51)	2.2 (2.87)	0.97 (3.31)	11.01 (15.07)	23.95 (22.44)	25.34 (78.20)	13.45 (30.64)
Middle	102.48 (76.68)	13.22 (6.220	5.58 (3.90)	3.08 (2.55)	5.5 (27.13)	5.34 (7.64)	34.77 (46.13)	36.5 (87.43)	10.97 (20.27)
Rich	89.06 (72.39)	11.97 (6.67)	6.91 (10.97)	2.01 (2.80)	1.97 (3.81)	7.59 (12.43)	26.84 (34.85)	28.01 (78.75)	20.94 (66.95)
Brahmins/Chhetri	98.69 (70.95)	11.54 (5.62)	7.08 (6.59)	2.98 (2.74)	0.94 (1.97)	5.97 (10.47)	24.87 (21.44)	24.11 (64.84)	11.21 (18.96)
Janajati	92.61 (73.91)	12.55 (7.90)	8.90 (33.60)	2.06 (2.91)	2.80 (12.83)	9.07 (12.49)	28.45 (37.48)	31.77 (89.83)	20.48 (59.24)
Dalits	126.02 (79.90)	17.00 (7.98)	4.60 (6.38)	1.36 (2.19)	0.23 (0.82)	15.45 (19.86)	20.98 (18.18)	19.16 (62.35)	9.48 (37.15)
Overall	98.69 (80.52)	12.85 (7.49)	7.65 (25.35)	2.24 (2.82)	1.87 (9.66)	9.04 (13.54)	26.30 (31.08)	27.64 (79.29)	16.09 (47.56)

Note: 1 Bhari fuelwood (head load) is about 50 kg; Figures in the parentheses are Standard Deviation (SD)

The amount and types of different combinations of energy consumed by households from different categories is presented in Table 7.

On an average, the households consumed 98.69 bhari and 7.65 bhari of firewood and agricultural residues respectively per year. The amount of LPG used by the households was rather small (1.87 cylinders) whilst they used 27.64 kg of charcoal, which is mostly used for heating per year. For lighting, households used electricity (26.30 units monthly), kerosene (9.04 litres) and candles (16.09 packs) yearly. Households relied on kerosene and candles for lighting particularly during the hours of power-cuts due to the load shedding. Households on average spend 12.84 hours a week in collecting fuelwood and 2.24 hours per week in collecting agricultural residues.

However, poorer households consumed more firewood (106 bhari/year) compared to middle (102 bhari/year) and richer (89.06 bhari/year) households and spend more time in collecting firewood (13.45 hours/week) compared to middle income households (13.22 hours/week) and richer (11.97 hours/week). Also, Dalit households significantly depended on firewood (126.02 bhari/year) compared to Janajati (92.61 bhari/year) and Brahmins/Chherti (98.69 bhari/year). They also spend more time collecting firewood (17 hours/week) compared to Janajati (12.55 hours/week) and Brahmin/Chhetri (11.54 hours/week). Similarly, both the amount of agricultural residues (4.60 bhari/year) and time (1.36/week) was significantly less compared to both Janajati (8.90 bhari/year; 2.06 hours/week) and Brahmin/Chhetri (7.08 bhari/year; 2.98 hours/week). This is because they had less amount of landholding compared to Janajati and Brahmin/Chhetri castes. High dependency on fuelwood for Dalits might be for two reasons. Firstly, the households are usually located near to forests where they have easy access to fuelwood. Secondly, they have a high level of poverty and can not afford to buy LPG for cooking. The use of LPG was significantly lower amongst the Dalits compared to other castes whilst they used more kerosene than other castes.

Table 8 shows different combinations of fuels used by households for various purposes. Only a quarter of the respondents (24.1%) had access to LPG gas. Even though households had access to LPG, they preferred to use fuelwood for cooking big meals and preparing animal feed and boiling water on cost grounds, as LPG is expensive for rural farmers. Mostly people with a good income and those running local teashops, and hotel and restaurant businesses used LPG, whilst other households resorted to conventional fuelwood and agricultural residues. Almost 98 % of the households relied on fuelwood as a main source of energy, which is higher than national average of 88%. Households used other sources of energy such as agricultural residues, biogas and LPG for cooking, boiling water and making tea/coffee. It was a common practice for household members to sit around the fireplace for warmth in rural Nepal, in which case fuel wood was mostly used in the kitchen. Some households with fireplaces outside the house preferred to use agricultural residues (Dhusin) for heating particularly during winter. Use of electricity for cooking was not so common mainly because of lack of appropriate utensils like rice cookers and also being too expensive.

All the three case study villages were connected with electricity. However, from Table 8, it is clear that households in all three villages suffered from severe power-cuts at time when they need it most i.e. during evenings and nights. Although the availability of electricity was characterised with frequent power-cuts, 96.3% of respondents had access to electricity. A small proportion of respondents (3.3%) had access to solar power for lights, which were installed at at the households own cost with no subsidies from the Government, meaning poor households simply could not offered to have solar power installed in their houses.

Despite a government programme on biogas, only 1.7% of the respondents were using biogas in the sample villages. Whilst uptake of biogas

Table 8: Fuel combinations used in the case study villages

		Households' Various Tasks Requiring Energy				
Sources of Fuel	**Cooking**	**Boiling**	**Making Tea/Coffee**	**Heating**	**Brewing**	**Lighting**
Fuelwood	60.5 (178)	63.3 (186)	58.4 (171)	40.1 (118)	43 (126)	1 (3)
LPG	1.7 (5)	1.0 (3)	1.7 (5)	0.3 (1)	-	-
Fuelwood and Kerosene	0.7 (2)	0.7 (2)	0.7 (2)	-	-	-
Fuelwood and Biogas	2.4 (7)	0.7 (2)	2.0 (6)	1 (3)	-	-
Fuelwood and LPG	19.0 (56)	8.5 (25)	20.1 (59)	1 (3)	0.7 (2)	-
Fuelwood and Agricultural Residues	11.9 (35)	24.1 (71)	11.6 (34)	56.1 (165)	14 (41)	-
Fuelwood, Biogas and LPG	1.7 (5)	0.3 (1)	1.0 (3)	0.3 (1)	-	-
Fuelwood and Sawdust	.3 (1)	0	0.7 (2)	0.3 (1)	-	-
Fuelwood, Agricultural Residues and LPG	1.7 (5)	1.4 (4)	2 (6)	0.3 (1)	-	-
Biogas and LPG	-	-	0.3 (1)	-	-	-
Fuelwood, Agricultural Residues and Charcoal	NA	NA	NA	0.3 (1)		
Kerosene						2.4 (7)
Solar						0.3 (1)
Electricity						28.6 (84)
Solar and Electricity						2.7 (8)
Electricity and Kerosene						51.7 (152)
Kerosene and Candle						0.3 (1)
Electricity, Kerosene and Wax Candle						7.1 (21)
Electricity and Candle						4.1 (12)
Biogas and Electricity						0.7 (2)
Solar, Electricity and Kerosene						0.3 (1)
Solar and Kerosene						0.3 (1)

in Lakuri Danda was virtually non-existent reportedly due to the cold climate where anaerobic digestion is slow. Biogas uptake in Khudi and Hamsapur were low despite being climatically viable.

Agricultural residues and fuelwood were mostly used by residents for brewing local liquor. Historically, the practice of making alcohol was not usually undertaken by higher castes (Brahmins and chhetri) and is common for ethnic castes (Janajati and Dalits). Only 18% of Brahmin/Chhetri brewed alcohol of which 75% used fuel wood whilst the remaining 25% used agricultural residues for fuel. A higher proportion of households making local alcohol belonged to the Dalits community (78.6%) and Janajati (73.2%). Fuelwood occupied a prominent position as fuel source for both Dalits (66.7) and Janajati (76.7%) for brewing purposes. The proportion of Dalits and Janajati using fuelwood and agricultural residues for brewing purpose were 30.3% and 22.5% respectively. Only a small proportion of Dalits (3%) and Janajti (0.8%) made partial use of LPG for brewing purposes, using it in combination of fuelwood.

5.3.3 Source of fuelwood in the villages

The main source of fuelwood for households and communities in the case study villages was local forests, which are community managed. Some households also used trees from on their own lands for fuelwood whilst a small proportion of respondents bought trees from their neighbours land for fuelwood. Table 9 presents the sources of fuelwood in the responding households. Community forest rules are strict so they are not allowed to cut down trees for fuelwood from forest.

Table 9: Sources of fuelwood in the villages

Fuel source	Community Forest	Private Land	Neighbour's Land
Primary (N=295)	68.8 (201)	31.2 (91)	na
Secondary (n=293)	30 (88)	64.2 (188)	5.8 (17)

Usually households buy trees from other neighbouring farmers during the dry season, cut branches, trunks and twigs and prepare fuelwood (Chirpad or Daura). The fuelwood is usually neatly piled up next to the houses for use during the monsoon season. The piles of fuelwood are locally called "Khaliyo". Respondents reported that even though local community forestry is the primary source of fuelwood, they also used trees in their private land and vice versa.

Photo 23: Khaliyo of Fuelwood in Khudi,

5.3.4 Dependency on fuelwood

Based on their dependency and use of different types of fuels, households were asked to provide scores ranging from 1 to 6 where 1 means mostly dependent, and therefore of most importance, and 6 means least dependent, and therefore least important for them for each of the households purposes such as cooking, heating and lighting. The average scores are provided on Table 10.

Table 10: Dependency and importance of various fuels

Fuel Source	Purpose	Mean Score
	Cooking	4.7
Charcoal	Heating	4.8
	Light	5.89
	Cooking	1.14
Fuelwood	Heating	2.34
	Light	5.44
	Cooking	4.18
Agricultural Residues	Heating	3.19
	Light	5.88
	Cooking	5.9
Animal Dung	Heating	6.1
	Light	6.37
	Cooking	4.65
LPG	Heating	5.76
	Light	6.89
	Cooking	5.4
Biogas	Heating	5.8
	Light	6.72
	Cooking	5.87
Kerosene	Heating	6.02
	Light	3.32
	Cooking	5.80
Solar	Heating	5.84
	Light	5.99
	Cooking	5.99
Electricity	Heating	5.91
	Light	1.62

5.3.5 Cook-stoves

Households used different types of cooking stoves in Nepal and this was reflected amongst the villagers in the study sites. The types of cooking stoves used in the villages included open fires, kerosene stoves, mud stoves, gas stoves and improved cook stoves. Table 11 shows the various types of stove used in the villages. In many rural villages, households have an open fireplace where they cook both food and animal feed. Usually, open fireplaces are in the middle of the house and residents sit around the fireplace for warmth during cold seasons. A significant proportion (about 70%) of respondents used open fires for cooking food for family and domestic animals, whilst 13% households used a traditional mud stove.

Table 11: Type of cook-stoves used in the villages

Type of Cook-stove	Percentage (N)
Open Fire	46.4 (136)
Kerosene Stove	1.4 (4)
Mud Stove	7.5 (22)
Gas Stove	2 (6)
Improved Cook stove	8.2 (24)
Open Fire and Gas Stove	15.7 (46)
Mud Stove and Gas Stove	5.5 (16)
Open Fire and Mud Stove	4.4 (13)
Improved Cook stove and Gas Stove	5.5 (16)
Open Fire and Improved Cook Stove	3.4 (10)

Less than a third (28.7%) of the households reported to have access to LPG gas, whilst only 13.7% households reported to be using improved cook-stoves. The average price of LPG is NRs. 1500 per cylinder and will normally last for a couple of months for an average family size of five, which is considered expensive for economically disadvantaged rural households. A small proportion of respondents

(1.4%) used kerosene stoves. Whilst the kerosene stoves produce less smoke, they are still detrimental to human health due to smoke inhalation. It is important to note that households used more than a single type of cook-stove. Generally, households that reported to use LPG and biogas for cooking also used fuelwood, particularly for cooking animal feeds, which is done outside the house on an open fire (Ageno). Also, it was common practice for the villagers to cook food for the family inside the house either on an open fire (Ageno) or mud stoves (Chulo) and improved Cook stove (Sudhariyeko Chulo). Most types of cook-stove used the villages were highly inefficient with heat wasted giving out heavy smoke in the kitchen, causing a health hazard.

Photo 24: Local woman cooking a meal on a traditional Chulo in Lakuri Danda

5.4 Health hazards

In addition to respiratory and eye diseases highlighted in Chapter 1, heavy dependency on firewood has other health implications. Women and children often carry heavy bundles of firewood or wooden logs on their shoulders, head and back from forests to home and local markets. The traditional ways of transporting heavy loads leads to women, children and men suffering from muscular strain, head, neck pain and back pains. Women and young girls are vulnerable whilst collecting firewood from the forest as many cases of rape and beatings taking place (Haile, 1991; Cecelski 2000, UNDP, 1997). Studies on sexual health in Nepal reported that many incidents of underage, illicit and unprotected sexual behaviour takes place whilst collecting firewood and animal fodder from forests in Nepal putting individuals at risks of pregnancy, contracting sexually transmitted diseases and damaged reputations (Puri and Busza, 2004. In many cases, uterine prolapse among rural women in Nepal is attributed to carrying heavy firewood and similarly women often face a risk of miscarriages with such heavy workload (Earth and Staphit, 2002; Haile, 1991; UNDP, 1997).

In the case study villages, lack of access to and unaffordability of clean fuels such as LPG and biogas has meant that an overwhelming proportion of respondents in all the three case study sites depended primarily on fuelwood from the forest and secondarily on agricultural residues from fields. As a result of continued exposure to health hazards arising from smoke inhalation, respondents reported multiple health problems as shown in Figure 4. A significant proportion of respondents reported to have suffered from eye irritation (85.3%) and coughs (76.1%). Other health problems reported by respondents include neck and back pain (41.4%) from carrying fuelwood, burns (33.4%) from fire, Asthma (24.1%), Bronchitis (12.4%) and 1% lung cancer. Two individuals reported to have suffered lung cancer were female and the remaining one was male. Qualitative interviews with respondents who reported to have suffered lung cancer were non-smokers and it is possible that the smoke inhalation from the kitchen might have contributed to the disease.

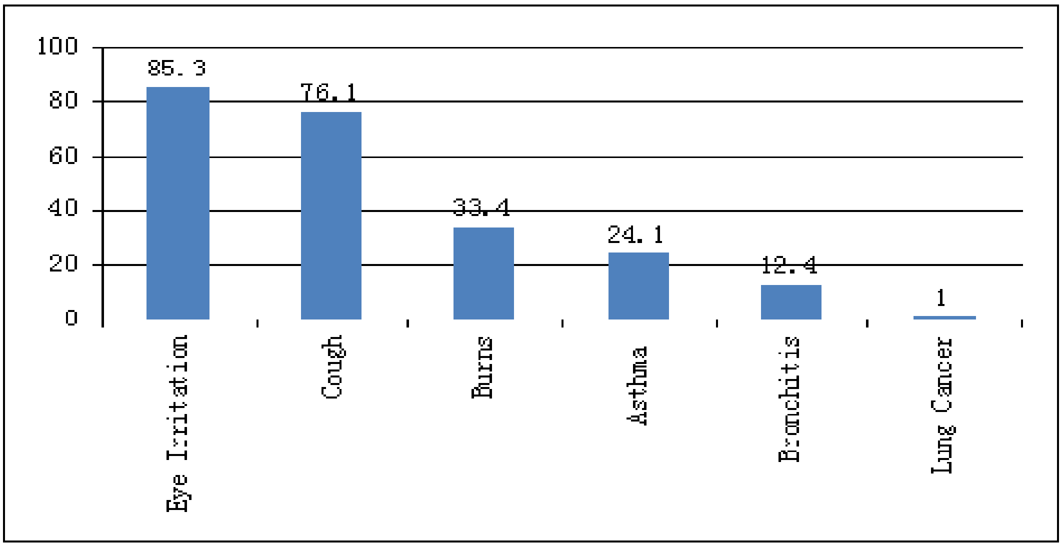

Figure 4: Reported Health Problems Due to Burning Fuelwood

The households attached different degree of importance for different fuel sources depending on the purpose they were used and degree of dependency on them. The respondents mostly used firewood for cooking, heating and boiling purposes whilst electricity was mostly used for lights. Electricity was not normally used for heating and cooking due to cost. The households also did not have access to rice cookers and the use of pressure cookers was common in the study villages. Food cooked with pressure cookers used either fuelwood or LPG rather than electricity.

5.5 Gender dimensions in fuel provision

Understanding of power relation and gender dynamics within the households and communities remains critical for successful implementation of any bio-fuel project such as energy gardens. In order to assess the gender dynamics within the households, involvement of males and females in various external and internal activities such as fetching water, cooking, cleaning, collecting fuelwood, purchasing fuels, participating in meetings, visiting local places, deciding on children’s education, health treatment visiting banks and taking loans etc. were considered. Field observations, as well as survey and interview data, indicate that because women have gained formal rights, their roles within the households and in the community have begun to change despite cultural and traditional roles assigned to them. More women have begun to play some part in communal activities such as attending meetings of local social organisations such as FUGs, women's groups and local co-operatives and are increasingly seeking employment outside the household. However, whilst such changes are achievements towards creating gender balanced communities, much work needs to be done to achieve full balance.

Table 12 indicates, that as in many rural areas in Nepal, households and communities in the case study sites were also characterised by the dominance of males in decision- making both outside and within the household (Acharya et al., 2010; Furuta and Salway, 2006). Household activities such as cleaning/collecting dung, cooking food, cleaning utensils and clothes, fetching water, collecting fuelwood etc. were primarily undertaken by females, where as activities such as attending meetings, visiting banks, and taking loans, decisions on education and health care, etc. were undertaken mainly by males.

Table 12: Gender dimensions in household activities

Activities	Female	Male	Both
Buying Household Items (N=290)	47.9 (139)	31 (90)	21 (61)
Selling Agricultural Products and Livestock (N=265)	36.2 (96)	47.5 (126)	16.2 (43)
Attending NGO and Community Meeting (N=279)	25.8 (72)	57.3 (160)	16.8 (47)
Visiting to Agriculture and Veterinary Service (N=251)	35.9 (90)	51.4 (129)	12.7 (32)
Making payments for Fuels (N=188)	48.4 (91)	42 (79)	9.6 (18)
Fetching LPG Cylinders (N=127)	38.6 (49)	54.3 (69)	7.1 (9)
Cooking Animal Feed (N=282)	85.5 (241)	5 (14)	9.6 (27)
Cooking Food for Family (287)	93.7 (269)	2.1 (6)	4.2 (12)
Cutting and Drying fuelwood (N=279)	51.3 (143)	21.1 (59)	27.6 (77)
Fetching Water (N= 289)	73.7 (213)	4.5 (13)	21.8 (63)
Undertaking Agricultural Activities (N =281)	36.7 (103)	8.2 (23)	55.2 (155)
Watching news on TV/listening to Radio (N =255)	9.0 (23)	42 (107)	49.0 (125)

Cleaning Utensils and Clothes (N = 286)	92.3 (264)	2.8 (8)	4.9 (14)
Dung/Collection/Clearing (N =237)	81.3 (208)	5.9 (15)	12.9 (33)
Visiting Banks (N =217)	22 (53)	66.8 (161)	11.2 (27)
Deciding Children's School (N =286)	18.9 (54)	59.4 (170)	21.7 (62)
Deciding Fuel/Stove (N =284)	57.4 (163)	23.2 (66)	19.4 (55)
Deciding Food for Family (N = 289)	57.8 (167)	22.5 (65)	19.7 (57)
Health treatment (N =289)	21.5 (62)	56.1 (162)	22.5 (65)
Buying Utensils and Kitchen Items (N = 289)	70.2 (207)	12.5 (36)	15.9 (46)
Decisions on Taking Loans from Banks (N=287)	13. 6 (39)	62.7 (180)	23.7 (68)

The male members of the household also took part in meetings and village level discussions of public interest. The male members are also the individuals who make the decisions on behalf of all family members and decide on livelihood activities. Thus their decisions have major implications for the welfare of the entire family. Whilst there is are clear gendered roles in the of undertaking household activities, it was reported that more men share household activities with women. Enhancing and sustaining such changes and consideration of such power relation and gender roles in the community will be critical for a successful implementation of energy gardens in Nepal.

5.6 Biofuel Projects in Nepal: Opportunities and Challenges

Biofuels have been argued to be a clean energy. However, such a claim is true only at the point of use as biofuel can have detrimental effects on the environment due to deforestation if production is done at on an industrial scale and forests and agricultural lands are converted to biofuel cultivation. Therefore, understanding of public perceptions is critical for a successful implementation of biofuel projects in Nepal.

5.6.1 People's Understanding of Biofuels

Despite their rural nature and high incidence of poverty and illiteracy in the villages, more than a quarter of respondents had heard about biofuels, although they were not involved in cultivation and production of biofuels. Farmers in the villages found the concept of energy gardens interesting as almost 95% of the respondents were willing to hear more about energy gardens and biofuels generally.

Table 13: Public understanding of liquid biofuels

Understanding	Percentage (N)
Heard about biofuel	27.3 (80)
Interested in to learn about biofuel	94.3 (250)
Already growing plants suitable for biofuel	11.7 (34)
Farmers willing to undertake biofuel production	73.4 (213)

Farmers gained knowledge on biofuel from various sources. The major sources of information on issues related to biofuels included newspapers (7.2%), academic study (18.8%), Radio/TV (49.3%) and NGO activities (24.6%). Rural location of the villages coupled with high illiteracy in the villages means that few people read newspapers, whilst a high proportion of respondents knew about biofuels from radio and television. In fact, a small proportion of farmers in the villages (11.7%) were already growing crops that were suitable for biofuel production.

5.6.2 Biofuel crops in the villages

Many rural villages were cultivating oilseed crops such as mustard, rapeseed, sesame and sunflower, mainly for producing cooking oils. However, they were not used for biofuel production, as the quantities produced were small and used for household consumption. Non-edible oil bearing plants such as *Jatropha* were grown along the boundaries. Other areas such as field bunds, boundaries, uncultivated and stray land were commonly used for cultivating potential biofuel crops. Some trees such as Chiuri were found in wild in local forests and used for producing butter and also used as wild fruit. A significant proportion of respondents (96%) considered community forestry to be very important and viable areas for introducing biofuel plants. The concept of introducing oilseed plants in the local community can be a viable option for implementing energy gardens in Nepal as even marginal farmers can benefit from such interventions because of their involvement with local forestry. In fact, almost 87% of the respondents agreed that there are plant species in the local community forests, which can be used for producing biofuels. In fact, 85% of the respondents reported that there is demand for biofuels in their areas and local markets and towns whilst almost 98% of them reported that in fact the community will welcome the implementation of biofuel projects in their villages.

Table 14: Areas suitable for biofuel plant cultivation

Area	Already Growing	Willing to Cultivate
Field bunds	5.9 (2)	0.4 (1)
Boundaries	2.9 (1)	na
Uncultivated/stray land	38.2 (13)	2.7 (7)
Bund and boundaries	2.9 (1)	0.4 (1)
Bund and uncultivated land	14.7 (5)	0.8 (2)
Boundaries and uncultivated land	20.6 (7)	na
Bund, boundaries and uncultivated land	11.8 (4)	na
Community forests	2.9 (1)	95.7 (245)

5.6.3 Public Concerns about Biofuels

As a way of overcoming concerns about biofuels, energy gardens are geared towards creating small-scale community-based biofuel projects with minimum impacts on the local environment. Understanding perceptions of the possible impact of such endeavour will be critical for public acceptance of biofuel. Therefore, we asked respondents what effects the production and utilisation of biofuels will have on the local environment in their villages. Because the concept of Energy Gardens involved planting tree species without loss of forests, the villagers generally responded positively. The responses are presented in Table 15. About two thirds of the respondents reported that biofuel projects will contribute positively whilst 12.7% reported that such project will have detrimental effects on local environment. Some local villagers were neutral in their reply regarding impacts of biofuel projects on local environment whilst 9.3% of them reported that uncertainty remained regarding impacts of such projects on local environment.

Table 15: Public perception of Energy Gardens on the local environment

Perception of Impacts	Percentage (N)
Positive	66.7 (194)
Negative	12.7 (37)
Neutral	11.3 (33)
Uncertain	9.3 (27)

Whilst the local farmers were excited and responded positively about the prospect of community based biofuel projects, they also had some concerns about impact on their livelihoods. The concerns were around issues such as changes in cropping pattern, use of water and land resources and quality of the local environment. Generally, respondents were concerned about the competitive use of land and water resources for the cultivation of biofuel crops displacing food crops in long term. Also, the villagers were concerned about the possible influence of biofuel projects on the choice of crops, as a preference of biofuel crops over food crops and cash crops might lead to changes in the cropping pattern, which can lead to lead to food shortages and increased food prices. About a third (33%) of the respondents mentioned that they are concerned about possible changes in the cropping pattern due to biofuel crop plantations whilst 12% had concerns about increasing food prices. A small proportion of respondents reported that they had concerns regarding land and water resource diversion away from crop production. However, their concerns on the impact of energy gardens on local environment were mixed. Generally, biofuel projects were perceived positively as more than 46% of respondents reported positive impacts as compared to 18.6 % reporting deterioration in local environment.

Table 16: Aspects villagers considered changing due to biofuel Energy Gardens

Aspects Considered to Change due to Biofuel	Percentage (N)
Changes in cropping pattern	26.5 (74)
Increase in food prices	6.1 (17)
Water diversion from crop irrigation to biofuel	2.5 (7)
Improvement in Local Environment	26.9 (75)
Deterioration in Local Environment	11.8 (33)
Increase in food prices and deterioration in deterioration in local environment	1.8 (5)
Changes in cropping pattern improvement in local environment	15.4 (43)
Changes in cropping pattern and deterioration in local environment	5 (14)
Increase in Food Price and Improvement in Local Environment	3.9 (11)

5.6.4 Perceived Benefits of Biofuels

Biofuel projects such as Energy Gardens can have multiple benefits to the local residents. Generally, Nepal has one of the highest rates of unemployment in South Asia and rural unemployment is higher compared to urban areas and nationally. Any development project such as biofuel projects will have positive effect in creating jobs and reducing unemployment locally. More than 63% of respondents believed that biofuel projects will provide employment opportunities to local people. Almost 84% of the respondents either strongly agree or agree that biofuel projects such as Energy Gardens provide employment opportunities to local community members. Because of employment opportunities locally, 34% of respondents believed that such projects can help reduce migration and help stop brain drain. A significantly higher proportion of respondents (about 98%) perceived that biofuel projects will help reduce poverty as a result of new employment and business opportunities resulting from the initiation of biofuel related projects such as participating in cultivation and selling raw products such as the seeds to biofuel companies. In fact, 88% of the respondents either strongly agree or agree that biofuel projects will reduce poverty amongst economically disadvantaged local farmers. Increased energy security will enable farmers to run additional businesses enhancing their earning potential and security livelihoods.

Table 17: Perceived benefits of Energy Gardens to households

Types of Benefits	Yes	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Do not know
Employment	69.9 (184)	36.5 (104)	47.4 (135)	12.6 (36)	1.4 (4)	none	2.1 (6)
Reduce Poverty	97.8 (288)	36.2 (104)	51.6 (148)	9.1 (260	1.4 (4)	none	1.7 (5)
Energy Security	54.4 (157)	37.7 (107)	49.6 (141)	8.5 (24)	0.4 (1)	0.4 (1)	3.5 (10)
Improve Health	74.4 (215)	NA	NA	NA	NA	NA	
Reduce Migration	34.1 (98)	40.8 (117)	46 (132)	5.6 (16)	none	0.3 (1)	7.3 (21)

More than half of the respondents (54.5%) believed that biofuel project will provide energy security locally and provide them much needed respite from increasing load shedding problems. Respondents also were hopeful for improving their health, as clean fuel will be available from biofuel projects rather than having to relying fuelwoods, which produced a lot of smoke.

The anticipated costs and benefits in committing in and engaging with biofuel related activities will have an influence on whether or not community members participate in biofuel projects such as the proposed Energy Gardens project. We asked the respondents how they weigh costs and benefits as a result of participating in biofuel projects. The results are presented in Table 18. Generally, villagers believed biofuel projects to be economically viable as more than two thirds of the respondents believed that the anticipated benefits of engaging in biofuel projects would either exceed greatly or moderately over the costs of doing so. The proportion of respondents who believed that the costs of undertaking biofuel projects will exceed the monetary benefit remained low (about 19%). A small proportion of respondents (about 7%) did not know how the costs and benefits of involving in biofuel project will balance, whilst about 12% believed that costs and benefit will balance.

Table 18: Benefits of Energy Gardens to households

Ways benefit will be felt	Percentage (N)
Benefit greatly exceeds costs	39.1 (109)
Benefit moderately exceeds costs	26.9 (75)
Benefit equals costs	11.8 (33)
Costs moderately exceeds benefit	17.6 (49)
Costs greatly exceeds benefit	1.1 (3)
Do not know	3.6 (10)

5.6.5 Factors important for biofuel projects

In addition to economic and environmental concerns about biofuels, villagers also considered government policies to be conducive for them to engage in biofuel projects. Other factors that farmers considered important were the availability of technical and financial support from both government and non-governmental organisations at various stages of the biofuel projects. Obviously, developing and enhancing market opportunities for villagers to trade biofuel products was considered equally important. Table 18 presents the factors that the respondents considered important for initiating biofuel projects in the local villages. It is clear that the villagers considered more than one single factor to be important for successful implementation of biofuel projects. Financial aspects remained by far the most important factors for the villagers as more than 73% made reference to financial support, which was followed by government policy on biofuels at 38.3% . The proportion of farmers referring to technical support as an important factor remained at 22.7% whilst 23% referred to creating and improving markets as important factor in addition to technical/financial support and government policies.

Table 19: Important aspects for implementing Energy Gardens

Variables	Percentage (N)
Government Policy	5.9 (17)
Technical Support	4.9 (14)
Financial Support	31.8 (91)
Government Policy and Technical Support	6.6 (19)
Government Policy and Financial Support	16.4 (47)
Technical Support and Financial Support	11.2 (32)
Government Policy and Market	9.4 (27)
Financial Support and Market	13.6 (39)

Whilst the villagers considered factors such as the availability of financial and technical support, conducive government policy and creation and development of markets for biofuels remain important factors for them to engage in a biofuel project, the actors involved in such endeavours was considered crucial for successful implementation of any biofuel projects. Many farmers reported that government support in the form of insurance (97.6%) and tax rebates (72%) are important to them and provision of such support systems will encourage farmers to undertake biofuel projects.

5.6.6 Involvement of local organisations in biofuel projects

Table 20 presents responses of the villagers on the different actors who should be part of the biofuel projects. It is clear that the villagers considered involvement of the local communities and co-operatives very important. The villagers also considered NGOs with relevant expertise and financial support can contribute significantly by collaborating with local communities in biofuel projects. Despite its inefficiency and corruption, government is still considered an important part of any future biofuel projects as it is ultimately responsible for policy formulation and can also play an important role in providing financial support for the villagers. For creating and developing markets for products and services in biofuels, the private sector plays an important part. The private sector also can inject financial resources to cover start-up costs in biofuel projects and work in collaboration with local communities and various governmental and non-governmental organisations for implementing biofuel projects.

Table 20: Organisation most suitable for Energy Gardens

Organisations	Percentage (N)
Community and Co-operatives	40.4 (115)
Private sector	1.8 (2 (32)
Government	11.2 (32)
NGOs	7.7 (22)
Community and Private Sector	3.2 (9)
Community and Government	4.2 (12)
Private sector and Government	9.8 (28)
Private sector and NGOs	0.4 (1)
Community, Co-operatives and Private Sector	14.7 (42)
All of the above	0.4 (1)
Do not know	1.4 (4)

An overwhelming proportion of community members' involvement in biofuel projects is partly due to the high level of social capital in rural villages in Nepal. The villagers considered that there is trust amongst the members of the public and if there is need they can form groups and work collaboratively in issues of public interest. In fact a high proportion of respondents (97%) agreed that the community has a high level of trust and 86% of the respondents in fact agreed that community members can easily form co-operative groups to undertake biofuel projects if they are implemented in their villages.

Although none of the case study sites had irrigation canals particularly for pakho bari, villagers had formed Water Users' Associations (WUAs) for the purpose of co-ordinating activities associated with provisioning and improving drinking water facilities in the villages. Community forestry programmes were successfully implemented all three case study villages and had an active Forest Users' Groups (FUGs). Villagers had also formed Saving and Credit Group (SCGs) through micro-finance schemes. Significantly, a large proportion of villagers were members of those local organisations. More than 77% of the sample households were members of the local Water Users's Association, whilst 89.8% of them had joined local micro-finance schemes. Similarly, 94.6% of households were members of the local women's group whilst 97% of the respondents were active members of the local Forest Users' Groups. Whilst respondents had varied opinions on the performance and efficacy of those organisations, the fact that so many rural households were united together to form local organisations and work collectively for the benefit of their community clearly indicates a high degree of social capital in the villages.

However, when asked to rate the performance of their local organisations, the responses were very mixed with some local organisations performing well whilst other lagged behind as presented in Table 21. The proportion of respondents reporting neutral or unsatisfactory for WUA was particularly high (20.5%) compared to 2.4% for FUG, 3.2% for WUG and 5.3% for local micro-finance schemes. Only a small proportion of respondents reported highly unsatisfactory performance for FUG (0.3%) and micro-finance (0.4%). Generally, FUG, WG and local micro-finance were reported to be performing either highly satisfactory or satisfactory by the respondents. The performance of the local women ‘s group was rated the highest with 95.2% reporting either highly satisfied or satisfied, which was followed by FUG and local micro-finance schemes both at 94.4 being rated either highly satisfied or satisfied.

The rationale for investigating the number and type of local organisations working in the villages was to assess the level of co-operation amongst the community members. The basic idea is that collaborative formation and operation of local organisation will provide opportunities for local residents to consolidate their efforts towards community development.

Table 21: Reported performance of local organisations in study villages

Performance	WUA (N=215)	FUG (N=286)	WG (N=279)	Saving Credit (N=265)
Highly Satisfactory	31.2 (67)	47.2 (135)	48 (134)	35.5 (94)
Satisfactory	48.4 (104)	47.2 (135)	48.7 (136)	58.9 (156)
Neutral	14 (30)	3.1 (9)	2.5 (7)	4.5 (12)
Unsatisfactory	6.5 (14)	2.1 (6)	0.7 (2)	0.8 (2)
Highly unsatisfactory		0.3 (1)		0.4 (1)
Not members				

The respondents were asked which of the locally operating organisations (Water Users’ Associations, Forest Users’ Groups, Women Groups and local saving and credits) are mostly likely to get involved with communal biofuel projects such as Energy Gardens. The results of the survey are presented in Table 22. A high proportion of respondents (71.4%) reported that the local FUGs are most likely to be involved in biofuel projects either solely or in collaboration with local women groups and micro-finance schemes. Biofuel projects involving women groups and saving credits schemes either solely on in combination is 57.8% and 24.5% respectively. Only a very small proportion of respondents (1.8%) reported that the WUA is the most likely group to be involved in biofuel projects. The fact that a high proportion of respondents reporting FUGs as the group most likely to get involved in the project is because a high proportion of villagers reported FUGs having realistic chance of doing so. Furthermore, household activities such as cooking, cleaning and collecting firewood were mostly carried out by women and they were naturally the first victim of arduous work and health complications due to smoke

Table 22: Local organisations likely to be involved in Energy Gardens

Local organisations most likely get involved in biofuel projects	Percentage (N=279)
Water users' Association (WUA)	1.1 (3)
Forest Users' Group (FUG)	33.3 (93)
Women's Group (WG)	22.6 (63)
Saving Credit Group (SCG)	2.2 (6)
WUA and FUG	0.7 (2)
FUG and WG	17.6 (49)
FUG and SCG	4.7 (13)
WG and SCG	2.5 (7)
FUG, WG and SCG	15.1 (42)
I do not know	0.4 (1)

inhalation. This could account for the higher proportion of women groups willing to get involved in biofuel projects such as energy gardens as a way of overcoming hardships they are enduring because of high dependency on fuelwood for energy. Given the fact that biofuel projects such as Energy Gardens are community based has meant that micro-finance schemes such as local savings and credits groups also have a natural inclination for getting involved in communal biofuel projects.

PART: SIX
Potential Biofuel Plant Species in Nepal

6.1 Floristic heritage of Nepal

Nepal has a unique geographical position within the landmarks of Central Himalaya. It harbours extreme altitudinal gradients with varied topography and climatic conditions making it diverse in terms of floral and faunal diversity. The floristic heritage of Nepal is characterized by six adjoining floristic regions, *viz.* Central Asiatic in the North, Sino-Japanese in the North East, South East Asia-Malaysian in the South East, Indian in the South, Sudano-Zambian in the South-West and Irano-Turranean in the West (GoN 2012). An assemblage of environmental variables as precipitation, temperature, snowfall etc. gives rise to a unique assemblage of biotic heritage in Nepal. In total Nepal represents 35 forest types, 75 vegetation units and 118 ecosystems (GoN 2012) with many hotspots of important biological resources. According to a recent study, about 4.27 million hectares of land area in Nepal is forested (29%) followed by farmland (21%), grassland (12%), shrub land and degraded land (10.6%), and uncultivated land (7%) as shown in Table 23.

Table 23: Land use data of Nepal (representing major land use types

S.N	Land use type	Land use cover	
		Hectare (in millions)	Percentage
1	Forest	4.27	29
2	Shrub land and degraded forest	1.56	10.6
3	Grassland	1.7	12
4	Farmland	3.0	21
5	Uncultivated land	1.0	7

Source: Bhuju *et al.* 2007

Nepal's share of flowering plant species is 2.76% of the global total (Bhuju *et al.* 2007). The total number of flowering plant species (angiosperms) recorded from Nepal is 6,501 with 284 endemic species (GoN 2012).

All other known plant species representing different groups and status of endemism under non-flowering group are presented in Table 24 below.

Table 24: Number of non-flowering plant species recorded from Nepal

Plant group	Number of total species	Number of endemic species
Algae	807	12
Fungi	2025	157
Lichens	771	48
Bryophytes	1150	30
Pteridophytes	534	8
Gymnosperms	31	

Source: GoN 2012

Plants, as important biological resources, provide an array of ecosystem goods and services, which may be tangible or intangible (Shrestha 2012). Some of the important services provided by plant species to support human life include food, forage, construction materials, fuelwood, oil, medicine, aesthetic pleasure etc. Nepali people have been utilizing the plants and plant products since time immemorial (Rajbhandari, 2001). Many rural communities in Nepal have wide indigenous knowledge on plant species and thus plants and plant derivatives together become the basic livelihood sources for them.

6.2 Survey of plant species

In conjunction with the household survey, key informant interviews and focus group discussions, surveys of plant species were carried out to identify those plants which have been used by the communities for oil extraction historically; and if those plant species are still available in local forests, private lands and field bunds. Mr. Bishnu Rijal, a postgraduate student at The Central Department of Botany in Tribhuvan University who worked as a research assistant in the project assisted in conducting the plant survey. The plant survey involved interviewing local elderly people in the village and transect walks in nearby forested areas. Only a few plants whose identification was uncertain were prepared as herbarium specimens Traditionally, many elderly people had used local plant species for oil extraction to meet oil needs for cooking, body massage and lubrication for local mills. Many individuals who were interviewed during the fieldwork used local and colloquial names for plant species in their own languages such as Gurung, Tamang and Newari languages and mentioned that some plants had religious significance and have been used for generations. The interviews with elderly villagers revealed some interesting insights about the use of plant species for oil extraction. It was noted that many plants were used for fuelwood, edible oil, non-edible oil, food, fodder, environmental uses, making baskets, art and crafts, utensils such as brooms, poison, fibre and cordage, umbrella, roofing materials, gums, tobacco wrapper, toothbrush, dye and many social and religious functions.

In addition to the plant survey carried out in Lamjung, Gorkha and Dolakha district, and further fieldwork was carried out in Dhading district as a part of Mr. Bishnu Riajal's ongoing MSc. Dissertation on "Potential Bioenergy Plants in Dhading District", under the supervision of Prof. Krishna Kumar Shrestha (Tribhuvan University, Nepal) and Prof. Jon Lovett (University of Leeds, UK). The study area includes six VDCs of Dhading District namely: Salyantar, Aaginchowk, Budathum, Baseri, Mulpani and Phulkharka, ranging from 500-2920 m. The field work was conducted from May 8, 2014 to August 11, 2014, and all six VDCs of Dhading district were visited. During the fieldwork, 5 community meetings were conducted, 8 resource maps were prepared, and 78 households were surveyed for the exploration and documentation of bio-energy plants in Dhading district.

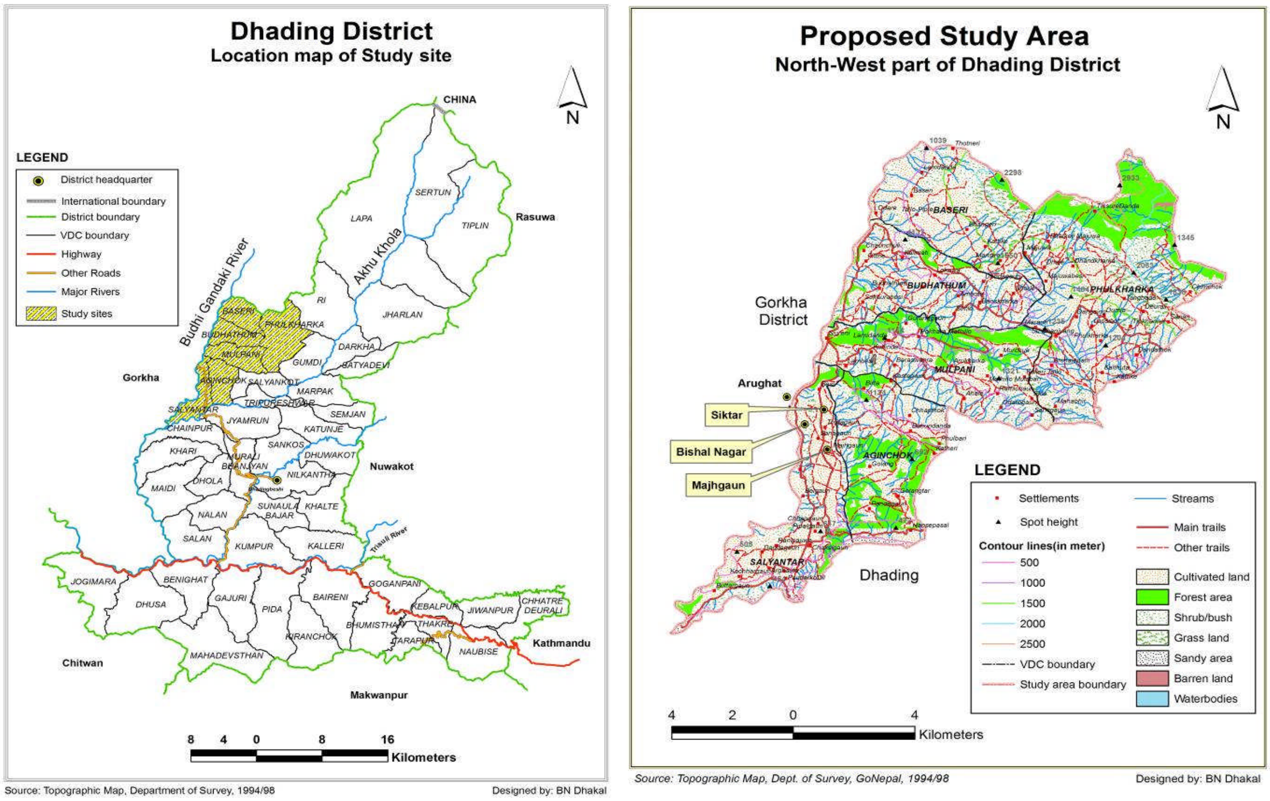

Fig 5: Map of Dhading District showing Plant Survey Areas

Given the remit of the research, we mainly focused on plant species, which could be used for biofuel and biomass energy. Finally, the list of the plants that can be used only as the source of the bio energy was listed. Some names of plant species were noted in local dialects, and reference to their Nepali names was also noted. This made the identification process for those plant species easier at later stage of the research. Only a few plants whose identification was difficult were prepared as herbarium specimens. The names of plant species are provided in **APPENDIX II.**

6.3 Methods of plant survey

The process of identification was started by comparing the field names with some of the literature by renowned taxonomists of Nepal.

6.3.1 Taxonomy literature by Nepali authors

The following resources were used for identification of plant species:

a) Dictionary of Nepalese Palnts Names

Written by Keshab Shrestha, Ph.D. from Natural History Museum, Tribhuvan University, the book comprises the list of almost all the higher plants with Nepali names, scientific names, family names, English names and Miscellaneous Ethnic names.

b) Annonated Checklist of Nepal

Written by Prof. Krishna K. Shrestha (one of the collaborators in this project) with his colleagues, the books is also available online and comprises all the plant names of species found in Nepal with scientific names (Genus & species), Family name, distribution, and photo on the margin.

6.3.2 Taxonomy literature by non-Nepali authors

Literature by non-Nepali authors was also consulted during the identification process. The most useful among them was the CONCISE FLOWERS OF THE HIMALAYAS by Oleg Polunin & Adam Stainton with its supplement. The book was useful due to the photo plates and the botanical descriptions of the plants. The other book consulted was the HILL'S ECONOMIC BOTANY by (Late) Dr.

Albert F Hill; Harvard University, USA, which describes plants with their economic value and illustrations made easy for identification of plants.

Besides these, Mr. Rijal also consulted Prof. Dr. Krishna Kumar Shrestha who is the president of Ethno-botanical society of Nepal (ESON) for the identification of the plants. In addition to this he gathered information regarding biofuel plants from his friends and colleagues working and studying in Taxonomy Unit, Department of Botany at Tribhuvan University, Kathmandu.

Regarding people's perceptions on plants, the team found out that the people of Lakuri Danda VDC of Dolakha district were comparatively more conscious and have made use of plants species and benefited more from the plants especially for the provision of fuels for household and community use, compared to fuel, than the other two VDCs. Respondents of Khudi and Hamsapur were comparatively less aware of and had little knowledge of biofuel plants despite having cultivated *Jatropha* along the boundaries. Similarly, we observe that vegetation and forest density in Khudi VDC was usual and of a moderate type whilst they were thicker, denser and more varied in Lakuri Danda and Hamsapur VDCs. Overall, the major vegetation in all the VDCs were similar due to almost similar environmental conditions and altitude. Major plant species were: *Schima wallichii, Alnus nepalensis, Pinus roxburghii*, *Symplocos pyrifolia*, *Shorea robusta, Rhododendron arboreum*, *Melia azederach*, *Mangifera indica, Maesa chisia, Ficus religiosa*, *Eurya acuminata, Dalbergia sisso, Buddleja asiatica*, *Ageratina adenophora*, *Gaultheria fragrantissima*, *Artemisia indica, Jatropha curcas, Brassica rapa*, *Helianthus annus* etc.

A private company namely Dabur Nepal and some NGOs had worked in Lakuri Danda and installed a small-scale oil extracting plant. The use of *Gaultheria fragrantissima* Wall. (winter green) and production of *Solanum tuberosum* L. (Potato) to a large scale also indicates consciousness of people about the commercial use of plants in Lakuri Danda VDC. Similarly, the production of

Amomum aromaticum Roxb (Nepal cardamom) in Hamsapur VDC by most of the people as a major source of cash crop indicates that the people are in search of plant species suitable for their climatic and soil conditions without necessarily replacing conventional food crops in the local areas.

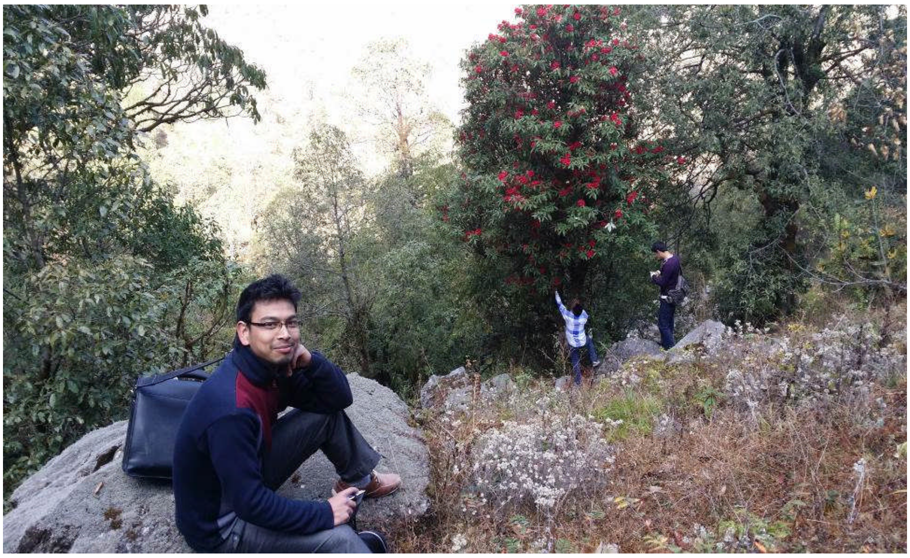

Photo 25: Energy Gardens Project team undertaking plant survey in Lakuri Danda VDC, Dolakha district, Nepal.

6.4 Potential biofuel species

There are many indigenous species of plants that can be used to produce natural oil as fuel. Most of the indigenous communities in Nepal have been rely on such species from time immemorial to meet their household energy demand. In fact, in principle any single species that has the potential to produce seeds can produce biofuel. Thus the potential of any species to produce oil depends on the presence/absence of seeds. In the mean time quantification of crude oil value and quantity and quality are the major criteria to select suitable species for this purpose.

6.4.1 Oil yielding plant species

The present study came up with a preliminary listing of 68 oil yielding plant species in Nepal with significant number of indigenous species. These species were represented by 38 plant families. The Fabaceae was the largest family with seven species. Similarly Anacardiaceae, Brassicaceae, Euphorbiaceae and Rosaceae all shared four species in common and Asteraceae, Meliaceae and Sapotaceae shared three species.

Most of the species with oil yielding potential were trees (n = 39; 57%), followed by herbaceous life forms (n = 19; 28%), shrubs (n = 7; 10%) and climbers (n = 3; 5%) as shown in Figure 5. Analysing the distribution range along the altitudinal gradient it was found that most of the species were distributed in tropical-temperate climates (n = 42; 72%) (Figure 6), compared to a very few species (n = 16; 28%) having distributional ranges all the way from tropical to alpine (tundra) climates.

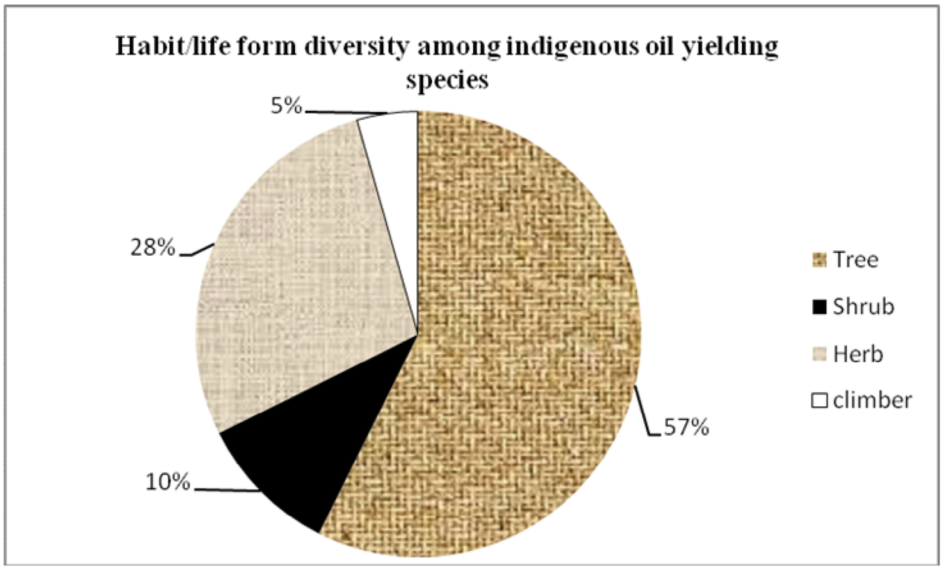

Figure 5: Life form diversity of indigenous oil yielding plant species

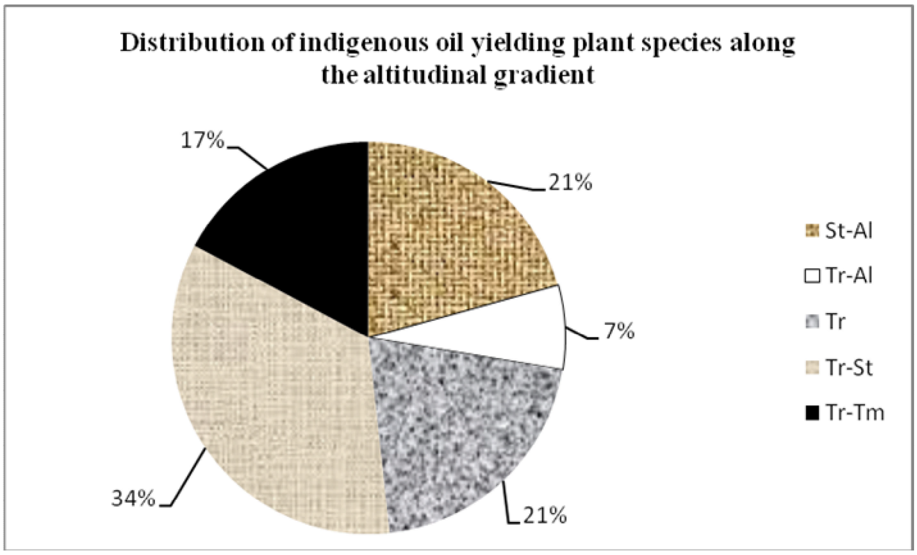

Figure 6 : Distribution pattern of indigenous oil yielding plant species

Note: Abbreviations in figure (6): St-Al = subtropical-alpine; Tr-Al = tropical-alpine; Tr = tropical; Tr-St = tropical-subtropical; Tr-Tm = tropical-temperate.

The preliminary checklist of potential indigenous oil yielding plant species further showed that there are equal contributions of both edible and none-edible plant species (Figure 7). The edible species were mostly represented by the agricultural and horticultural crop whereas the none-edible species were mostly the wild varieties (for details please refer APPENDIX II).

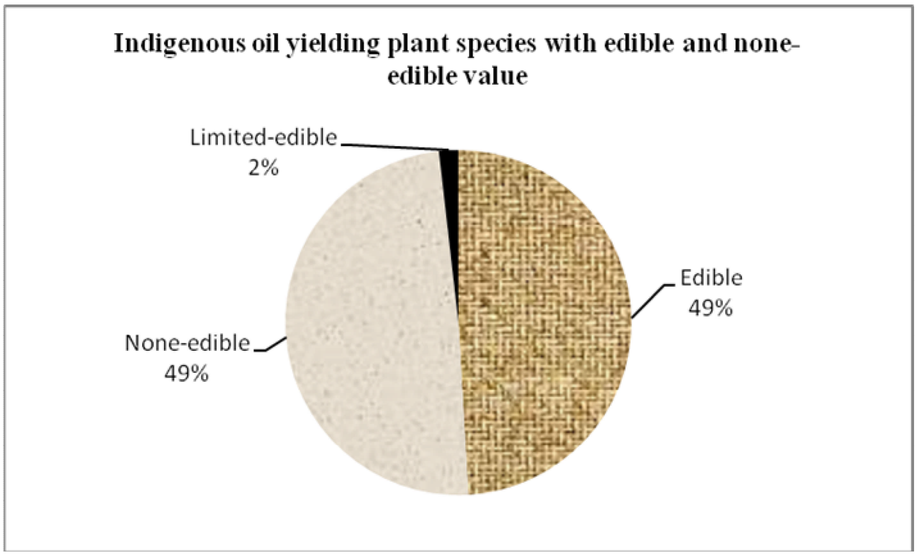

Figure 7: Indigenous plant species with edible and non-edible value

There was a high proportions of Himalayan endemic plant species having potential for oil production. Most of the species we surveyed were represented by their distribution ranges restricted to the Himalaya and adjoining places. A preliminary survey on oil content of some indigenous oil yielding plant species suggests good potential for oil extractions (**APPENDIX II**). However owing to incomplete available information results are not described here.

6.4.2 Indigenous fuelwood species

A total of 158 species representing 58 families were identified as having indigenous fuelwood values. Fabaceae was the dominant family represented by 17 species, followed by Euphorbiaceae with 15 species, Moraceae with 13 species, Anacardiaceae with 7 species and, Lauraceae, Rosaceae and Verbenaceae sharing six species in common (see **APPENDIX II**).

Most of the indigenous fuelwood species were trees (n = 114; 75%), followed by shrubs (n = 33; 22%), herbs, climbers and species with multiple life forms (shrubs/trees) shared the equal number of species (n = 2; 1%) as presented in Figure 8.

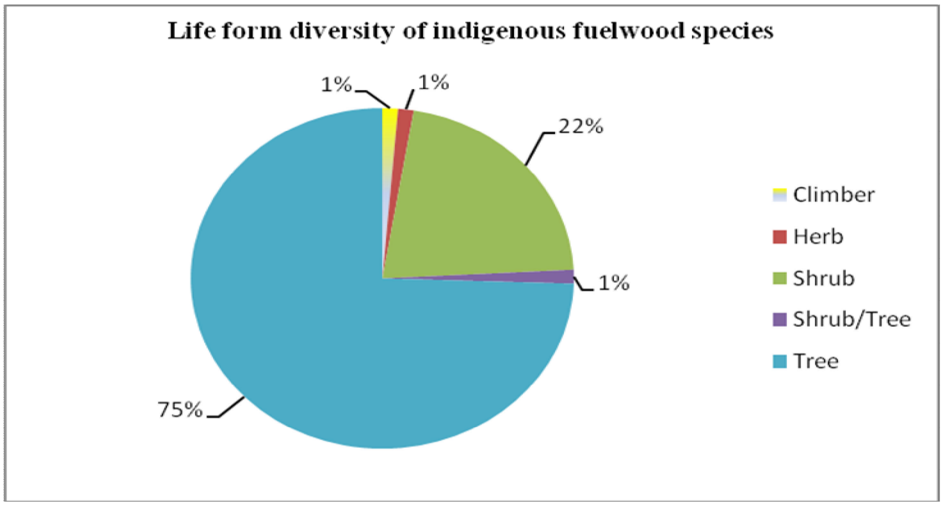

Figure 8: Life form diversity of indigenous fuelwood species

Analysing the distribution range along the altitudinal gradient it was found that most of the species were distributed in tropical-temperate climates (n = 93; 77%) as shown in Figure 9. Similarly, a total of 16 species (13%) were distributed from subtropical-temperate habitats, while a few (n = 9; 8%) had typical subtropical distribution and two species (2%) were of subtropical to alpine habitat.

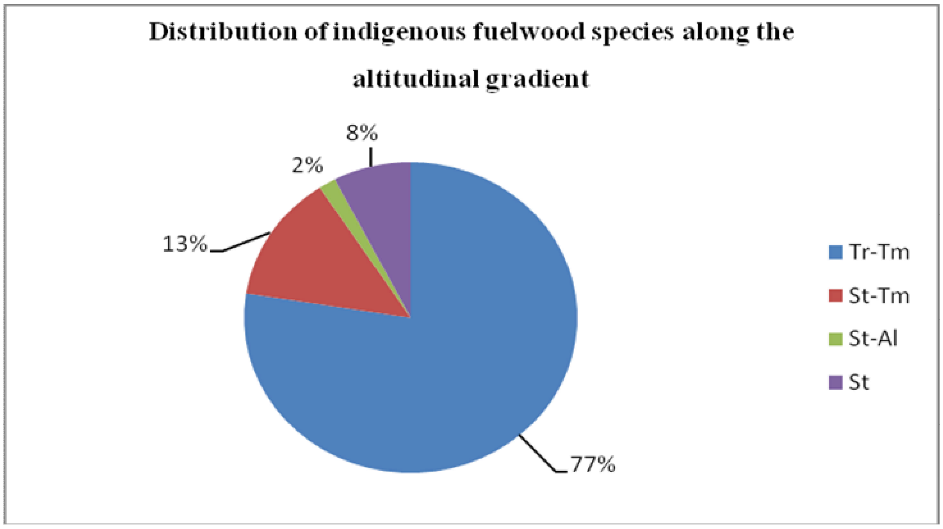

Figure 9: Distribution pattern of indigenous fuelwood species

Note: Abbreviations in figure (9): Tr-Tm = tropical-temperate; St-Tm = subtropical-temperate; St-Al = subtropical-alpine; St = subtropical.

6.4.3 Indigenous charcoal producing species

Analysis of this category was just based on assessing the highly potential charcoal production species only. Otherwise most of the fuelwood producing and timber plants have potential to produce charcoal (Annexes 2-4). A total of eight prioritized species for indigenous production of charcoal in Nepal were identified during the preliminary phase of this research. Those species were represented by individual families. All the prioritized charcoal producing species were of trees and mostly confined to the tropical-temperate regions (see **APPENDIX II**).

6.4. 4 Indigenous timber species

An attempt was also made to identify the potential indigenous timber species of Nepal. Identification of potential timber species was also thought to be of importance because of their potential to produce biomass in the form of charcoal. A preliminary research finding documented 65 species of indigenous timber in Nepal represented by 26 families. Fabaceae again was the dominant family represented by 11 species, followed by Combretaceae with 7 species, Pinaceae with 6 species and Fagaceae with 5 species.

6.5 Discussion

This preliminary finding is purely based on review of some relevant research products, field study in Nepal as well as experiences gained during the project visit in Bangalore, India. We have documented some of the promising indigenous plant species in Nepal having potential for biofuel/biomass production. The findings suggests that there is a richness of indigenous oil yielding, fuelwood, charcoal producing and timber plant species in Nepal and a number of Himalaya endemics are recorded in our preliminary documentation. Most of the species we recoded are based on Himalay and adjoining regions (Pan-Himalay/Sis-Himalaya). The addition of timber species as potential energy producing plant species in Nepal came with the logic of their potential to produce charcoal, which is a prime energy resource in Nepal being utilized by rural communities from time immemorial.

Although potential indigenous biofuel plant species are found representing diverse physiographical and ecological conditions of Nepal from east to west, our preliminary finding suggests a greater richness of such plant species in the lowland Terai region and Mid-hill ecosystems of Nepal. Historically, the marginal poor having a primary livelihood base on subsistence agriculture and forest products inhabit the rural settings of these ecosystems in Nepal. There are many degraded and fallow lands available especially in Mid-hills that can be utilized for the purpose of biofuel plantations of larger commercial scale. People in this region also have rich indigenous knowledge of fuel production. Rural lighting techniques and bio-briquettes are some of the examples of such traditional practices.

The sustainability of any biofuel project depends on the interaction of economic viability, social suitability and environmental durability (SNV & WWF 2009), thus there should be particular attention while selecting species, sites and tools and techniques of production. Our research findings suggest that indigenous plant species have economic potential, are socially acceptable and environmentally sound. People in rural communities can easily identify and believe in the potential of such species because they are familiar with them. They have experiences on their productivity, longevity, production potentials, and environmental suitability and so on.

Although this study tried to identify preferences for selected plant species (done for some species, for details please refer to the annexes) it was not possible to identify preferences for all the species documented because of lack of information in the literature. Furthermore, determining preferences is a difficult task as it requires data on many different aspects of the species, including ecology (abundance, habitat suitability etc), social use preferences, and economics.

PART SEVEN:
Technologies Suitable for Creating Bioenergy on a Community Scale in Developing Countries

Andy Ross and James Hammerton

7.1 Introduction

This report identifies current and future technologies for utilising biomass on a small to medium scale for implementation in rural communities. The report primarily focusses on technologies currently available for small-scale power generation, mechanical energy for agriculture and space heating and cooking together with the different fuel options and production technologies. The report identifies technologies that may become significant in the future and developments in integrated renewable energy systems incorporating biomass.

7.2 Electricity production from biomass

Power production from biomass on a small scale is almost totally realised via Internal Combustion Engines (ICE). Product gas from biomass gasification, biogas from anaerobic digestion and liquid biofuels are all examples of biomass products that can be used in internal combustion engines. The use of steam turbines in CHP systems require high temperatures and pressures and are too costly for small scale applications. Gas micro-turbines are being developed for CHP applications making use of advances in automotive turbocharger technology. They can be driven by hot flue gases or indirectly heated air and are more suited to smaller scale operation. The use of Stirling engines driving a standard generator are less sensitive to impurities in product gas than internal combustion engines and offer some potential for long term, low maintenance operation. Biogas from anaerobic digestion or syngas from gasification can be used as fuel for a micro-turbine CHP system or used as a fuel for a Stirling engine. A conventional, reciprocating steam engine can also be used for electricity generation, and specialist products have been developed for biomass CHP applications. This is well established, well proven technology but low efficiency, giving a high heat to electricity ratio.

7.2.1 Spark ignition engines

This type of engine ignites a compressed air-fuel mixture in a cylinder with a spark from a spark plug causing a rapid expansion. The piston is forced down which produces work. Such engines can utilise liquid and gaseous fuels.

Spark ignition (SI) engines are generally set up for use with liquid fuels in particular gasoline, but can also run using (bio)methanol or (bio)ethanol with little modification. Running with methanol or ethanol increases thermal efficiency as higher compression ratios and leaner fuel mixtures can be utilised compared to gasoline (x). Methanol SI engines produce less emissions of CO, HC and NO_x but more aldehydes than gasoline engines (Vancoillie et al., 2013, Wagner, 1996). Emission reductions are similar for ethanol SI engines although NO_x can be higher at certain operating conditions (Hsieh et al., 2002). Both have lower energy density and so auxiliary components such as a larger fuel tank and fuel injectors might be needed (Kowalewicz, 1993).

Gaseous fuels can also be used. Compressed natural gas, biogas, syngas and hydrogen can all be used in spark ignition engines. SI engines designed to run on gas are readily available, although liquid fuel engines can be modified by removing the fuel injectors or carburettor and replacing it with a gas mixer at little expense (Foley, 1983).

7.2.2 Compression ignition engines

Compression ignition (CI) engines combust fuel by injecting into a cylinder at high pressures. This causes the fuel to ignite without a spark. Diesel is the most commonly used fuel in these engines. This can be substituted for bio-diesel, plant oils, pyrolysis oils and ethanol-diesel blends. The use of plant oils can be problematic as they can begin to crystallise when cooled, reducing the fuel flow rate to the engine. Under these conditions incomplete combustion occurs and the engine stops (Dwivedi and Sharma, 2014). Heating the fuel tank is a common method of preventing this. There are several different waste oils that can be used in CI engines ranging from engine oils to used cooking oils. Fuel properties such as viscosity and cetane number can impair the direct use of plant oils due to blocking of injectors although they can be used directly in the presence of suitable additives. Normally, the properties of vegetable derived fuels are improved by a process called trans-esterification to produce what we call biodiesel.

Gaseous fuels can also be used but some modification is required as they do not combust under pressure. The best option is to operate using a dual fuel. In this case a mixture of air and gaseous fuel is drawn into the engine cylinder and compressed. A small amount of liquid fuel that will ignite under pressure (such as diesel) is injected into the cylinder to create a flame required to ignite the gaseous fuel. There is an efficiency penalty compared to running the engine using just diesel but is a more efficient conversion of the gaseous fuel than via an SI engine. The requirements to convert a CI engine to run in dual fuel mode is similar to that for an SI engine- the installation of a gas mixer on the air intake manifold is needed.

7.3 Mechanical energy from biomass

ICE engines are commonly used in small agricultural machinery. A large number of applications in agriculture and construction have been developed ranging from small stationary ICE for the operation of saw mills, pumping of water, dairy operations etc, to the fuelling of tractors and diggers for more intensive farming activities. In each case, the main source of mechanical energy is from the ICE including both 2 stroke and 4 stroke spark ignition engines and diesel engines.

7.4 Heat for cooking

Cooking in developing countries where fossil fuels are unavailable is almost exclusively realised by combustion of biomass. The type of biomass used and the type of appliance used varies considerably but one of the main health issues associated with the use of biomass for cooking is the inhalation of smoke. Solid fuels such as woody biomass can be pre-treated to produce cleaner burning solid fuels via carbonisation to produce charcoal. Stove design can be improve combustion efficiency and reduce smoke production. One significant development is the gasification stove which burns biomass much more cleanly and is essentially burning hydrogen. Alternatively, gaseous fuels such as biogas or syngas can be burnt in modified gas burners and used for cooking. The problem with using syngas is the presence of CO and the problem of using biogas is the CO_2 diluent although both of these issues can be overcome with the correct burner design. Liquid fuels can also be used for cooking however the switch from fossil to biomass derived liquids is more challenging as vegetable oils tend to have high viscosity and do not burn well in atmospheric burners.

7.5 Biofuel production technologies

7.5.1 Anaerobic digestion

Anaerobic digestion utilises bacteria in an oxygen deprived environment to break down biomass into biogas. The majority of the gas produced is methane followed by carbon dioxide and trace amounts of hydrogen sulphide, ammonia, nitrogen and oxygen. A range of feedstocks can be used including vegetation, animal manures, sewage and effluents from industries using biomass (Nallathambi Gunaseelan, 1997).. The most common limitation of useable biomass is the nitrogen content which can inhibit methane production if the concentrations are too high (Yenigün and Demirel, 2013). Once the organic matter has reached the end of its usefulness for producing biogas, the remnants (digestate) can be used as a fertiliser (Rösch et al., 2012). The digesters contain a significant amount of water with the biomass- solids typically accounting for just 3-25% of the total mass within the reactor (Nallathambi Gunaseelan, 1997). Biomass remains in the digester for several weeks as the process is very slow. The digester must also be kept warm at roughly 35°C which is often done by burning approximately 20% of the produced gas depending on the ambient temperature of the surroundings (reference). Solar heating using a flat-plate collector and heat exchanger can also be used as an alternative to burning gas (Axaopoulos et al., 2001). The produced gas is often purified to remove hydrogen sulphide, ammonia and siloxanes which are toxic and corrosive. Biogas contains approximately 35-75% vol methane and a higher heating value between 15 and 30 MJ/Nm^3 (Abatzoglou and Boivin, 2009).

7.5.2 Gasification

Gasification is a process in which a solid fuel such as biomass is converted into a gas containing carbon dioxide, carbon dioxide, hydrogen and methane. This is useful as the gaseous fuel burns cleaner and can be more easily converted into electricity or mechanical work by using an internal combustion engine. To do so, the gas produced must have less than 30 g/Nm^3 of particulates and less than 50-100 g/Nm^3 of tar (Milne et al., 1999). It is considered the cheapest method to convert biomass into electricity. The medium in which the solid fuel is gasified is very important and has a large effect on the composition of the produced gas.

The simplest medium to gasify biomass in is air. The feedstock is heated to approximately 700-1100 °C in a sub-stoichiometric supply of air although in more complicated systems, steam and oxygen can be used. There are four distinct phases of reaction in gasification. The first is the drying of the feedstock, which occurs in the cooler sections of the reactor vessel. To evaporate moisture consumes a lot of energy and therefore drier feedstocks are preferable- to produce a gaseous fuel with a reasonably high heating value, the moisture content of the feedstock should be in the region 10-20% depending on the system employed (Basu, 2010). The pyrolysis stage sees volatiles driven off from the solid fuel and thermally broken down into smaller condensable and non-condensable gas molecules. The condensable part becomes tar once cooled which can be problematic when using the produced gas. If in high quantities, it needs removing either with filter systems or by cracking to produce light hydrocarbon fractions which increases the volume of fuel produced.

The solid char remaining after devolatisation then reacts with oxygen in the air. Depending on the stoichiometry of the air supplied, the char is converted to a mixture of carbon monoxide and carbon dioxide. The reaction supplies heat for the other stages. Several other reactions occur producing more product gas such as water-gas shift reactions where carbon monoxide and steam react to form hydrogen and carbon dioxide. There is also a large amount of carbon dioxide from oxidation reactions producing heat in the reactor. The combustible fraction is mostly hydrogen and carbon monoxide but can also contain large amounts of methane. Good clean up of the product is important if reliable operation is to be achieved. A down-draft fixed bed gasifier is usually used as this design tends to give lower levels of tars as they can be cracked within the gasifier.

7.5.3 Vegetable oil derived fuels

Small-scale mechanical extraction of vegetable oils can be performed using an expeller press in a similar manner to olive oil extraction. Oils normally require extensive cleaning but crude vegetable oils can be converted to biodiesel in relatively simple reactors whereby the lipids are reacted with methanol in the presence of either an alkali or acid catalyst. Alkali catalysts have higher efficiency at lower temperatures but the presence of free fatty acids in the lipid fraction will lead to saponification reactions (soap formation). To avoid this, acid catalysts can be used. The production of biodiesel assumes a readily available source of methanol, which is normally fossil derived. If methanol is unavailable, bioethanol can be used instead although this leads to lower conversion rate. The use of raw vegetable oils is possible but can lead to deposits in injectors unless suitable additives are added to the fuel. Blending with fossil diesel can also deposition reactions.

7.5.4 Fermentation

Fermentation is the conversion of sugars into bioethanol. The majority of bioethanol is produced from food crops, so-called 1st generation bio-ethanol although there is significant development in the production of 2nd generation bioethanol from lignocellulosic biomass.

The first step of the process is to hydrolyse the biomass into fermentable sugars. Hydrolysis maybe chemical or enzymic includes heat, acid or high-pressure treatment. This involves severe chemical treatment for lignocellulosic biomass but is usually enzymic for starch and sugar based crops. The mixture is then fermented in anaerobic conditions by bacteria for a few days before it is distilled to remove the majority of the water. It is usually then dehydrated using molecular sieves to produce anhydrous ethanol, this is required if the ethanol is to be blended with gasoline.

Bioethanol can be used as an automotive fuel for SI engines either pure or mixed with other fuels. Ethanol fuelling increases thermal efficiency at all speeds and higher power at high engine speeds (Costa and Sodré, 2010). It can also be used for heating. It burns cleanly and a flue is not required. The largest energy penalty in bioethanol production is the distillation step.

7.5.5 Pyrolysis of biomass

Pyrolysis involves the thermal degradation of biomass in the absence of oxygen and can be used to produce liquid, solid and gaseous fuels depending upon the operating parameters. For low cost simple designs, pyrolysis is normally used to produce charcoal, a cleaner burning fuel and the gaseous and liquid products are burnt to sustain the process. Under certain conditions, the oil can be collected and it is possible to use this as a fuel if blended with diesel although there are problems with storage and handling. Pyrolysis oil is a low quality fuel, it has a high oxygen content and a low HHV. Gaseous fuels such as methane and hydrogen can be produced from the high temperature pyrolysis of biomass although at lower temperature pyrolysis, the gas is exclusively burnt to sustain the pyrolysis process.

Pyrolysis char when added to soil, is called 'biochar'. Biochar can be used as a soil additive to reduce nutrient leaching and can be used to reduce odour from manure and composting. The use of biochar in environmental management is an expanding area of research and it is likely that biochar could provide benefits within rural communities for a range of applications.

7.6 Future perspectives for rural bioenergy

7.6.1 Novel feedstock

The cultivation of microalgae for production of biomass for either AD, fermentation or extraction of lipids has a high potential for small-scale community bioenergy. Assuming a suitable climate, microalgae can be cultivated in open or closed systems to produce either high lipid or high carbohydrate containing biomass under the right control. This biomass can be used directly in AD to produce biogas or can be extracted to produce liquid biofuel. Residues from extraction can be used for animal feed and animal manures can be used to provide nutrients for cultivation. Fast growing biomass, such as microalgae, require significant amounts of nutrients and this would likely limit the scale of cultivation. The use of microalgae in integrated renewable energy systems is likely to increase and has many applications.

7.6.2 Fuel cells

Microbial fuel cells (MFCs) are an interesting development that can potentially directly produce electricity from a range of biomass and simultaneously treat wastewaters. The direct conversion of fuel into electricity rather than heat means that the limit in thermal efficiency by the Carnot cycle is avoided and therefore higher thermal efficiencies can be achieved (>70%) (Du et al., 2007). Whilst achievable efficiencies are high, the rates of power generation by lab-scale MFCs are still very low and more development in this area is required.

MFCs consist of an anaerobic chamber containing fuel and an anode. Separated by a Proton Exchange Membrane (PEM), is an aerobic chamber containing a cathode. Dry air is usually passed across this. The anode and cathode are electrically connected allowing the flow of electrons. Protons pass through the PEM where they react with oxygen in air producing water. One of the advantages of this process is that it can be performed at ambient temperatures.

Direct Carbon Fuel Cells (DCFCs) are another type of system where solid carbonaceous matter is converted to electricity at temperatures within the range of 600-900°C. Carbon content of the fuel is proportional to the power density of the fuel cell and also allows for a higher current density (Ahn et al., 2013). The development of DCFC could significantly reduce the cost of fuel cell operation as these do not require expensive precious metal catalysts. The fuels that can be used must have a high carbon content and thus there is a lot of interest in using biomass chars and biocoal created by hydrothermal carbonisation (Munnings et al., 2014). This technology is still under development but it is likely to have significant impact for small-scale electricity production and its fuel is readily produced form different types of biomass.

7.6.3 Integrated solar thermal

There is increasing interest in the use of concentrated solar energy being used as an energy source for driving endothermic chemical transformations during fuel processing. Examples include, solar decomposition of water and thermochemical cycles. These primarily include solar reforming, solar cracking, solar pyrolysis and solar gasification although there are many additional applications for using concentrated solar for providing process heat for chemical transformations such as solar distillation, solar trans-esterification, or providing low levels of heat for AD. The solar energy is concentrated by utilising trough, tower and dish systems. The advantages include an increasing calorific value to fuel, gaseous products that are not contaminated with combustion products and reduction in emissions. Advancement in DCFC may have additional applications for solar thermal although for high temperature operation, complexity and expected cost are likely to rapidly increase.

7.6.4 Hydrothermal processing of biomass

This involves the processing of biomass in water under pressure and can convert high moisture content biomass such as manures into high energy density fuels while removing inorganic contaminants. The products include a solid coal like fuel, a fuel oil or a syngas depending on the severity of the treatment. To produce a gaseous fuel, the water must be at least 374°C and at 22.1 MPa (Munnings et al., 2014) and so the process requires significant heating. There is significant interest in coupling the process with concentrated solar energy (Lu et al., 2011). By doing so, the need for burning a fuel to heat the process is reduced and a free energy source is utilised. Hydrothermal processing can also represent a potential pre-treatment for anaerobic digestion or fermentation and a route for recycling nutrients back to agriculture.

7.5.5 Pulverised fuels in ICE

There is potential for using pulverised fuels such as biomass directly in ICE. Although the use of biomass directly is in its infancy, significant research has been performed using coal dust. Research into using coal dust either as a dry powdered fuel or as a slurry in either diesel fuels or water has been ongoing for many years Piriou et al., 2013). In early research, dry powdered coal was used in very large diesel engines (over tens of litres per cylinder) at slow engine speeds. More recent research has considered engines as small as 0.9 litres per cylinder. Engine wear was reported to be the biggest issue in these tests followed by fuel metering. The mean coal dust particle sizes of the fuels used are typically between 60 and 100 μm.

There are some advantages to using biomass dust over coal- biomass usually contains less ash than coal leading to a reduction in wear and clogging of valves. Furthermore, the higher volatile content and surface area of biomass increases the rate of combustion Piriou et al., 2013). As with coal, trace compounds in biomass could be important to the suitability. Sulphur content in coal has been an issue with tailpipe emissions. The presence of alkali metals in biomass may cause further issues with wear in engines due to their corrosive nature. It is thought biomass particles below the size of 30 μm would be suitable for direct combustion in diesel engines.

PART EIGHT
Second Phase Fieldwork

8.1 Energy Gardens trekking in Baglung

Interaction and public awareness programmes were held at various places in rural Nepal. On 7th October, the Nepal Energy Garden team organised a day trekking from Narayansthan -6 Balewa to Bhairabhsthan, Amala Chaur VDC, Baglung district. The trekking team included a local band that played songs about the energy crisis in the villages and the potential role a project such as Energy Gardens can play to overcome such energy crisis. All the participants enjoyed the trekking and discussions on energy issues in the village, which culminated into worship (Puja) at the local Bhairabhnath temple on the hilltop, which was followed by a group picnic. Altogether more than 40 villagers including women, school students, dalits, local priest took part in the event. The local priest at the Bhairabhnath temple offered blessings to the participants that the dream of creating Energy Gardens in Nepal will soon be fulfilled. The idea of using the local belief system to raise awareness on energy gardens was positively received by the community members.

Photo 26: Energy Gardens Promotion in Baglung

8.2 Energy Gardens interactions in Lamjung

A similar interaction programme was also held at at Timure village of Chakratirtha VDC, in Lamjung district where the villages were invited to share their experience of being highly dependent on fuelwood in the household and communities. They reported that whilst community forests have grown in recent times, they have placed many restrictions on the collection of forest products including fuelwood and fodder. Whilst the Forest Users' Group arranges annual fuelwood collection, the allocated quota of fuelwood is not sufficient even for small households. These restrictions have meant that villagers are either forced to use expensive LPG gas or use trees and shrubs, including bamboo, from private lands, which are not efficient and produce too much smoke in the kitchen. The participants mentioned that they have suffered frequent power cuts due to loadshedding and have been forced to use expensive imported LPG as fuelwood is in short supply. Many households simply could not afford LPG gas and have depended on fuelwood for cooking and heating. They collectively agreed that Energy Gardens Project will be very much welcomed in their villages as it will help to reduce poverty, improve livelihoods and enhance energy security in the village.

Photo 26: Local woman using charcoal for making utensils in Lamjung

8.3 Energy Gardens interactions in Gaindakot, Nawalparasi

Another energy gardens promotion event was held in Gaindakot, Nawalparasi district on 15th October 2014 to highlight interdisciplinary and pro-poor nature of the project and how it can play a vitally important part in overcoming energy crisis in the country. The event coincided with the visit of the local pastor, who was holding a service for the congregation in the village. Many participants in the event were Dalits who had recently converted to Christianity and the congregation was an excellent meeting place for the local villages together with the Christian communities in Gaindakot area. The Pastor of the local Church led the congregation and all the participants offered prayers for realisation of the aims and objectives of the Nepal Energy Gardens project.

8.4 Energy Gardens Dohori Songs in Gorkha

Dohori (duet songs) are folkloric popular music genre in Nepal, which plays a significant role in the lives of many villagers in rural Nepal to express themselves on various personal and social issues. As, such a Dohori evening was held at a Dalit village in Mathillo Sera village of Duwakot village where an overwhelming proportion of the residents relied on fuelwood from the local forests. The Dalits in the village have recently formed a local Dalit organisation to support each other during the time of hardship. The local Dalit organisation assisted the Energy Gardens team with the logistics for organising a Dohori evening. Altogether 30 villages including men, women and school children participated in the programme with great excitement. The villages were grouped in one team and the Energy Gardens team was in the opposite team for Dohori. The programme stated in the evening at 7 P.M. after dinner continued for 3 hours until 10 P.M. The villagers had the opportunity to ask questions about Energy Gardens project in the form of songs whilst the Energy Gardens team addressed those concerns in the form of songs.

Photo 27: Energy Garden Dohori Songs in Gorkha

8.5 Energy Gardens Deusi-Bhailo programme in Lamjung

Similarly, Deusi-Bhailo was organised at Panchabhai Chaura of Dhamilikuwa VDC in Lamjung district to promote Energy Gardens projects in the villages. Deusi-Bhailo are traditional songs, which are sung by the villagers during the Diwali (Tihar) festival where they go around houses singing, dancing and collecting money, sweets and food. The visitors also offer blessings for prosperity to the families of the houses they visit. The venue for Deusi-Bhailo is a crossroad and a local market place where a lot of villagers visit during the festival. A project banner was displayed to raise the profile of the project during the Dusi-Bahilo programme. A team of local musicians was invited to play traditional musical instruments (Panche baja) on the occasion. Many local villagers joined the Energy Gardens team for singing, whilst others, particularly the ladies, danced to local music. This was an innovative way of disseminating research and increasing the profile of the project.

Photo 28: Energy Gardens Deusi-Bhailo in Lamjung

8.6 Energy Gardens team meeting in Kathmandu, Nepal

Nepal Energy Gardens Project team meeting was held at SAP Falcha House, Kathmandu, Nepal on 29th October to appraise all the work carried out so far and to plan for future work. The following individuals participated in the meeting:

Bishnu Pariyar (University of Leeds)
Krishna K. Shrestha (ESON)
Laxmi R. Joshi (ESON)
Sudarsan Khanal (ANSAB)
Roshan Manandhar (Practical Action-Nepal)
Bhim B.K. (FEDO)

8.7 Decisions made in response to meeting agenda

a. **Regarding Payment**: Project partners haven't received payment until that date. Until that date partners are voluntarily working and the problem is with partner organization’s annual auditing. This is solely a responsibility of Bishnu ji to ask University of Leeds to provide partners allocated payment within a week.

b. **Partner’s strength to execute project**: Each partner has a great strength to execute the project, however all four partners do not have strength for quality research and reporting. For example, FEDO may not take part for the next session of the project if it is asked for a pure academic research report. It is agreed that research oriented partners will contribute towards the academic outputs whilst partners such as FEDO will contribute towards capacity building and non-academic reports.

c. **Contribution to the reports/outputs**: Interim report is ready and under revision by Prof. Lovett. We have enough material to prepare a final technical report. However, each partner’s effort will be required to collect as much information as possible. For example, ESON’s effort to prepare a complete diagnosis of each indigenous biofuel plant species is under way.

d. **Concern of FEDO:** The project coordinator should provide a report template with specific questions and output to focus. We are not a research institution so do not expect a full technical research report from our institution. Bishnu ji will prepare a report template and ask FEDO for their input before the submission of final technical report. As a project coordinator Bishnu ji reserves right to push partners to completed their assignment on time.

e. **Regarding workshop appraisal**: Prepare a workshop proceeding for wider circulation. ESON is executed for this task. Bishnu ji will provide all the reference material of the workshop (including audio-visuals, presentations etc.) to Mr. Laxmi Joshi before he leaves for UK. ESON will ask Bishnu ji to allocate necessary costs for reporting (including DSA), once approved by him

ESON will proceed. Time necessary for this task will be 15 working days for a researcher.

f. **Meeting with DFID**: Project partners will have a meeting with DFID representatives tomorrow. Prof. Shrestha will set the agenda (one page concept note) by tonight and circulate to the team before they meet at DFID Nepal office.

i. The meeting seeks local collaboration with DFID Nepal other than the regular support from DFID UK. The project partners will ask DFID Nepal authorities about the research, capacity building and development support though energy smart village projects under energy garden concept in Nepal.

ii. The capacity building support will be in the form of PhD and MSc research support to the students both based in Nepal and UK.

iii. The energy smart village is a brand new concept in Nepal, hence has great possibility to get DFID support. The idea is that the project partners in Nepal will develop a concept of energy smart villages in 5 sites of Nepal (representing different physiography). The energy gardens will be executed together with rural gasification systems. These projects will be allocated a certain amount of budget. With the support from local communities the projects will be executed to make villages energy smart.

g. **Second round application**: The concept for the second round application will be based on the present research activities and its output. The proposed budget for next round application will be nearly 200 thousand pounds. A detail work plan will be prepared by the team later, including the sites for research, criteria for prioritization of research sites etc. Bishnu ji will work closely with Prof. Lovett on this task.

h. **Building further collaboration**: Sharing with additional partners will share the allocated budget. Since the projected budget is too low we should now fix the tentative minimum budget for next round project. The minimum required budget for a lead partner organization will be 7,000 pounds +3,000 pounds for collaborator. However, the volume of budget will depend on the task allocated and performed.

i. **Research exchange/mobility**: Further collaboration with University of Leeds should open the opportunity of academic exchange to Nepali partners. We strongly suggest Leeds to enhance such opportunities in the form of PhD, MSc programs and short term visits. The ideal PhD program would be like a Sandwich degree. Student will enrol to Leeds and work for Nepal Energy Garden Project (with the stay and work in both countries and institutions). Both Nepali partners and University of Leeds will facilitate researchers from either institution to the respective countries.

j. **Further funding opportunity**: Collaborators will try for novel research opportunities like Newton Fund. Any innovative research idea for partners will also be supported through collaborations and team contributions.

k. **Research publication**: Everybody will get credit of publications based on their contributions.

l. **Research impact (Dohori, Deusi-Bhailo)**: The project has both societal (in the form of awareness rising) and research impact and will continue getting recognition.

m. **Biomass Sample**: There is a need for obtaining biomass samples from Nepal for laboratory analysis in Leeds urgently. Prof. Shrestha and ESON will take up this matter urgently to facilitate the process of acquiring biomass samples.

Ideal sites for demonstrations of energy garden concept in Nepal: Five sites will be selected representing different physiography (say development regions) of Nepal. These sites will represent different ethnic clusters, Dalit settlements, Community forests etc. Each partner organization will lead each energy smart village projects. For example ESON will lead an ethnic community (the Limbu community in Panchthar district in east Nepal) in collaboration with ICIMOD, Ministry of Forest Conservation and RECAST. Similarly FEDO will lead a energy smart village project in Karnali and Far west region. ANSAB will lead a community forestry based energy smart village in collaboration with FECOFUN and so on. All collaborating institutions will support the innovation of lead agency.

Each energy smart village projects will be provided with a significant proportion of budget (say GBP 20,000) to execute different research and development activities.

8.8 Other pertinent issues discussed

- Job responsibility should be clearly allocated and well defined:
- Project partners should be trained in reporting.
- Communication is largely lacking, we should have regular meetings and discussions and sharing of experiences. Each partner organization can call meetings turn by turn.
- For the next phase of project the lead organization members should get an opportunity to meet and share progress in Nepal, India as well as in UK.
- Plan for series of workshops for the next phase.

Table 27: Five work packages for Second Round of Energy Gardens Proejct

S.N.	Lead Agency	Collaborator
01	University of LEEDS	BGCI, FEDO
02	ANSAB	FECOFUN, Ministry of Energy
03	ESON	RECAST, DPR
04	Practical Action	NAST, AEPC
05	HASAAN Biofuel Park	ICRAF New Delhi

8.9 Concept Note for Discussion at DFID Nepal

Project Title: 'Energy Smart Villages in Nepal'
Duration: Three Years (2015-2018)
Sponsor: DFID (Requested Grant: GBP 2 million)
Supported by: Ministry of Energy (Government of Nepal), Alternative Energy Promotion Centre (AEPC),
Team Leader: Prof. Jon Lovett; Deputy Team Leader; Dr. Bishnu Pariyar (Post Doctoral Fellow); Coordinator Nepal Chapter: Prof. Krishna K. Shrestha
Collaborators: University of Leeds, Botanical Garden Conservation International (UK); ANSAB, ESON, Practical Action, and FEDO (Nepal); and Hassan Biofuel Park (India).
Associate Collaborators: Nepal Academy of Science & Technology (NAST), Research Centre for Applied Science & Technology (RECAST, TU), Federation of Community Forests Users Group Nepal (FECOFUN), Department of Plant Resources, Ministry of Forests & Soil Conservation (Nepal); World Agroforestry Centre (ICRAF, New Delhi).

8.10 Proposed Project sites

Western Nepal (Humla, Karnali): Lead organization: University of Leeds, with FEDO (Focal Group: Dalit Women)

Central Nepal (Dolakha/ Lamjung): Lead organization: ANSAB, with FECOFUN (Focal Group: Community Forests User Group)

Eastern Nepal (Panchthar): Lead organization: ESON, with RECAST (Focal Group: Limbu Ethnic community)

Associate Collaborators in Cross Cutting Issues:
Practical Action Nepal, Nepal Academy of Science & Technology, Department of Plant Resources (Nepal); Hassan Biofuel Park, and ICRAF (India), Botanical Garden Conservation International (UK).

8.11 Proposed Activities and Expected Outputs

- Selection of potential Native Energy yielding Plants (Top 10 species of trees, based on Phase I project), and plantation in villages, field edges, range lands, etc.

- Promotion of Gasification system for rural electrification, using bioenergy plants, waste products (such as rice husk, saw dust, sugarcane bagasse, etc.), weeds, leaf litters, etc.

- Initiation of 'Energy Smart Villages' (ESV), at least one ESV in three physiographic zones, representing Western, Central and Eastern Nepal.

- Such ESV will be capable of producing sufficient bioenergy required for cooking, lighting, heating, and running audio visual devices, water pumps, etc. (without using firewood, LPG Gas, etc.)

- Maintaining greenery in the forests and villages (by *in situ* and *ex-situ* conservation)

- A sum of Rs. 50 lakh (GBP 30,000) will be allocated to establish Energy Smart village in one district (Total GBP 90,000), and the community will contribute about half of the money in terms of their labour and other logistics.

- Execution of capacity building programs, such as training workshops, exposure visits, exchange of visits, support to Master's students and PhD scholars to conduct their thesis works on bioenergy and other issues.

CHAPTER: NINE
Potential Integration of Biofuel Plant Species in Farming System

9.1 Major biofuel plant species in Nepal

Whilst results of a detail plant survey are reported in Part Five, this section is devoted to investigating plant species that can be integrated into farming systems in Nepal. Three types of biofuels are discussed –transport biofuels, for example biodiesel based on oil from rapeseed or ethanol from wheat; solid biofuel which combines heat and power applications and are made from waste and by-products (leaf litter, sawdust, rice hull pellets and briquettes for example); and fuels from algae and other non-traditional materials and are still largely experimental.

This section of the report reviews the current options of the first two types of bioenergy, as these are more viable in the country considering the participation of smallholders and the production potential of the bioenergy. As the participation of rural households in fuelwood collection is high and the fuelwood covers a significant share of the total household energy consumption in the country, this study also considered fuelwood trees as the energy garden plants. From the presentation point of view, the energy options are divided into solid biofuel and liquid biofuel in this section.

9.2 Solid biofuel

The prioritized products for biofuel include fuel wood, beehive briquettes, pellets and charcoal. Other attractive options include biomass electricity, sawdust briquette and pellets.

9.2.1 Fuel wood

The primary sources of fuel wood are both forest and private land. About 65% of households rely on forest for the collection of their fuel wood. Community-managed forest and private forest are major source of fuel wood with 44% and 24% of household relying on them respectively (CBS 2011). The annual sustainable fuel wood supplied as estimated by Water and Energy Commission Secretariat (WECS) of the government of Nepal for 2008/09 was 12.5 million tons, of which 7.14 million tons can be sustainably harvested from community forest alone. The fuel wood is also collected in the form of by-products of wood processing industries as the estimated residue recovery rate is about 40 to 50% for saw milling and plywood production. The major plant species used for fuel wood in different regions in Nepal are listed in Table 25 .

Table 25: Major species used as fuel wood in Nepal according to physiographic zones

Terai	Hills	Mountains
Sal (*Shorea robusta*), sissoo (*Dalbergia sisoo*), Masala (*Eucalyptus* spp.*)*, karma (*Adina cardifolia*), jamun (*Syzygium cumini*), saj (*Terminalia tomentosa*), Siris (*Albizia* spp.), mango (*Mangifera indica*)	Chirpine (*Pinus roxburghii*), alder (*Alnus nepalensis*), chilaune (*Schima wallichi*), katus (*Castenopsis* spp), siris (*Albizia* spp.) oak (*Qurecus* spp.)	Laliguras (*Rhododendron* spp.), blue pine (*Pinus wallichiana*), oak (*Qurecus* spp.), bhojpatra (*Betula utilis*), dhupi (*Juniperus indica*)

Source: Subedi et al. (2014)

9.2.2 Briquette and pellets

Briquettes and pellets could be made from otherwise weed or unwanted forest biomass, agricultural crop residue, and residues from medicinal and herbal plant processing and municipal solid waste. In Nepal, community forest-based briquette enterprises in Sindhupalchok, Dolakha, Lalitpur, Dhading, Chitwan, Lamjung, Parbat and Jhapa districts are producing briquettes from the otherwise unwanted forest biomass, such as invasive weeds and shrubs from their community forests. Because of the early stage of the industry, raw materials are mainly sourced from community forests, and the sourcing has not been practiced from other forest management regimes. This study has identified a number of plant species that are currently used for briquette production according to different regions of Nepal. These are listed in Table 26.

Table 26: Major species whose residues can be utilized for Bio-briquette

Terai	Hills	Mountains
Banmara (*Ageratina adenophora*), lahare banmara (*Mikania micrantha*) titepati (*Artemisia capillaries*), lantana (*Lantana camera*), eucalyptus, *Cymbopogon* spp. (lemongrass, citronella)	Timur (*Zanthoxylum armatum*), sugandhakokila (*Cinamomum glaucescens*), banmara (Ageratina adenophora), titepati (*Artemisia capillaries*), wintergreen (*Gaultheria fragrantissima*), pine needles, mentha (*Mentha arvensis*), lantana (*Lantana camera*)	Lauth salla (*Taxus baccata*), sunpati (*Rhododendron anthopogan*), dhupi (*Juniperus indica*)

Source: ANSAB (2014)

9.3 Liquid biofuel

Table 27 below presents the list of major plant species in Nepal that can be used as liquid biofuel. As the focus of this study is on the non-food crop, so the edible oilseed crops such as soybean, sunflower, rapeseed and peanut; starch crops such as maize, wheat, barley, rye, potato and cassava; and sugar crops such as sugar beet and sweet sorghum have not been considered in this study.

Table 27: Major biodiesel and bioethanol producing plant species

Biodiesel	Bioethanol
Edible oilseed crops: soybean, rapeseed, sunflower, peanut, palmoil **Non-edible oilseed crops:** Jatropha (*Jatropha curcas)*, Neem *(Azadirachta indica)*, ashoka (*Saraca asoca*), Mahuwa (*Madhuca indica),* nageshwori *(Mesua ferrea),* koiralo *(Bauhinia variegate),* simal (*Bombax ceiba*), katush (*Castanopsis indica*), khote salla (*Pinus roxburghii*), rittha (*Sapindus mukorossi*), bhalayo/kag bhalayo *(Semecarpus anacardium),* moringa/sahijan (*Moringa oleifera*), adir/castor (*Ricinus communis)*	**Starch crops:** Maize, Wheat, Barley, Rye, Potatoes **Sugar crops**: sugar cane, sugar beet, sweet sorghum, cassava **Cellulosic materials**: miscanthus, willow, poplar, switchgrass

Regarding the potential for commercial development of non-edible oil seed crops, Jatropha, a major common hedge plant is the key crop. Jatropha is also a multipurpose, drought resistant and perennial plant not needing much water, hence can be produced in marginal land. It has been estimated that 30% of the land area is climatically favorable for the cultivation of Jatropha (Boswell 1998). The National Biofuel Program of the government has also focused on the promotion of Jatropha for the production of biodiesel (Refer Appendix IV) for major policy and legislative provisions that have impact on biofuel development in Nepal). Apart from Jatropha, other non-edible oilseed-bearing plants are rittha, salla, neem and katush that are cultivated in marginal lands. Visit to Hassan Biofuel Park, Banglore show that mahuwa and nageshwori that are available in the country are also high oil-yielding plants. Distribution pattern of species with more oil content than these tree species such as pongami, paradise tree and other species that are available in Banglore can also be explored in Nepal.

9.4 Potential for integration of biofuel species into farm and forest systems in Nepal

There is a great potential for commercial development of biofuels in Nepal by integrating into existing farm and forestry systems and planting in marginal and uncultivated waste lands. For the possible integration, the following strategies are presented.

9.4.1 Identification of the forest area based on important biofuel species

Forestlands in Nepal have not been systematically zoned on the basis of their availability of biofuel plants. Based on the study, the area under forests excluding the critical areas (that need to be protected for special purpose, such as scientific studies, biodiversity conservation or ecological function) could be identified for the production of biofuel plants in the country. For this, as a start, the following list of recommended species could be considered along with the continuous process and mechanism of identifying, assessing and prioritizing, which would be based on the emerging markets and technology of production and value addition.

Preliminary list of commercially potential biofuel species from natural forests:

- Fuel-wood from hard-wood species with high calorific value for meeting fuel wood demand mostly in rural households especially for cooking, room heating during winter, preparing livestock feed (e.g. kudo), liquor production and for sale in the local market – sal (*Shorea robusta*), sissoo (*Dalbergia sissoo*), karma (*Adina cardifolia*), jamun (*Syzygium cumini*), saj (*Terminalia tomentosa*), sirish (*Albizia* spp.) and botdhangero (*Largestromea parviflora*) in Terai; chilaune (*Schima wallichii*), katus (*Castenopsis indica*) and alder (*Alnus nepalensis*) from hill regions.

- Fuel-wood from soft-wood species except oak and rhododendron with high caloric value for meeting demand in rural households especially for cooking, room heating, preparing livestock feed and liquor production - using blue pine (*Pinus wallichiana*), fir (*Abies* spp.), spruce (*Picea smithiana*), rhododendron (*Rhododendron* spp.) and oak (*Quercus* sps.) in mountain regions.

- Briquettes and pellets - forest weeds (e.g., eupatorium and lantana) and other forest-based biomass waste - herbs, litter, shrubs, woody climbers available mostly in community-managed forests in hill regions.

- There is a vast scope to promote plantation of commercially most important forest species, such as fast growing timber species in non-forested public and private lands, especially in Terai and mid hills. In this example, denuded forest and hence low biodiversity, yet close to road and processing facility make it a good fit for plantation.

Preliminary list of commercially potential products from plantations:

- Primarily solid fuel (briquette, pellet) with some fuel-wood production from plantation with high calorific value fuel wood species – sissoo (*Dalbergia sissoo*), babool (*Acacia arabica*), poplar (*Populus* spp.), eucalyptus, bakaino (*Azadirach indica*), and mango (*Mangifera indica*) in Terai; alder (*Alnus nepalensis*) and sirish (*Albizia* spp.), chilaune (*Schima wallichii*), katus (*Castenopsis* spp.) in hill regions; *Salix* sps., poplar, temperate fruits (including apple, apricot) in mountain regions.

9.4.2 Introduction of biofuel species into existing community forestry system

Because of the very small landholding of the Nepalese farmers, it is not often possible for planting biofuel species mainly trees in the edges of the farming lands. There is possibility of integration of these plants in the community forests. Because of the community forestry program in Nepal, the communities are well organized, which can be taken as a positive factors for introducing these plants. Because the CFUGs are organized, the community will be able to coordinate in production related activities as well as the processing and marketing related activities of the final product.

Some of the high oil yielding plant species could be introduced in subgroups in community forest (Refer Box 1 for the subgroup model in Nepal's community forestry). For example, jatropha, castor and moringa could be the candidate species but the plant species should be listed based on the feasibility of plantation considering climatic and social factors in the area. ANSAB's experience with subgroups in Dolakha district by providing certain patches of degraded and barren land within the community forest to the ultra-poor forest dependent groups shows that introduction of income generating crops and trees in these areas promote economic empowerment of the groups through cultivation and collection of non-timber forest products. Activities in the planting, harvesting, processing and distribution of the products can generate income for the rural poor.

Box 1: Subgroup model in Nepal's community forestry

A subgroup is a small group of people, particularly ultra-poor, women and Dalit, who share a common interest in terms of natural resource management and occupation; live in a geographical proximity to each other; are members of a Community Forest User Group (CFUG); and are heavily dependent on the forest resources for their livelihoods. This subgroup is formed under the Community Forest (CF) guidelines and the forest management plan of CF. The group has their own management plan (subgroup and enterprise development), operating procedure and bank account.

ANSAB introduced the subgroup model in 2003 by facilitating the provision of certain patches of degraded and barren land within the community forest to the ultra-poor forest dependent groups for income generating activities and formed 74 subgroups in three districts that encompassed 1,779 ultra-poor households in 22 different CFUGs in between 2003 and

2005. As the plantation function by the subgroup, Sunsari subgroup of Bhitteri CFUG, for example, planted more than 20,000 Argeli (*Edgeworthia gardenerii*) cuttings and some fodder species in the allocated land between 2003 and 2012, where Argeli (*E. gardenerii*), Lokta (*Daphne bholua*) and Chiraito (*Swertia chirayita*) were found feasible NTFPs listed for plantation. ANSAB's experience with subgroups shows that subgroup in community forest is a promising way to improve governance and enhance forest ecosystems and local livelihood within CF. The major impacts of sub-group models in the CF are increased inclusiveness, the active participation and empowerment in all activities of the women and poor, micro fund mobilization for income generation, forest based enterprise development and the restoration and improved management of forests. The model was recognized by district stakeholders by promoting the concept elsewhere. Government of Nepal revised CF program development guideline in 2009 incorporating the provision of well being ranking and allocating degraded land of CF to the poor groups.

9.5 Integration of biofuel plant species to the farming system

Biofuel plant species could be integrated into the farming system as erosion control crops, windbreaks in larger tracts of agricultural land, and as intercropping in agroforestry practices. Considering existing farming systems, which are mostly of the subsistence type, farming is dominated by smallholders, with low technical know how and poor extension programmes. It is necessary to provide support for introducing biofuel plant species into farming systems. Furthermore proper research on the plants' characteristics, social acceptability, market, and government subsidy and facilities is necessary for introducing the suitable biofuel crops.

9.5.1 Biofuel plant species in integrated farming system

Some literature (e.g. GIZ 2011) show that energy crops such as jatropha, castor and moringa can be cultivated without compromising food production. These crops also help to protect soils against erosion and can protect crops against damage caused by animals. Cultivation of jatropha or other energy crops could be done as living fences or in intercropping agroforestry system.

Possible intercropping of cereal crops, seasonal vegetables, leguminous crops, annual and perennial grasses, timbers or important medicinal plants in agroforestry practices could also be taken into consideration while selecting biofuel species for intercropping in agricultural lands. Jatropha and castor and could potentially be intercropped as part of different cropping systems. There is also potential to produce moringa through intercropping with food crops.

9.5.2 Biofuel species in marginal and uncultivated wasteland

As cultivation in marginal and uncultivated wasteland will not compete with food crops, these lands could be utilized by introducing plant species having low production costs. Eucalyptus and pine plantations could be considered on marginal lands. Similarly on uncultivated wasteland, jatropha and other non-edible oilseed bearing plants can be cultivated. Marginal and uncultivated lands are also suitable for growing cellulosic biomass crops such as miscanthus, willow and switchgrass.

9.6 An overview of Biofuel related Policy and Legislative Provisions in Nepal

The following are the biofuel related policy and legislative provisions, which are relevant for Nepal Energy Gardens project. The review of the regulation will help to shed light if the institutions are sufficiently conducive enough to implement the project in Nepal.

a) Biofuel Policy emphasize on the production of liquid biofuels for transport from Jatropha *(Jatropha curcas)*-based biodiesel; high priority for the private sector involvement and investment. b) Climate Change Policy 2011 promotes clean energy, such as renewable energy, alternative energy and green technology to reduce green house gas emission; financial resource generation from public-private partnership. c) National Adaptation Program of Action (NAPA)

2010 promotes bio-energy with the technical support of private sector; formation of a multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC). d) Rural Energy Policy 2006 emphasizes on environment friendly, affordable and sustainable Renewable Energy Technologies (RETs); enhancing capacity of local bodies and facilitation; integration of RETs with economic and other developmental activities; special promotional activities focusing poverty reduction & positive impacts on women and children; and involvement of private sector, community, CBOs and NGOs. e) Subsidy Policy for Renewable (Rural) Energy 2013 provide additional incentives to poor, women and marginalized groups and communities; reduce supply/consumption gap between rural and urban; support RET market by attracting private sector; support long-term target of the government replacing subsidy by credit.

Government of Nepal has been implementing National Biofuel Program since the fiscal year 2008/09 by focusing particularly on promotion of Jatropha (*Jatropha curcas)* for the production of biodiesel in a country where Alternative Energy Promotion Center (AEPC) has been taking a leading role. As an effort to find alternative energy sources, the Nepal government has developed policy and programs to produce and promote feedstock for biodiesel since 2007. The government has provisioned the mandatory use of 10 percent ethanol in government vehicles in Kathmandu.

The following policy and legislative provisions have impact on biofuel plant based enterprises:

a) The Interim Constitution of Nepal 2007 has guaranteed the right to clean environment as a fundamental right of people which broadly identified alternative energy products i.e charcoal and briquette as a priority energy type. b) Forest Act 1993 and Forest Regulation 1995 has given legal rights to CFUGs for the establishment of Forest Based Enterprises in forest area considering the availability of forested products of community forestry. It has provisioned permit from DFO to transport legally produced charcoal by paying NRs. 0.20/kg tax in the case national forest c) Industrial Policy 2010 lists forestry and agriculture as highly prioritized enterprises and offers support in technology, market, skills and research. Similar support and priority is given to locally established enterprises d) Company Act 2000 and Cottage and Small Industry Guideline 2011 provides scope for registration of enterprises in various model e). Value Added Tax Act 1995 has a provision of exemption of value added tax (VAT) on charcoal and equipment related to bioenergy; and local production of cottage industries. f) Income Tax Act, 2001 has a provision of tax exemption in the production and marketing of forest products, which are produced by forest-based cooperatives. g) The Financial Act 2013/14 has provided tax exemption in land registration for NTFP farming and processing which could benefit biofuel enterprise also.

PART TEN:
Lessons Learnt and Future Plans for Nepal Energy Gardens

10.1 Some Reflections and Lessons Learnt

Success of biofuel project in Hassan is because of the adoption of many measures that are tested at different levels. For example, quality planting materials are available on site; an effective mechanism is developed to procure seed materials; the market is assured because of base price fixation and buy-back guarantee; food planting area (food security) is not affected as the plantation is done in field margins or as shade trees; and the existing dairy cooperative model is adopted as an institutional mechanism.

Currently, bio-fuel discourse in Nepal has very much been focused on Jatropha. Other plants with high oil-yielding seeds such as Chiuri, Amphi, Ritha, Machhino, Kholme etc are already available in Nepalese forests. But they remain under studied and under-utilised. The full lists of Nepalese plant species that can be used for biofuel production are given **Appendix II.**

Whilst the climatic conditions in high hills and mountains is significantly different from India, Nepal's southern Terai has comparable climatic conditions where bio-fuel crops such as pongamia, neem, paradise tree, mohua etc. can be grown. Neem and Chiuri are already available in the forests, whose distribution pattern can be explored in Nepal.

Because of the very small landholding of the Nepalese farmers as compared to those in Karnataka, it might not be possible for planting these trees in the edges of the farming lands. However, the biofuel plants can be cultivated along the boundaries and uncultivated lands, which are abundant in many rural villages.

Nepal has many successful community forests including in villages considered for scoping study. There are already oil bearing plants such as Chiuri, Ritha, Machhino, Amphi etc in the forests and there is possibility for integrating these plant species in the community forests. The introduction of plant species in community forests has both institutional resilience and egalitarian distribution, as the poorest of the poor can also benefit from the project. Certain patches in the community forests can be allocated for planting these trees. In fact, the survey data demonstrated that significantly higher proportions of farmers are willing to introduce non-invasive biofuel plants species in community forests.

Many rural villages have high social capital such as trust, which was evident in the villages considered for this research too. Communities have a track-record of organising themselves in groups such as WUAs, FUGs, women groups and local micro-finance groups, which can be integrated into community based biofuel programmes.

Farmers in the villages not only have high social capital, they are also very willing to consider planting biofuel plants. However, they had some concerns about the possible competition with the food crops. Once the nature of the energy gardens was explained, those concerns are significantly reduced as a significantly higher proportion of farmers reported that they are willing to cultivate biofuel plants as long as they do not directly compete with food crops.

The State Government in Karnataka has established the base price for the seeds and oil and the University of Agricultural Science has buy-back guarantee with the farmers. The State Government has also provided IRs 4 crore to the project. These sorts of much needed enabling environment has been the important requirement for the successful operation of the model; the assurance of the fund and infrastructures needs to be considered while replicating in countries like Nepal, where the Government has other priorities.

Bio-fuel produced at local community level can be expensive when they are transported to the centre for using in transportation sector. They also have to compete with the fossil fuel while the value chain emerges, where the government has given subsidies in fuel. Given the shortage of energy in the villages, there is a high demand for biomass based energy and energy gardens can provide a viable option towards meeting some of the energy demands in the communities.

As a way of developing sufficient economic model for community development where biofuels plays a role could be developed in Nepal. For example, small-scale enterprise activities according to the bio-fuel production potential could be designed, that use the energy produced at the community level.

Given the availability of areas for cultivation such as boundaries, uncultivated lands and community forests, involvement of communities in the production stage of raw materials (seeds) is straight forward and can be undertaken with minimum resources as long as quality assurance is achieved. However, more effort will be required during the processing and final product development, technical issues on processing, storing and transportation.

10.2 Potential for Uptake in Nepal

Whilst big industrial scale biofuel plants using oil producing trees for biofuel in Nepal could be challenging because of non-existence of large scale oil refinery. But small-scale community-based energy gardens are appropriate to meet households and community energy needs. There is both the demand for this and communities are willing to get involved with energy gardens. In addition to already available areas for biofuel plants cultivation such as used land, boundaries, bunds, there is also a huge potential for such plants to be introduced in community forests. The synergy between energy gardens and already successful community forests in Nepal combined with public acceptability and high social capital in the communities makes Energy gardens very compelling for full scale implementation. The government of Nepal has high priority on renewables and alternative sources of energy, community-based biomass energy such as energy gardens are likely to receive support from the policy circle as well. Therefore, mobilizing the community for energy gardens has the potential to change the lives many farmers by enhancing livelihoods and providing energy security. Whilst the lesson learnt from the research thus far is outlined above in Section 8. 1, there is a compelling case that if the communities can access to initial funding, the policy transfer from Hassan to rural villages in Nepal is possible and can be as successful as in Hassan.

10.3 Future Plans for Expansion

Given the novelty of the Energy Gardens concept and multiple benefits to the local community in overcoming energy poverty and protecting local environment, we are planning to expand the project both in Nepal and outside.

Firstly, we have a plan to apply for Climate Change Innovation Fund from the ESRC Centre for Climate Change Economics and Policy to start a collaborative research with the International Centre for Integrated Mountain Development (ICIMOD) to implement small scale Energy Gardens in the selected villages where ICIMOD has worked through its REDD+ programme. Combining results of the Energy Gardens project with ICIMOD's work, we plan to organise community members as co-operative groups. Attempts will be made to provide them a revolving fund so that they can make recruit and expand their network amongst the community members interested in embracing energy gardens as their households and community energy mix. They will also technically be assisted to start and run small enterprises in producing and selling seeds. We are also preparing work to seek funding from the Newton Fund for a full-scale intervention of Energy Gardens.

Secondly, building on the discussion Dr. Bishnu Pariyar (PDRA working on the project) with Minister for Agriculture in Nepal during the fieldwork, we are also planning to take the Government of Nepal on-board to provide necessary institutional support for implementing Energy Gardens in Nepal. The Ministries we intend to collaborate will be Ministry of Agriculture Development and Ministry for Energy. We are in discussion with Dr. Swarnim Wagle, Member of National Planning Commission of Nepal to develop a comprehensive policy framework on Energy Gardens and implement it through Alternative Energy Promotion Centre (AEPC) in collaboration with Energy Garden project team.

Thirdly, as a way of understanding African perspectives on Energy Gardens, we are in discussion with colleagues at the Centre for Centre for Research in Energy and Energy Conservation (CREEC) at Makerere University, Uganda for a possible expansion to Uganda. This expansion will be a multi-national collaboration with southern Partners (Nepal, India and Uganda) and Northern Partners (University of Leeds, and BGCI). This will enable knowledge transfer from Northern to Southern partners and amongst Southern partners as well.

APPENDIX II

Nepal Energy Garden Project

School of Geography

UNIVERSITY OF LEEDS

Household Survey Questionnaire

Conducted at: Khudi VDC (Lamjung); Hamsapur VDC (Gorkha) and Lakuridanda VDC (Dolakha).

3rd March- 9th April 2014

Language translated to: Nepali

Namaste!

Would you like to participate in the interview?

yes ☐ → Proceed to question A

no ☐

A. IDENTIFICATION OF DATA

A1. Name of the VDC

A2. Name of Ward/Settlement

A3. Name of Respondent

A4. Respondents' caste group

A5. Ethnicity/Caste of Respondent

A6. Type of Settlement Urban Peri-Urban Rural

A5. Is the Respondent Household's Head Yes No

A6. If No to A5, please state your relationship within the households -------------------

A7. Type of House and Ownership

Type of House	Number	Ownership 1= owned, 2= rented; 3 = provided	Roof Type 1= thatched, 2 tin/tile, 3= concrete

A8. How long have you lived in this area: --------Years

B. Demographic Information

Identification Code		Sex	Age	Educa tion Status (scho ol yr)	Time Spent for biogas weekly			Time and Money spent in		Energy week		Acquisition		OCCUPATION (ADULTS)		Residing	
	Name of Family member (Note - Start with HH Head)	1= M2=F						Fuelwood		Dung		Agricultural residue				Inside	Outside
					Time	Money	Subsidi es	Time	Money	Time	Money	Time	Money	Primary	Secondary		
1	HH Head:																
2																	
3																	
4																	
5																	

6																	
7.																	

Occupational code: Agriculture = 1; Works overseas = 2; Business = 3; Industry = 4; Services = 5; Student = 6; Wage labour = 7

Other (specify)= 8---

C. LANDHOLDING, TENUTRE AND PRODUCTION SYSTEMS

C1. What type and how much Land you have got?

Type of Land*		Land Holding Pattern and Area in *Ropani*		
		Owned land	*Shared crop In*	*Shared crop out*
Khet	Canal irrigated (nahar)			
	Irrigated by local water sources (kulo)			
Pakho Bari				
Khar Bari				

C2. How long the field crop production can meet your household food demand?

i) . < 3 months ii). 3 to 6 months iii). 6 to 9 months iv). 9 to 12 months v). > than 12 months

c3. What are the major crops you have produced in the past year and annual income from selling agricultural products?

SN	Unit	Total Production	Unit Sold	Unit Price (Rs)	Total Income (Rs)
1	Rice				
2	Maize				
3	Millet				
4	Wheat/ Legumes				
5	Mustard				
6	Barley				
7	Fruits				
8	Potato/ Vegetables				
9	Peanuts				
10	Biofuels				

C4. Income from different sector and occupation

Sources of income	Amount per month	Amount per year if Monthly estimation is difficult
Agriculture		
Service		
Shop/business/trade		
Cottage industries		
Foreign Employment		

C5. Households Livestock and Income from Livestocks

Type of animal	No. Of animals	Local costs per cattle	Milk production per day (Litre)	Consumption/Selling			Total In NRs.
				Consumed daily	Sold outside		
					Quant	Unit price	
Goat/sheep							
Pig							
Chicken/Duck							
Cow							
Buffalo							

C6. Which Chemical Fertilizers did you use last year

SN	Chemical Fertilizer (Kg/thumse/dokho)		Costs in NRs	Received on Time (please tick)
1	DAP			
2	Urea			

3	Potash				
Over	Chem. Fert.				
Che	Mical	Fertiliser received	On time?	Yes	No
4.	Manure				

D. HOUSEHOLDS ASSETS AND INCOME STATUS

D1. Type of Household Items

Items	Yes /no
TV	
Electric fans / room heater	
Water filter	
Pressure cooker	
Radio	
Mobile phone	
LPG cylinder	
Mixer/grinder	
Motorcycle	
Two wheeler moped / scooter	
Livestock	
Type of roof of the house	Thatch / Tile or sheet / RCC
Land holding	Landless / irrigated land / non irrigated land

D2. Type of indebtedness

i. Daily consumption purposes from informal sources (friends, relatives or money lenders)
ii. For buying energy (LPG, Bhari wood, Kerosene etc.)
iii. For production purposes from informal sources (friends, relatives or money lenders)
iv. For other purposes from informal sources (friends, relatives or money lenders)
v. Borrowing from institutional agencies
vi. No indebtedness

E. PUBLIC PERCEPTIONS OF BIOFUELS

E1. Have you heard about bioenergy?

a) Yes b) No

E2. If No to E1, would you like to know about bioenergy?

a) Yes b) No

E3. Could you please express your level of knowledge on biofuel in the following scale?

1 is the highest ---------------------5 is lowest				
1	2	3	4	5

E4. How did you know about biofuels

a) Newspaper b) Academic study c) Radio/TV d) NGO/INGO e) Government programme f) online media.internet g) others

E5. What does energy mean in your opinion

a) Fuelwood+ biochar + biodiesel b) Biodiesel+ biochar +briquette

c) Briquette + biodiesel+ bioethanol d) Fuelwood+ biochar + biodiesel + briquette+ bioethanol e) All of the above

E6. Please indicate the importance of the following sources of biomass energy for households and community in the given scale (Mark X in the appropriate box)

Sources of Biomass Energy	1 is the most important --- 5 is the least important				
	1	2	3	4	5

Forest products (fuelwood)					
Agricultural residues					
Waste materials					
Biogas					
Briquette					
Biofuel (Biodiesel/bioethanol)					
Biochar					
Wood based industrial wastes					
Others (specify)					

E7. Have you already cultivated/grown plants in suitable for bioenergy including biofuel production in your field?

a) Yes b) No

E8. Yes to E5, where have you grown bioenergy plants? (Tick as many as appropriate)

a) Cultivated field b) Field-bunds c) Boundaries
d) Uncultivated/stray land e) All of the above

E7. If No to E5, would you consider growing bioenergy plants or local plant species for biofuel production?

a) Yes b) No

E8. If Yes to E7, where would you consider planting biofuel crops?

a) field b) field-bunds c) boundaries d) uncultivated/stray land
e) introduce in local community forests f) All of the above

E9. If No to E7, why would you not consider planting biofuel crops, please select from below:

a) I am happy with food crop

b) There is no established market for biofuels

c) I do not know much about biofuel

d) I do not want biofuel plants competing with food crops

e) Others, please specify ----------------------------------

E10. How would energy contribute to the local economy? [**Tick as many as you want**]

a) Add new jobs b) provide energy security locally c) reduce poverty
d) improve health e) reduce migration f) all of the above

E11. How would bioenergy contribute to the local environment

a) Positively b) Negatively c) Neutral d) uncertain/unknown

E12.What is the status of the local forest
a) Increasing b) Decreasing c) Same

E13. How are/will be the costs and benefits of biofuels related

a) Benefits greatly outweigh costs
b) Benefits moderately outweigh costs
c) Benefits equal costs
d) Costs moderately outweigh benefits
e) Costs greatly outweigh benefits

E14. In what ways you have felt/will feel the impact of biofuels

a) Changes in the crops planted
b) Increase in local food prices
c) Water Resources diverted from other important needs
d) General increased in quality of local environment
e) General decrease in quality of local environment

E17. Please rank the following issues from 1 to 5 based on their importance for developing biofuel policy in Nepal (1 is the most important and 5 is the least important)

Ranking	Issues
	Biofuel policy promotion
	Subsidies to farmers
	Market development/marketing support
	Tax exemption to producers
	Community participation
	Biofuel certification
	Biofuel project implementation

E18. Now, I would like to ask some questions about your perceptions of biofuel, please tick as appropriate.

SA= strongly agree; A= agree; N=neutral; D=disagree; SD=strongly disagree; DK=don't know.

SN	Statements	SA	A	N	D	SD	DK
1	If communities want biofuel growing in the field they should be insured by the government if biofuel project fail						
2	Biofuel can be an important aspects of local economy						
3	Biofuel is socially acceptable						
4	The government should have a properly policy on biofuel						
5.	There is no proper link between potential biofuel plant growers and policy makers						
6.	If tax rebate in given, people are willing to try new plant species for biofuel production						
7.	There is a demand for biofuel for local use such as running mills, pumps, lamps, stove etc.						
10.	The villagers will welcome specialists for coming to their village for research, study and intervention on biofuel						
11	There are locally available plant species suitable for biofuel production						
12	Biofuel crops compete with food crops						
13	As long as the biofuel plants do not displace food crop, I will be willing to plant them along the field						

	bund, shade and uncultivated land						
14	Biofuel creates employment opportunities						
15	Bioenergy is the main alternative source energy in Nepal						
16	Bioenergy can significantly generate income for rural households						
17	Bioenergy is carbon neutral						
18	Use of bioenergy is environmentally friendly						
19	Use of bioenergy makes local people self-reliant on energy						
20	Bioenergy is renewable energy source						
21	Government should promote biofuel/bioenergy						
22	Significant works are needed to form cooperative groups for biofuel cultivation and marketing						
23	Households in the community trust each other and can work together to form co-operative						

E19. In your opinion, the implementation of biofuel should be through which of the following? [**select more than one if needed**]

a) Community partnership b) co-operatives c) private sector d) Government sector
e) NGO/INGO f) Other (please specify) --------------

E20. Please choose one from the following

a) I am optimistic for the future of biofuel production in Nepal
b) I am pessimistic for the future of biofuel production in Nepal
c) I do not know about the future of biofuel production in Nepal
d) I do not see future for biofuel production in Nepal

E21, if d is selected from E22, give reasons.

a) lack of property government policies
b) Lack of technical manpower
c) Financial constraints
d) Lack of market
e) All of the above

f) Any other (please specify--------------------)

E22. If you are producing/ will produce biofuel, please fill the details for costs associated with it (please indicate hours or NRs. whichever is appropriate/available).

Households Distance		Mode of Transport				Total Costs NRs.
	Hours to visit	Walk (hrs)	Cost of Labour (NRs)	Public Vehicle (NRs.)	Cost for Snacks (NRs)	
Household distance from the nearest forest						
Household distance from the furthest forest						
Household distance to the nearest market/town						
Costs of Nursery preparation (NRs)						
Cost of sappling preparation (NRs)						
Costs of visiting (Hours)						
Costs of fertilisers for biofuel						
Costs of pesticides for biofuel						
Costs of visiting technical places/people including biogas technicians.						

E23. Please list five most important local plant species for bioenergy production in your communities (eg. ritha, sajiban, machhino, chiuri, salla etc.)

(a)---------------------- (b)------------------------------(c) ----------------------------

(d)---------------------- (e)---------------------------- f) do not know

E24. What do you do when you save time from collecting firewood as a result of biofuels including biogas if produced in the future (**tick as as many as appropriate)**

Activities	How many hours	
	Daily	Weekly
Involved in alternative income generating activities		
Better care of family		
More time for study		
More time for social activities		

F. HOUSEHOLD ENERGY CONSUMPTION

F1. Please fill the details about fuel sources/consumption in various tasks in your households (please put the **MOST IMPORTANT** for each tasks).
1=firewood, 2= agricultural residues, 3= animal dung, 3=biogas, 4= LPG, 5= Kerosene, 6= Solar, 7= electricity, 8= Others (specify)

Tasks	Main source of fuel
Cooking (including boiling waters for drinking)	
Making tea/coffee	
Lighting	
Room heating	
Heating water for other purposes	
Spirits brewing for self-consumption	
Cooking food/drink for selling	

F2. What do you when you save time from collecting firewood as a result of not having to dependent on the future.

Activities	How many hours	
	Daily	Weekly
Involved in alternative income generating activities		
Better care of family		
More time for study		
More time for social activities		

F3. Have suffered any health complications as a result of using firewood as a source of fuel?

a) Yes b) No

If Yes to F3, which of the following health complications have experienced? **(Tick as many as apply to you).**

a) eye irrigation b) bronchitis c) asthma d) cough e) Tuberculosis

f) lung cancer g) any other (specify) ---

F4. Please select the degree with which your household is being affected due to lack of energy including electricity

Activities	Degree of Affect				
	Heavily affected	Moderately affected	Slightly affected	Neutral	Not affected at all
Cooking					
Lighting					
Business/Industry					
Communication/Entertainment					
Heating					
Fridge/AC/Fan					
Education					

F6. In the past 7 days, how many hours (total) did your household NOT have electricity
Please mention hours -----------------------------------

F7. Which of the following activities do you think are being mostly affected due to lack of energy in your household

a) Cooking b) Lighting c) Business/industry d) Communication/entertainment

e) Heating f) Fridge/AC/Fan g) any other (please specify) ----------------

F8.What type of stove does your household mainly use for cooking?

a) OPEN FIREPLACE b) KEROSENE STOVE c) MUD stove d) GAS STOVE
e) SMOKELESS OVEN f) others (please specify) -----------------------------

F9. Where did you mailny collect the firewood?
a) OWN LAND b) COMMUNITY MANAGED FOREST c) GOVERNMENT FOREST d) OTHER (pelase specify) ------------------------------

F10. Please rate the following fuel sources for your households (C=cooking; H= heating; L= lighting)

Overall Importance (scale 1 to 6) 1 most importance and 6 least important

Purpose	Charcoal			Firewood			Agricultural residues			Animal dung			Gas						Kerosene stove			Solar			Electricity		
													LPG			Bio Gas											
	C	H	L	C	H	L	C	H	L	C	H	L	C	H	L	C	H	L	C	H	L	C	H	L	C	H	L

F11. Please fill up the details about your household expenditure on Energy in last year.

Particulars	Unit	Total Consumed	Unit Costs	Total Costs (NRs)	Reliability			
					High	Med.	low	Not at all
Firewood from forest	bhari							
Fuelwood purchased	bhari							

Agricultural residue		bhari							
Animal Dung		Doko/thumse							
Gas	LPG	cylinder							
	Biogas	One off							
		Subsidies							
		Regular Maintenance							
Kerosene/Diesel for tuki batti		litre							
Electricity		Unit							
Charcoal		kilo							
Candle (weekly)		Single/poka							
Solar									
Inverter									

F.

G.

HO

USEHOLD

AWARENESS/PARTICIPATION/SOCIAL CAPITAL

G1. Which community groups are operating in your area

SN	Organization	Rate their performance					Mostly likely to Involve in biofuel enterprise	**Statement:** There is a realistic Change of Community based enterprise for biofuel production and marketing				
		vs	s	n	w	vw						
	WUA							SA	A	N	D	SD
	FUG											
	Women Group											
	Saving/Credit											

G2. Are you or any members of your household on a management or organising committee for any of these groups?

a) Yes b) No

G3. If Yes to F2, are any female members of the household involved in a management committee?

a) Yes b) No

G4. How often do you or members of your household participate in scheduled meetings of these organisations?

a) Always b) Usually c) Sometimes d) Rarely e) Never

G5. At what stage do you and your family members participate in organisation activities?

a). Planning and decision-making b). Implementation c). Benefit sharing d)

e) Evaluation

G6. How do you evaluate the rate of your and family members participation in Water User Group?

a). Strong participation b). Occasional participation c). Not very often d). Hardly ever

G7. Do you or any members of your household belong to any decision-making bodies at the village or district level? (e.g. VDC)

a) Yes b) No

G8. If yes to G7, how often do you or members of your household participate in scheduled meetings of these decision making bodies?

a) Always b) Usually c) Sometimes d) Rarely e) Never

G9. How many religious or other informal, non-family events in the community have you attended in the last year? (e.g. festivals, dances, sports, village meetings, birth/marriage/funeral ceremonies, etc.)

If **none**, why?

H. Gender Dimensions

H1. Who does following tasks mostly? (Men/ women/ boys/ girls)

Who carry-out the following activities?	Mostly	Sometimes	Time spend in week (hours) Mention monthly figure if weekly too small but mention the time.
a. Purchasing of daily household items from the market			
b. Selling agricultural and livestock products			
c. Attend community/NGO/Group meetings			
d. Visit Agri. Service centre or veterinary for advice			
e. Collecting fuels			
f. Purchasing fuels – making payment			
g. Fetching LPG Cylinder			
h. Cooking			
i. Cooking feed for animal (if any)			
j. Making food and drink for sale (if any)			
k. Fuel wood processing (cutting, drying)			
l. Fetching water			
m. Carryout farming activities			
n. Getting update information by watching TV, listening radio or reading newspaper			
o. Visiting banks and MFIs			
P. cleaning clothes/utensils			
Q. Dung collection			

*Note: Here school going children below age of 15 years are referred as boys and girls and above 15 years old all are referred as man and woman.

H.2 Who makes the following decisions (Men/ women/ boys/ girls)

Who carries out the following activities?	Mostly	Sometimes
a. Deciding about children's school		
b. Deciding about stove and fuel		
c. Deciding about foods for family		
d. Deciding about health check-ups and treatment		
e. Purchasing of kitchen utensils		
f. Purchasing of assets/lands		
g. Deciding about taking loan		

*Note: Here school going children below age of 15 years are referred as boys and girls and above 15 years old all are referred as man and woman.

THANK YOU!

APPENDIX II

List of potential biofuel species in Nepal based on empirical study and secondary literature

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
Rutaceae	*Aegle marmelos* (L.) Correa	Bel	T	600-1500	Himalaya (Kashmir to Nepal), India, Burma, Indo-China, Malaysia. Widely cultivated		49		Shrestha & Parajuli, 2002 http://efloras.org
Sapotaceae	*Aesandra butyracea* (Roxb.) Baehni	Chiuri	T	200-1500	Subtropical Himalaya (Kumaun to NEFA)	None edible			field study http://efloras.org
Asteraceae	*Ageratina adenophora* (Spreng.) R.M. King & H. Rob. (Syn. *Eupatorium adenophorum* Spreng.)	Banmaara, Kal Jhar	S	850-2200	A pantropic weed, native of Mexico	None edible			field study http://efloras.org
Alangiaceae	*Alangium salviifolium* (L.f.) Wangerin	Amphi, Ankool	T	150-350	Tropical Himalaya, India, Ceylon, Thailand, Indo-China, China	None edible			field study http://efloras.org
Anacardiaceae	*Anacardium occidentale* L.		T	upto 1000m					http://biofuelkarnataka.in
Umbelliferae	*Anethum sowa* Kura.		H	upto 2000m		Edible oil			field study
Fabaceae	*Arachis hypogaea* L.	Badam, Mum	H	800-1000	Cultivated widely throughout the world	Edible oil			Bhattarai, 2009 http://efloras.org

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
		Phalee							
Asteraceae	*Artemisia indica* Willd.	Titepaati	S	300-2400	India, Himalaya, Burma, Thailand, S. China, Japan	None edible			field study http://efloras.org
Meliaceae	*Azadirachta indica* A. Juss.	Nim	T	900m	Himalaya, India. Widely cultivated	None edible	35-42		http://biofuelkarnataka.in field experience to HASAAN Bhattarai, 2009 http://efloras.org
Sapotaceae	*Bassia butyracea* Roxb. = *Diploknema butyracea* (Roxb.) H.J. Lam.	Chiuri	T	300-1500	Himalaya	Edible oil			Bhattarai, 2009 http://efloras.org
Fabaceae	*Bauhinia variegata* L.	Koiralo	T	150-1900	Himalaya (Swat to Bhutan), India, Burma, China		20-30		http://biofuelkarnataka.in http://efloras.org
Bombacaceae	*Bombax ceiba* L.	Simal	T	200-1200	Himalaya (Kashmir to Bhutan), India, S. China, S.E. Asia	None edible			Bhattarai, 2009 http://efloras.org
Brassicaceae	*Brassica botrytis* var. …….	Brokauli	H	100-500		Edible oil			field study Gustafsson & Lannér-Herrera 1997
Brassicaceae	*Brassica campestris* L. = Brassica rapa L.	Sarsyu, Tori	H			Edible oil,			Bhattarai, 2009, field study

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
						Industrial oil			
Brassicaceae	*Brassica juncea* (L.) Czern.	Raayo	H			Edible oil			field study
Brassicaceae	*Brassica napus*L.	Kayanula/ Kalo sarsyun	H		Sometimes cultivated in Nepal for oil from seeds	Edible oil			Bhattarai, 2009
Euphorbiaceae	*Bridelia stipularis* (L.) Blume		C	150-200	Nepal, N. India, Sikkim, Burma, S. W. China (Yunnan), Indo-China, W. Malaysia		20-30		http://efloras.org
Cannabaceae	*Cannabis sativa* L.	Bhang	H	200-2700	Asia	Edible oil			Bhattarai, 2009 Field study http://efloras.org
Fagaceae	*Castanopsis indica* (Roxb.) Miq.	Dhaale Katush, Katush	T	1200-2900	Himalaya (Nepal to NEFA), Khasia, Burma, W. China, Indo-China	None edible			field study http://efloras.org
Meliaceae	*Chukrasia tabularis* A. Juss.		T	400-900	Nepal, India, east to S. China, Malaysia		20-28		http://biofuelkarnataka.in http://efloras.org
Araceae	*Cocos nucifera* L.	Nariwal	T			Edible oil			Bhattarai, 2009

Family	**Latin Name**	**Nepali Name/Local name**	**Life form**	**Elevation ranges**	**Range of distribution**	**Use value**	**Oil (%)**	**Preference**	**Sources**
Cordiaceae	*Cordia dichotoma* Forster	Bohori	T	200-1400	W. Asia, Subtropical Himalaya, India, Ceylon, east to China and S. Japan, Australia, sometimes cultivated	None edible			field study http://efloras.org
Cucurbitaceae	*Cucurbita pepo* L.	Farsi	C			Edible oil			field study
Thymelaeaceae	*Daphne bholua* Buch.-Ham. ex D. Don	Khagatpate /Lokta	S	1700-3500		Edible oil			Bhattarai, 2009
Daphnipyllaceae	*Daphniphyllum himalense* (Benth.) Mull. Arg.	Nepali Raktachandan	T	1200-2500		Edible oil			Bhattarai, 2009
Fabaceae	*Erythrina suberosa* Roxb.	Pholidha	T	900-1200	Himalaya (Kashmir to Bhutan), India, Burma, Indo-China		20-25		http://biofuelkarnataka.in http://efloras.org
Polygonaceae	*Fagopyrum esculentum* Moench	Mitho Faapar	H	1800-4100	C. Asia, widely cultivated	Edible oil			field study http://efloras.org
Euphorbiaceae	*Ficus nerifolia* Sm.	Dudhilo	T			None edible			field study
Ericaceae	*Gaultheria fragrantissima* Wall.	Dhasingare	S	1200-2600	Himalaya (Nepal to NEFA), Khasia, N. Burma	None edible			field study http://efloras.org
Fabaceae	*Glycine max* (L.) Merr.	Bhatmash	H	1000-170	Widely cultivated	Edible			Bhattarai, 2009

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
				0		oil			Field study http://efloras.org
Asteraceae	*Guizotia abyssinica* (L.f.) Cass	Jhuse til	H	900-1900	A native of tropical Africa, cultivated in India and Himalaya	Edible oil			field study http://efloras.org
Asteraceae	*Helianthus annus* L.	Suryamukhi Phul	H	130		Edible oil			Bhattarai, 2009 Field study http://efloras.org
Euphorbiaceae	*Jatropha curcas* L.	Sajiwan	S	500-1200	Native of New World Tropics, cultivated in other tropical areas	None edible	30-35		Bhattarai, 2009 http://biofuelkarnataka.in field experience to HASAAN Field study http://efloras.org
Juglandaceae	*Juglans regia* L.	Sano Okhar	T			Edible oil			Bhattarai, 2009
Linaceae	*Linum usitatissimum*L.	Attashi, Alas	H	150-3800	Cultivated in temperate regions and in India, Kashmir, Tibet	Edible oil			Bhattarai, 2009 http://efloras.org
Sapotaceae	*Madhuca longifolia* (Koenig) Macbride	Mahuwa	T	150	Tropical Himalaya, India, Ceylon		25-35		http://biofuelkarnataka.in http://efloras.org

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
Anacardiaceae	*Mangifera indica* L.	Aamp	T	300-700	Tropical Himalaya, India, Ceylon, Burma, Indo-China, Malaysia, widely cultivated and often naturalised in Tropics	None edible			Bhattarai, 2009 http://efloras.org
Meliaceae	*Melia azedarach*L.	Bakaino	T	700-1100	Himalaya, east to China. Cultivated	None edible			Bhattarai, 2009 http://efloras.org
Clusiaceae	*Mesua ferrea* L.	Nageshwori , Nag Keshar, Rukh Keshar	T	400-900	Nepal, India to Vietnam and Malay Peninsula, Ceylon, Andaman Isl	None edible			field experience to HASAAN Bhattarai, 2009 http://efloras.org
Magnoliaceae	*Michelia champaca* L.	Aaule champ	T	600-1300	Nepal, India, Burma, Thailand, Indo-China, S. Yunnan; commonly planted in SE. Asia		45		http://efloras.org
Cucurbitaceae	*Momordica charantia* L.	Tite Karela	C	300-2100	Tropical Africa, Tropical Asia, widely cultivated	Edible oil			field study http://efloras.org

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
Lauraceae	*Neolitsea umbrosa* (Nees) Gamble	Khapate	T	1700-3500		Limited edible			Bhattarai, 2009 http://biofuelkarnataka.in Field study http://padme.rbge.org.uk/floraofnepal/?page=onlineflora&wildcard
Solanaceae	*Nicotiana tabacum* L.	Kaancho paat, Surti, Lampate Surti	H	800-1800	Tropical America, widely cultivated as tobacco and naturalized	None edible			field study http://efloras.org
Oleaceae	*Olea cuspidata*Wall. ex G. Don	Nepali Jaitun	T	1100-2600	Afghanistan, Himalaya (Kashmir to Nepal)	Edible oil			Bhattarai, 2009 http://efloras.org
Euphorbiaceae	*Phyllanthus emblica* L.	Amala	T	150-1400	India, Himalaya (Kumaun to Bhutan), Assanl, N. Burma, S. China, Indo-China, Malaysia	None edible			field study http://efloras.org
Pinaceae	*Pinus roxburghii* Sarg.	Khote Salla, Salla	T	1100-2100	Afghanistan, Himalaya (Kashmir to Bhutan)	None edible			field study http://efloras.org
Fabaceae	*Pongamia pinnata* (L.) Merr.	Karanjan/Karani	T	upto 1200 m		None edible	20-35		http://biofuelkarnataka.in field experience to HASAAN

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
									Bhattarai, 2009
Rosaceae	*Prinsepia utilis* Royle	Dhatelo	S	1500-2900	Himalaya (Hazara to Bhutan), S. Tibet, Assam, W. China	Edible oil			Bhattarai, 2009 http://efloras.org
Rosaceae	*Prunus amygdalus* Batsch	Badaam	T	2500-3500		Edible oil			field study http://efloras.org
Rosaceae	*Prunus armeniaca* L.	Khurpani	T	2900-3500	China, widely cultivated, sometimes escaped	Edible oil			Bhattarai, 2009 http://efloras.org
Rosaceae	*Pyrus communis* L.	Naaspati	T	600-2400		None edible			field study http://www.worldagroforestry.org/treedb2/AFTPDFS/Pyrus_communis.pdf
Brassicaceae	*Raphanus sativus* L.	Mula	H			Edible oil			field study
Euphorbiaceae	*Ricinus communis* L.	Aader	S	150-2400	Believed to be native of N.E. Tropical Africa; widely cultivated and occasionally naturalised throughout the tropics	Industrial oil	45-50		Bhattarai, 2009 http://biofuelkarnataka.in Field study http://efloras.org

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
Rubiaceae	*Rubia manjith* Roxb. ex Fleming	Majitho	C	1200-2100	Himalaya (Simla to Bhutan), Khasia	None edible			field study http://efloras.org
Sapindaceae	*Sapindus mukorossi*Gaertn.	Riththa	T	1000-1200	Himalaya, Assam, Burma, Indo-China, China, Taiwan, Korea, Japan	None edible	40-60		http://biofuelkarnataka.in field experience to HASAAN Field study http://efloras.org
Fabaceae	*Saraca asoca* (Roxb.) de Wilde	Ashok	T	150-1400	Himalaya (Kumaun to Nepal), India, Ceylon, Burma		50-60		http://biofuelkarnataka.in http://efloras.org
Anacardiaceae	*Semecarpus anacardium* L.f.	Bhalayo/Kag bhalayo	T	150-1200	Himalaya (Sirmore to Sikkim), India, Burma, Malaysia, N. Australia		30-35		http://efloras.org
Pedaliaceae	*Sesamum indicum*L.	Sisam/Til	H			Edible oil			Bhattarai, 2009 Field study http://efloras.org
Dipterocarpaceae	*Shorea robusta*Gaertn.	Saal	T	150-1500	Subtropical Himalaya (Garhwal to Assam), India	None edible			Bhattarai, 2009 http://efloras.org
Anacardiaceae	*Spondias pinnata* (L. f.) Kurz	Amaro	T	300-1400	Tropical Himalaya, India, Ceylon, Thailand, Malaysia, widely cultivated		25-30		http://biofuelkarnataka.in http://efloras.org

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
Sterculiaceae	*Sterculia villosa* Roxb. ex Sm.	Odane	T	300-600	Himalaya		25-30		http://biofuelkarnataka.in http://efloras.org
Gentianaceae	*Swertia angustifolia* Buch-Ham. ex D.Don	Chiraito	H	600-2600		None edible			field study http://gentian.rutgers.edu/genera/genSwerNepal2B.htm
Symplocaceae	*Symplocos pyrifolia* Wall. ex G.Don	Kholme	T	1000-2000	E. Himalaya (C. Nepal to NEFA)	None edible			field study http://efloras.org
Taxaceae	*Taxus wallichiana* Zucc.	Dhengre/Lauth salla	T	2300-3400	Afghanistan, Himalaya (Kashmir to Bhutan), Assam, N. Burma, Indo-China, W. China, Malaysia	None edible			field study http://www.eson.org.np/database/index.php?tax=1&work=display&obj=540&ischild=0
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Barro	T	300-1100	Nepal, India, Ceylon, Burma, Thailand, Indo-China, Malaysia		31		http://biofuelkarnataka.in http://efloras.org
Meliaceae	*Trichilia connaroides* (Wight & Arn.) Bentv.	Aakha taruwa	T	700-2400	Himalaya (Nepal to Bhutan), N. India, Burma, east to China, Malaysia	None edible			field study http://efloras.org
Poaceae	*Zea mays* L.	Makai	H		Widely cultivated in all warm countries	Edible oil			field study

Family	Latin Name	Nepali Name/Local name	Life form	Elevation ranges	Range of distribution	Use value	Oil (%)	Preference	Sources
Fabaceae	*Macrotyloma uniflorum* (Lam.) Verdc.	Gahat	H	450-2800	A native of India, widely cultivated in the tropics	Edible oil			field study http://efloras.org

Note: Abbreviations in life form: C = climber; H = herb; S = shrub; T = tree.

Annex 2. List of firewood species in Nepal based on empirical study and secondary literature

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Dabdabe, Hallunde, Holongre	100-1400	Himalaya (Swat to Bhutan), Assam, Burma, Indo-China, Ceylon, Andaman Isl., China, Malaysia, often cultivated	T		field study http://efloras.org
Fabaceae	*Acacia catechu* (L.f.) Willd.	Khayar	200-1400	Tropical Himalaya, India, Burma, Thailand, S. China	T		Rijal, 2011 http://efloras.org
Fabaceae	*Acacia rugata* (Lam.) Voigt	Sikakaee, Araare	400-800	Nepal, India, S.E. Asia, S. China, Malaysia	S		Rijal, 2011 http://efloras.org
Rubiaceae	*Adina cordifolia* (Willd. ex Roxb.) Benth. & Hook. f. ex	Karma	150-800	Himalaya (Kumaun to Sikkim), India,	T	I	Bhattarai T.N http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
	Brandis			Ceylon, Indo-China			
Sapotaceae	*Aesandra butyracea* (Roxb.) Baehni	Chiuri	200-1500	Subtropical Himalaya (Kumaun to NEFA)	T		field study http://efloras.org
Asteraceae	*Ageratina adenophora* (Spreng.) R.M. King & H. Rob. (Syn. *Eupatorium adenophorum* Spreng.)	Banmaara	850-2200	A pantropic weed, native of Mexico	S		field study http://efloras.org
Alangiaceae	*Alangium salviifolium* (L.f.) Wangerin	Amphi, Ankol	150-350	Tropical Himalaya, India, Ceylon, Thailand, Indo-China, China	T		field study http://efloras.org
Fabaceae	*Albizia julibrissin* Durazz	Rato siris			T		Rijal, 2011
Fabaceae	*Albizia lucidior* (Steud.) I. Nielson ex H. Hara	Padake	200-1000	Himalaya (Nepal to Bhutan), Assam, S.E. Asia, China	S		Rijal, 2011 http://efloras.org
Fabaceae	*Albizia procera* (Roxb.) Benth.	Seto siris	300-1100	Himalaya, India, Burma	T		Rijal, 2011 http://efloras.org
Fabaceae	*Albizia* sp.	Sirish/Ghokre			T		field study
Betulaceae	*Alnus nepalensis* D. Don	Utis	500-2600	Himalaya (Garhwal to Bhutan), Assam, Tibet, Burma, Indo-China, W. China	T	III	Bhattarai T.N field study http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Euphorbiaceae	*Antidesma acidum* Retz	Archal	150-1200	E. Himalaya (Nepal to Bhutan), India, Burma, S. China, Indo-China, Java	T		Rijal, 2011 http://efloras.org
Euphorbiaceae	*Antidesma bunius* (L.) Spreng.	Archale	1220	Himalaya (Nepal to Bhutan), S. India, Ceylon, Assam, Burma, S. China, Indo-China, Malaysia, N. Australia	S		Rijal, 2011 http://efloras.org
Moraceae	*Artocarpus lakoocha* Wall. ex Roxb.	Badahar		Himalaya (Kumaun to Bhutan), India, Ceylon, Burma, Malaysia	T	II	Bhattarai T.N field study Rijal, 2011
Meliaceae	*Azadirachta indica* A. Juss	Neem	900	Himalaya, India widely cultivated			field study http://efloras.org
Poaceae	*Bambusa* sp.	Baans		widely cultivated	T		field study
Fabaceae	*Bauhinia malabarica* Roxb.	Tanki	200-650	Tropical Himalaya (Kashmir to Sikkim), India, S.E. Asia, Malaysia. Commonly cultivated in tropics	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Fabaceae	*Bauhinia purpurea* L.	Koiraalo	300-1600	Tropical Himalaya (Kashmir to Bhutan), India, S.E. Asia, S. & W. China. Cultivated widely in tropics	T		field study, Rijal, 2011 http://efloras.org
Fabaceae	*Bauhinia semla* (Buch.-Ham. Ex Roxb.) Wunderlin	Kalo Koiralo	1200-1400	Himalaya (Simla to Nepal)	T		Rijal, 2011 http://efloras.org
Fabaceae	*Bauhinia tomentosa* L.	Aputo (Chepang)			S		Rijal, 2011
Berberidaceae	*Berberis asiatica* Roxb. ex DC.	Chutro	1200-2500	Himalaya (Garhwal to Bhutan), Assam, China (Yunnan). widely cultivated	S		field study http://efloras.org
Euphorbiaceae	*Bischofia javanica* Blume	Kainjal	150-1200	Himalaya, India east to C. China, Taiwan & Ryukyu, Malaysia, Polynesia	T		Rijal, 2011 http://efloras.org
Urticaceae	*Boehmeria rugulosa* Wedd.	Daar, Githa	300-1700	Himalaya (Garhwal to Bhutan)	T		field study http://efloras.org
Bombacaceae	*Bombax ceiba* L.	Simal	200-1200	Himalaya (Kashmir to Bhutan), India, S. China, S.E. Asia	T	III	Bhattarai T.N field study Rijal, 2011 http://efloras.org
Araliaceae	*Brassaiopsis hainla* (Buch.-Ham. ex D. Don) Seem.	Chuletro	1000-1800	E. Himalaya (Nepal to Assam), S.W.	S		field study http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
				China (Yunnan)			
Euphorbiaceae	*Bridelia retusa* (L.) Spreng.	Gayo, Rapsi (Chepang)	150-1200	Nepal, India, Ceylon, Burma, Indo-China, Malay Peninsula, Sumatra	T		field study Rijal, 2011 http://efloras.org
Euphorbiaceae	*Bridelia stipularis* (L.) Blume	Lahare Gayo			S		Rijal, 2011
Anacardiaceae	*Buchanania latifolia* Roxb.	Piyari	150-200	Nepal, N. India, Sikkim, Burma, S. W. China (Yunnan), Indo-China, W. Malaysia	T		Rijal, 2011 http://efloras.org
Loganiaceae	*Buddleja asiatica* Lour.	Bhimsen paati , Goihamro (Chepang)	350-2000	Himalaya (Chitral to NEFA), India, Burma, Indo-China, Malaysia, C. & S. China, Taiwan	S		field study Rijal, 2011 http://efloras.org
Fabaceae	*Butea monosperma* (Lam.) Kuntze	Palans	150-1200	Tropical Himalaya, India, Ceylon, S.E. Asia, Malaysia	T		Rijal, 2011 http://efloras.org
Verbenaceae	*Callicarpa arborea* Roxb.	Guren, Chyangsi (Chepang)	250-2000	Himalaya (Kumaun to Bhutan), India, Burma, S. China, Indo-China, Malaya	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Verbenaceae	*Callicarpa macrophylla* Vahl	Gunelo	300-1500	Himalaya (Kashmir to Bhutan), India, Burma, S. China, Indo-China	S		field study Rijal, 2011 http://efloras.org
Lecithydaceae	*Careya arborea* Roxb.	Kumbhi	200-600	Afghanistan to N. Malaya	T		Rijal, 2011 http://efloras.org
Flacourtiaceae	*Casearia elliptica* Willd.	Chillo garudpate, Sano Bethe	200-500	Tropical Himalaya (Kashmir to Nepal), India, Ceylon, Burma	T		Rijal, 2011 http://efloras.org
Flacourtiaceae	*Casearia graveolens* Dalzell	Golthaka	300-1200	Himalaya (Garhwal to Sikkim), India, Burma	T		Rijal, 2011 http://efloras.org
Fabaceae	*Cassia fistula* L.	Rajbriksha	150-1400	Widely cultivated in Africa, W. Asia, Himalaya, India, S.E. Asia, Malaysia, China, Polynesia; probably a native of E.India, Burma, Malay	T		Rijal, 2011 http://efloras.org
Fagaceae	*Castanopsis indica* (Roxb.) Miq.	Dhale Katus, Katus	1200-2900	Himalaya (Nepal to NEFA), Khasia, Burma, W. China, Indo-China	T	I	Bhattarai T.N field study http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Ulmaceae	*Celtis australis* L.	Khari	1300-2200	Himalaya (Kashmir to Nepal), India	T		Rijal, 2011 http://efloras.org
Anacardiaceae	*Choerospondias axillaris* (Roxb.) B. L. Burtt & A. W. Hill	Lapsi			T		field study
Meliaceae	*Cipadessa baccifera* (Roth) Miq.	Paireti	250-1700	Himalaya, India, Ceylon, Burma, Thailand, Indo-China, W. China, Malaysia	S		Rijal, 2011 http://efloras.org
Myrtaceae	*Cleistocalyx operculatus* (Roxb.) Merr. & L.M. Perry	Kyamunaa	200-1400	Subtropical Himalaya, Assam, Ceylon, Burma, east to S. China, Malaysia, Australia	T		Rijal, 2011 http://efloras.org
Rubiaceae	*Coffea arabica* L.	Kafi/Coffee					field study
Lamiaceae	*Colebrookea oppositifolia* Sm.	Dhursuli	250-1700	Punjab, Himalaya (Kashmir to Bhutan), India, Burma, S. W. China (Yunnan), Indo-China	S		Rijal, 2011 http://efloras.org
Combretaceae	*Combretum roxburghii* Spreng.	Dars	200-600	Himalaya (Punjab to Nepal), India, Burma, Indo-China, W. China	C		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Cordiaceae	*Cordia dichotoma* Forster	Bohori	200-1400	W. Asia, Subtropical Himalaya, India, Ceylon, east to China and S. Japan, Australia. Occasionally cultivated	T		field study Rijal, 2011 http://efloras.org
Fabaceae	*Crotalaria juncea* L.	Chhinchhine		Cultivated	H		field study
Fabaceae	*Dalbergia sissoo* Roxb. ex DC.	Sisau	200-1400	A native of tropical Himalaya (Kashmir to Sikkim), Assam, Bengal, but cultivated in tropical to subtropical Africa, W. Asia. Natural as well as cultivated	T		field study Rijal, 2011 http://efloras.org
Thymelaeaceae	*Daphne bholua* Buch.-Ham. ex D.Don	Lokta			S		field study
Daphniphyllaceae	*Daphniphyllum himalense* (Benth.) Mull. Arg.	Rakta Chandan			T		field study
Fabaceae	*Desmodium oojeinense* (Roxb.) H. Ohashi	Sandan	1200-1300	India, Himalaya (Kashmir to C. Nepal)	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Hydrangiaceae	*Dichroa febrifuga* Lour.	Basuli, Bhasak	900-2400	Himalaya (Nepal to Bhutan), India, Burma, east to C. China, Taiwan, Malaysia	S		field study http://efloras.org
Dilleniaceae	*Dillenia pentagyna* Roxb.	Tantari, Ram Phal	150-1500	Subtropical Himalaya, India, Ceylon, Burma, Andaman Isl., Thailand, Indo-China, S. China, Malaysia	T		Rijal, 2011 http://efloras.org
Ebenaceae	*Diospyros* L.	Tinju			T	I	Bhattarai T.N
Sapotaceae	*Diploknema butyracea* (Roxb.) H.J.Lam = Aesandra butyracea	Alasi sai (Chepang), Chiuri	200-1500	Subtropical Himalaya (Kumaun to NEFA)	T		Rijal, 2011 http://efloras.org
Sonneratiaceae	*Duabanga grandiflora* (Roxb. ex DC) Walp.	Laampate	250-1100	Subtropical Himalaya (Kumaun to Bhutan), S.E. Tibet, Assam, Burma, Indo-China, Malaya, Yunnan	T		field study http://efloras.org
Meliaceae	*Dysoxulum hamiltonii* Hiern	Bauri			T		field study Rijal, 2011

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Cordiaceae	*Ehretia laevis* Roxb.	Datingal	150-1100	Subtropical Himalaya (Kashmir to Sikkim), india, Burma, Thailand, Indo-China, Hainan	T		Rijal, 2011 http://efloras.org
Juglandaceae	*Engelhardia spicata* Lesch. ex Blume	Mauwa			T		field study
Fagaceae	*Erythrina stricta* Roxb.	Phaledo	1000-1600	Nepal, India, E. Tibet, Burma, Indo-China, China	T	III	Bhattarai T.N http://efloras.org
Myrtaceae	*Eugenia jambolana* Lam. = *Syzygium cumini* (L.) Skeels	Jamun	300-1200	Subtropical Himalaya, India, Ceylon, Malaysia, Australia	T	II	Bhattarai T.N http://efloras.org
Euphorbiaceae	*Euphorbia royleana* Boiss	Siudi	1100-1200	Himalaya (Kumaun to Nepal)	S		field study http://efloras.org
Theaceae	*Eurya acuminata* DC.	Baakle/Sano Jhigaane	1300-2500	Himalaya (Kumaun to NEFA), India, Ceylon	S		field study http://efloras.org
Moraceae	*Ficus auriculata* Lour.	Nimaaro, Timilo	250-1700	Himalaya (N. Pakistan to N. Burma), N.E. India, S. China, Indo-China	T		field study http://efloras.org
Moraceae	*Ficus benghalensis* L.	Bar	500-1200	Nepal, Pakistan,	T	III	Bhattarai T.N

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
				India; widely cultivated			field study http://efloras.org
Moraceae	*Ficus benjamina* L.	Shamee			T		Rijal, 2011
Moraceae	*Ficus cunia* = *F. semicordata* Buch.-Ham. ex Sm.	Khanayo, Khanyu	200-1700	Himalaya (Nepal, NEFA), India, Burma, S. China, Indo-China, Malaya	T	II	Bhattarai T.N field study, Rijal, 2011 http://efloras.org
Moraceae	*Ficus glaberrima* Blume	Pakhuri	600-1500	Nepal, Assam, Burma, S. China, Andaman Is., Indo-China, Malaysia	T	III	Bhattarai T.N http://efloras.org
Moraceae	*Ficus lacor* Buch-Ham.	Kabhro	500	Himalaya (Kumaun to Bhutan), India, Burma, Indo-China	T		field study http://efloras.org
Moraceae	*Ficus nerifolia* Sm.	Dudhilo			T		field study
Moraceae	*Ficus religiosa* L.	Peepal	150-1500	India; widely cultivated in S.E. Asia. Naural as well as cultivated	T	III	Bhattarai T.N field study, Rijal, 2011 http://efloras.org
Moraceae	*Ficus rumphii* Blume	Wagrans (Chepang) Pahare Peepal	200	Himalaya, India, Burma, Indo-China, Malaysia	T		Rijal, 2011 http://efloras.org
Burseraceae	*Garuga pinnata* Roxb.	Dabdabe			T		Rijal, 2011

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Ericaceae	*Gaultheria fragrantissima* Wall.	Dhasingare	1200-2600	Himalaya (Nepal to NEFA), Khasia, N. Burma	S		field study http://efloras.org
Euphorbiaceae	*Glochidion acuminatum* Müll. Arg.	Bahiro	910-1100	Himalaya (Nepal, Sikkim), Assam, S.W. China (S.E. Yunnan) (var. siamense Airy Shaw in Thailand and S.W. Yunnan)	T		Rijal, 2011 http://efloras.org
Euphorbiaceae	*Glochidion velutinum* Wight	Kaali Kath	150-1800	N. India, Himalaya (Kashmir to Bhutan), Bengal, N. Burma	T		Rijal, 2011 http://efloras.org
Verbenaceae	*Gmelina arborea* Roxb.	Khamari	200-1100	Himalaya (Nepal to Bhutan), India, Ceylon, Philippines	T		Rijal, 2011 http://efloras.org
Tiliaceae	*Grewia optiva* J.R. Drumm. ex Burret	Vimal, Jalma	150-1800	Himalaya (Kashmir to Nepal)	S		Rijal, 2011 http://efloras.org
Rubiaceae	*Haldina cordifolia* (Roxb.) Ridsdale	Kalam			T		Rijal, 2011
Apocynaceae	*Holarrhena pubescens* Wall. ex G.Don	Ban khirro, Madhisae Khirro	100-1500	Tropical Himalaya, India, Burma, Indo-China, Malaya	S		Rijal, 2011 http://efloras.org
Rubiaceae	*Hymenodictyon excelsum*	Bahuni Karam, Lati	150-300	Himalaya, India,	T		Rijal, 2011

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
	(Roxb.) Wall.	Karma		Burma, Indo-China, Malaysia			http://efloras.org
Euphorbiaceae	*Jatropha curcas* L.	Sajiwan	500-1200	Native of New World Tropics, cultivated in other tropical areas	S		field study http://efloras.org
Cupressaceae	*Juniperus* sp.	Dhupi salla			S		field study
Malvaceae	*Kydia calycina* roxb.	Daduchiple, Pulia	150-900	Himalaya (Kashmir to Bhutan), India, Burma, Thailand, Yunnan	T		Rijal, 2011 http://efloras.org
Cucurbitaceae	*Lagenaria siceraria* (Molina) Standl.	Dumri (Chepang), Lauka	200-2290	Tropical Africa and Asia; cultivated in all warmer regions. Naural as well as cultivated	T		Rijal, 2011 http://efloras.org
Lythraceae	*Lagestroemia parviflora* Roxb.	Chyansi			T		Rijal, 2011
Fabaceae	*Leucaena leucocephala* (Lam.) De Wit	Epil ipil	1500	Cultivated and naturalised widely in tropical and subtropical regions. Naural as well as cultivated	T		field study http://efloras.org
Liliaceae	*Lilium nepalense* D. Don	Khiraulo,	2300-3400	Himalaya (Kumaun			field study

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
		Khairaunla		to NEFA)			http://efloras.org
Lauraceae	*Litsea monopelata* (Roxb.) Pers.	Kutmiro			T		field study Rijal, 2011
Myrsinaceae	*Maesa chisia* Buch.-Ham. ex D.Don	Bilaaune, Bilauni	1200-2600	Himalaya (Nepal to Bhutan), Assam, N. Burma	S		field study http://efloras.org
Myrsinaceae	*Maesa montana* A. DC.	Krimighna Phal	250-1500	Tropical Himalaya (Nepal, Sikkim), Assam, east to W. China	T		Rijal, 2011 http://efloras.org
Magnoliaceae	*Magnolia campbelli* Hook.f. & Thoms	Chaanp			T		field study
Berberidaceae	*Mahonia nepaulensis* DC.	Jamaane mandro			S		field study
Euphorbiaceae	*Mallotus nepalensis* Müll. Arg.	Phirphire, Ghoge tank	1700-2400	Himalaya (Nepal to Bhutan), Assaln, S.W. China (Yunnan)	T		Rijal, 2011 http://efloras.org
Euphorbiaceae	*Mallotus philippensis* (Lam.) Müll. Arg.	Sindue, Rohini	150-1800	Himalaya (Kumaun to Bhutan), India, Ceylon, Indo-China, China, Malaysia, Australia, Polynesia	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Anacardiaceae	*Mangifera indica* L.	Mango	300-700	Tropical Himalaya, India, Ceylon, Burma, Indo-China, Malaysia, widely cultivated and often naturalised in Tropics	T	II	Bhattarai T.N field study Rijal, 2011 http://efloras.org
Anacardiaceae	*Mangifera sylvatica* Roxb. ex Wall.	Taksai	450-1000	Himalaya (Nepal, Sikkim), Assam, Andaman Isl., Burma, Thailand, Indo-China	T		Rijal, 2011 http://efloras.org
Melastomataceae	*Melastoma melabathricum* L.	Angeri, Chulesi	200	Tropical Himalaya, India, Ceylon, Burma, Thailand, Indo-China, Malaysia, Australia	S		field study http://efloras.org
Meliaceae	*Melia azederach* L.	Bakaaino			T		field study
Annonaceae	*Miliusa velutina* (Dunal) Hook. f. & Thomson	Kalikath	150-450	Tropical Himalaya, India	T		Rijal, 2011 http://efloras.org
Rubiaceae	*Mitragyna parvifolia* (Roxb.) Korth.	Tikul	150-200	Himalaya, India, Ceylon	T		Rijal, 2011 http://efloras.org
Moraceae	*Morus nigra* L.	Kimmu			T		field study
Moraceae	*Morus serrata* Roxb.	Chanaru (Chepang)	1600-2400	Himalaya (Kumaun to Nepal)	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Rutaceae	*Murraya koenigii* (L.) Spreng.	Asare, Mitho Neem, Mechiya Sag	150-1450	Himalaya (Garhwal to Sikkim), India, Ceylon, Burma, Indo-China, China. Frequently cultivated	S		Rijal, 2011 http://efloras.org
Rutaceae	*Murraya paniculata* (L.) Jack	Lathikath, Kamini phool	400-1050	Himalaya (Kashmir to Nepal), India, Ceylon, Burma, Indo-China, China, Malaysia	S		Rijal, 2011 http://efloras.org
Myricaceae	*Myrica esculenta* Buch.-Ham. ex D. Don	Kafal	1200-2300	Himalaya (Kashmir to Bhutan), India, Burma, east to W. & S. China and south to Malaysia	T		field study Rijal, 2011 http://efloras.org
Myrsinaceae	*Myrsine semiserrata* Wall.	Kali kath	1200-2700	Himalaya (Pakistan to NEFA), Assam, Tibet, N. Burma, W. & C. China	T		field study Rijal, 2011 http://efloras.org
Lauraceae	*Neolitsea cuipala* (Buch.-Ham. ex D. Don) Kosterm.	Jhapre	1200-1400	Himalaya (Garhwal to Sikkim), Khasia, N. Burma	T		Rijal, 2011 http://efloras.org
Lauraceae	*Neolitsea umbrosa* (Nees) Gamble	Khapate			T		Rijal, 2011

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Oleaceae	*Nyctanthes arbor-tristis* L.	Jagat, Rudilo, Parijat	200-1200	Subtropical Himalaya, India, often cultivated for its fragrant flowers	T		field study Rijal, 2011 http://efloras.org
Lauraceae	*Persea duthiei* (King ex Hook. f.) Kosterm.	Mahilo Kaulo	1000-2900	Himalaya (Kashmir to Bhutan), Khasia	T		Rijal, 2011 http://efloras.org
Lauraceae	*Persea gamblei* (King ex Hook. f.) Kosterm.	Kathe Kaulo	750-900	Himalaya (Kumaun to Bhutan)	T		Rijal, 2011 http://efloras.org
Lauraceae	*Persea odoratissima* (Nees) Kosterm.	Seto Kaulo	1000-2000	Himalaya (Kashmir to Bhutan), Assam, Burma, Indo-China, Malaysia	T		field study http://efloras.org
Euphorbiaceae	*Phyllanthus emblica* L.	Amalaa	150-1400	India, Himalaya (Kumaun to Bhutan), Assanl, N. Burma, S. China, Indo-China, Malaysia	T		field study http://efloras.org
Pinaceae	*Pinus roxburghii* Sarg.	Khote Sallo	1100-2100	Afghanistan, Himalaya (Kashmir to Bhutan)			field study http://efloras.org
Verbenaceae	*Premna barbata* Wall. ex Schauer	Gineri			T		Rijal, 2011
Verbenaceae	*Premna integrifolia* L.	Gidari			T		field study

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Rosaceae	*Prunus cerasoides* D. Don	Painyu	1300-2400	Himalaya (Punjab to Bhutan), S. Tibet, Assam, Burma, W. China	T		field study http://efloras.org
Rosaceae	*Prunus domestica* L.	Aalubakhara			T		field study
Rosaceae	*Prunus domestica* L. subsp. *insitiata* (L.) Schneid	Aalucha			T		field study
Myrtaceae	*Psidium guajava* L.	Belauti/Amba	450-1200	Tropical America, widely planted and naturalised in Tropical Asia	S/T		field study http://efloras.org
Rosaceae	*Pyracantha crenulata* (D. Don) M. Roem.	Ghangaaru	1200-2500	Himalaya (Kashmir to Bhutan), Tibet, Burma, China	S		field study http://efloras.org
Rosaceae	*Pyrus communis* L.	Naaspati			T		field study
Rosaceae	*Pyrus pashia* Buch.-Ham. ex D. Don	Mayal	750-2600	Himalaya (Kashmir to Bhutan), Assam, Burma, W. China	T		field study http://efloras.org
Fagaceae	*Quercus glauca* Thunb.	Falaat			T		field study
Fagaceae	*Quercus lamellosa* Sm.	Gogan, Banset	1600-2800	Himalaya (Nepal to Assam), N. Burma, Tibet, S.W. China (Yunnan)	T		field study http://efloras.org
Fagaceae	*Quercus semecarpifolia* Smith.	Khasru	1700-3800	Afghanistan, Himalaya (Chitral to	T		field study http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
				NEFA), S. Tibet, Burma, S. China			
Ericaceae	*Rhododendron arboreum* Sm.	Lali Gurans			T		field study
Ericaceae	*Rhododendron barbatum* Wall. ex G. Don	Chimal			T		field study
Euphorbiaceae	*Ricinus communis* L.	Aderi, Ander	150-2400	Believed to be native of N.E. Tropical Africa; widely cultivated and occasionally naturalised throughout the tropics	S		field study http://efloras.org
Rubiaceae	*Rubia manjith* Roxb. ex Fleming	Majitho	1200-2100	Himalaya (Simla to Bhutan), Khasia	C		field study http://efloras.org
Salicaceae	*Salix* sp.	Bainsh					field study
Euphorbiaceae	*Sapium insigne* (Royle) Benth. ex Hook. f.	Khirro	500-1800	Himalaya (Kumaun to Bhutan), Assam, Bengal, Ceylon, Burma, Indo-China, Malay Peninsula	T	III	Bhattarai T.N Rijal, 2011 http://efloras.org
Theaceae	*Schima wallichii* (DC.) Korth.	Chilaune	900-2100	Himalaya (Nepal to Bhutan), Assam. S. Tibet, east to W. China	T	I	Bhattarai T.N Field study http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Sapindaceae	*Schleichera oleosa* (Lour.) Oken	Kusum	200-300	Tropical Himalaya (Punjab to Nepal), India, Ceylon, Burma, Thailand, Indo-China, Malaysia	T		Rijal, 2011 http://efloras.org
Anacardiaceae	*Semecarpus anacardium* L.f.	Tingsi (Chepang) Bhalaayo, Kag bhalayo	150-1200	Himalaya (Sirmore to Sikkim), India, Burma, Malaysia, N. Australia	T		field study Rijal, 2011 http://efloras.org
Dipterocarpaceae	*Shorea robusta* Gaertn.	Sal	150-1500	Subtropical Himalaya (Garhwal to Assam), India	T	I	Bhattarai T.N field study, Rijal, 2011 http://efloras.org
Anacardiaceae	*Spondias pinnata* (L.f.) Kurz.	Amaro	300-1400	Tropical Himalaya, India, Ceylon, Thailand, Malaysia, widely cultivated	T		Rijal, 2011 http://efloras.org
Bignoniaceae	*Stereospermum chelonoides* (L. f.) DC.	Padari, Kuber bacha	150-250	Tropical Himalaya, India, Ceylon, Burma, Java (naturalised)	T		Rijal, 2011 http://efloras.org
Moraceae	*Streblus asper* Lour.	Khaksi	100-500	Himalaya (Kumaun to Nepal), India, Ceylon, S. China,	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
				Indo-China, Malaysia			
Gentianaceae	*Swertia chirayita* (Roxb. ex Fleming) Karsten	Chiraaito	1500-2500	Himalaya (Kashmir to Bhutan), Assam	H		field study http://efloras.org
Symplocaceae	*Symplocos pyrifolia* Wall. ex G.Don	Kholme/Kharaane	1000-2000	Himalaya (C. Nepal to NEFA)	S/T		field study http://efloras.org
Myrtaceae	*Syzygium cumini* (L.) Skeels	Jamun	300-1200	Subtropical Himalaya, India, Ceylon, Malaysia, Australia	T		Rijal, 2011 http://efloras.org
Myrtaceae	*Syzygium jambos* (L.) Alston	Fadir, Gulab Jamun	600-1400	Planted in Tropical Himalaya, Asia and Australia	T		Rijal, 2011 http://efloras.org
Fabaceae	*Tamarindus indica* L.	Imili	200-400	Pantropics in cultivation, possibly native in tropical Africa	T		Rijal, 2011 http://efloras.org
Combretaceae	*Terminalia alata* Heyne ex Roth = *Terminalia tomentosa* (Roxb.) Wight & Arn.	Asana, Saj	200-1400	Himalaya, India, Ceylon, Burma, Thailand, Indo-China	T	II	Bhattarai, T.N Rijal, 2011 http://efloras.org
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Barro	300-1100	Nepal, India, Ceylon, Burma, Thailand,	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
				Indo-China, Malaysia			
Combretaceae	*Terminalia chebula* Retz.	Harro	150-1100	Kumaun, Nepal, India, Ceylon, Burma (but not wild in Malaysia, fide Exell in Fl. Males.	T		Rijal, 2011 http://efloras.org
Meliaceae	*Toona ciliata* M. Roem	Tooni	200-1700	Afghanistan, Himalaya, India, Ceylon, east to China, Malaysia, Australia	T		field study Rijal, 2011 http://efloras.org
Euphorbiaceae	*Trewia nudiflora* L.	Velar, Gurel	150-1800	Himalaya (Kumaun to Nepal), India, Ceylon, Burma, Indo-China, S. China, W. Malaysia	T		Rijal, 2011 http://efloras.org
Sambhucaceae	*Viburnum mullaha* Buch.-Ham. ex D. Don	Malo/Malaayo			S		field study
Verbenaceae	*Vitex negundo* L.	Simali			S		Rijal, 2011
Rubiaceae	*Wendlandia puberula* DC.	Kainyo	700-2000	Himalaya (Garhwal to Assam), N. India, Burma	T		Rijal, 2011 http://efloras.org

Family	Latin Name	Nepali /common name	Elevation ranges	Range of distribution	life form	Preference	Source
Lythraceae	*Woodfordia fruticosa* (L.) Kurz	Dhainyaro, Daring	200-1800	Africa, W. Asia, Subtropical Himalaya, India, Ceylon, Burma, east to China	S		field study Rijal, 2011 http://efloras.org
Rubiaceae	*Xeromphis spinosa* (Thunb.) Keay	Main Kanda	100-1200	Himalaya, India, Indo-China, S. China, Malaysia	S		Rijal, 2011 http://efloras.org
Rubiaceae	*Xeromphis uliginosa* (Retz.) Maheshw.	Pindar		Himalaya (Garhwal to Sikkim), India, Burma, Indo-China	T		Rijal, 2011 http://efloras.org
Rhamnaceae	*Zizyphus mauritiana* Lam.	Bayar, Thulo bayar	200-1200	Tropical Asia, Australia, widely cultivated	S		Rijal, 2011 http://efloras.org
Rhamnaceae	*Zizyphus rugosa* Lam.	Kanta bayar	150-800	Himalaya (Punjab to Sikkim), India, Ceylon, Burma	T		Rijal, 2011 http://efloras.org

Note: Abbreviations in life form: C = climber; H = herb; S = shrub; T = tree.

Annex 3. List of potential charcoal producing species in Nepal based on review of secondary literature

Family	Latin Name	Nepali Name	Life form	Elevation ranges	Range of distribution	Preference	Sources
Fabaceae	*Acacia catechu* (L. f.) Willd.	Khair	Tree	200-1400	Tropical Himalaya, India, Burma, Thailand,	I	Bhattarai T.N http://efloras.org

					S. China		
Fagaceae	*Castanopsis indica* (Roxb.) Miq.	Katus, Dhalne Katus	Tree	1200-2900	Himalaya (Nepal to NEFA), Khasia, Burma, W. China, Indo-China	II	Bhattarai T.N http://efloras.org
Moraceae	*Ficus cunia* Buch.-Ham. ex Roxb. = *F. semicordata*	Khanyo	Tree			II	Bhattarai T.N
Lythraceae	*Lagerstroemia parviflora* Roxb.	both dhaiyanro	Tree	200-800	Tropical Himalaya (Kumaun to Sikkim), India, Burma	II	Bhattarai T.N http://efloras.org
Ericaceae	*Lyonia ovalifolia* (Wall.) Drude	Angeri	Tree	1300-3300	Himalaya (Punjab to Bhutan), Tibet, Assam, Burma, east to China, Malay Pen	II	Bhattarai T.N http://efloras.org
Myricaceae	*Myrica esculenta* Buch.-Ham. ex D. Don	Kafal	Tree	1200-2300	Himalaya (Kashmir to Bhutan), India, Burma, east to W. & S. China and south to Malaysia	I	Bhattarai T.N http://efloras.org
Theaceae	*Schima wallichii* (DC.) Korth.	Chilaune	Tree	900-2100	Himalaya (Nepal to Bhutan), Assam. S. Tibet, east to W. China	II	Bhattarai T.N http://efloras.org
Dipterocarpacea e	*Shorea robusta* Gaertn.	Sal	Tree	150-1500	Subtropical Himalaya (Garhwal to Assam), India	I	Bhattarai T.N http://efloras.org

Annex 4. List of timber species in Nepal based on review of secondary literature

Family	Latin Name	Nepali Name	Elevation ranges	Distribution	Habit	Source
Fabaceae	*A. catechu* (L. f.) Willd.	Khayer	200-1400	Tropical Himalaya, India, Burma, Thailand, S. China	T	Chaudhary http://efloras.org
Fabaceae	*A. odoratissima* (L. f.) Benth.	Kalo siris	150-500	Himalaya (Kumaun to Bhutan), India, Ceylon	T	Chaudhary http://efloras.org
Fabaceae	*A. procera* (Roxb.) Benth.	Seto siris	300-1100	Himalaya, India, Burma	T	Chaudhary http://efloras.org
Pinaceae	*A. spectabilis* (D. Don) Mirb.	Talish patra	2400-4400	Himalaya	T	Chaudhary http://efloras.org
Pinaceae	*Abies pindrow* Royle	Thingre salla	2100-2500	Eastern Afghanistan to W. Nepal	T	Chaudhary http://efloras.org
Fabaceae	*Acacia arabica* (L.) Willd. ex Delile	Babul, Babur			T	Chaudhary
Fabaceae	*Acacia catechu* (L.f.) Willd.	Khayer	200-1400	Tropical Himalaya, India, Burma, Thailand, S. China	T	Rijal, 2011
Rubiaceae	*Adina cordifolia* (Willd. ex Roxb.) Benth. & Hook. f. ex Brandis	Karma, Karam	150-800	Himalaya (Kumaun to Sikkim), India, Ceylon, Indo-China	T	Chaudhary http://efloras.org

Family	**Latin Name**	**Nepali Name**	**Elevation ranges**	**Distribution**	**Habit**	**Source**
Fabaceae	*Albizia lebbeck* (L.) Benth.	Siris	250-800	tropical Himalaya, India, Ceylon, S.E. Asia, S. China, but cultivated widely in tropics and subtropics	T	Chaudhary http://efloras.org
Betulaceae	*Alnus nepalensis* D. Don	Utis	500-2600	Himalaya (Garhwal to Bhutan), Assam, Tibet, Burma, Indo-China, W. China	T	Chaudhary http://efloras.org
Combretaceae	*Anogeissus latifolius* (Roxb. ex DC.) Bedd.	Banjhi	450--1200	Nepal, India, Ceylon	T	Chaudhary http://efloras.org
Rubiaceae	*Anthocephalus chinensis* (Lam.) A. Rich. ex Walp.	Kadam	200-800	Himalaya (Nepal), India, Ceylon, Burma, Indo-China, S. China, Malaysia	T	Chaudhary http://efloras.org
Betulaceae	*Betula utilis*D. Don	Bhoj Patra	2700-4300	Himalaya (Nepal to Bhutan), Tibet, W. China	T	Chaudhary http://efloras.org
Bombacaceae	*Bombax ceiba* L.	Semal	200-1200	Himalaya (Kashmir to Bhutan), India, S. China, S.E. Asia.	T	Chaudhary Rijal 2011 http://efloras.org
Burseraceae	*Boswellia serrata*	Salai			T	Chaudhary

Family	Latin Name	Nepali Name	Elevation ranges	Distribution	Habit	Source
Euphorbiaceae	*Bridelia retusa* (L.) Spreng.	Gayo	150-1200	Nepal, India, Ceylon, Burma, Indo-China, Malay Peninsula, Sumatra	T	Chaudhary Rijal 2011 http://efloras.org
Anacardiaceae	*Buchanania latifolia* Roxb.	Chiraunjee	150-2000	Himalaya (Kumaun to Nepal), India, Burma, Thailand	T	Rijal, 2011
Lecythidaceae	*Careya arborea* Roxb.	Kumbhi	200-600	Afghanistan to N. Malaya		Chaudhary http://efloras.org
Fagaceae	*Castanopsis indica* (Roxb.) Miq.	Katush, Dhalne katush	1200-2900	Himalaya (Nepal to NEFA), Khasia, Burma, W. China, Indo-China	T	Chaudhary http://efloras.org
Pinaceae	*Cedrus deodara* (Roxb. ex D. Don) G. Don	Devdaru	2000-2500	Afghanistan, Himalaya (Kashmir to W. Nepal).	T	Chaudhary http://efloras.org
Cordiaceae	*Cordia dichotoma* Forster	Bohori	200-1400	W. Asia, Subtropical Himalaya, India, Ceylon, east to China and S. Japan, Australia, sometimes cultivated	T	Rijal, 2011
Cupressaceae	*Cupressus torulosa* D. Don	Raj Sallo	1800-3300	Himalaya	T	Chaudhary http://efloras.or

Family	Latin Name	Nepali Name	Elevation ranges	Distribution	Habit	Source
						g
Fabaceae	*Dalbergia sissoo* Roxb. ex DC.	Sisau	200-1400	tropical Himalaya (Kashmir to Sikkim), Assam, Bengal, but cultivated in tropical to subtropical Africa, W. Asia	T	Chaudhary Rijal, 2011 http://efloras.org
Fabaceae	*Dalbergia latifolia* Roxb.	Satisal	300-1000	Himalaya (Kumaun to Sikkim), India, Indo-China, Malaysia	T	Chaudhary Rijal, 2011 http://efloras.org
Fabaceae	*Desmodium oojeinense* (Roxb.) H. Ohashi	Sandan	1200-1300	India, Himalaya (Kashmir to C. Nepal)	T	Rijal, 2011
Dilleniaceae	*Dillenia pentagyna* Roxb.	Tatari	150-1500	Subtropical Himalaya, India, Ceylon, Burma, Andaman Isl., Thailand, Indo-China, S. China, Malaysia		Chaudhary http://efloras.org
Cordiaceae	*Ehretia laevis* Roxb.	Datingal	150-1100	Subtropical Himalaya (Kashmir to Sikkim), india, Burma, Thailand, Indo-China, Hainan	T	Rijal, 2011
Verbenaceae	*Gmelina arborea* Roxb.	Khamari	200-1100	Himalaya (Nepal to	T	Rijal, 2011

Family	Latin Name	Nepali Name	Elevation ranges	Distribution	Habit	Source
				Bhutan), India, Ceylon, Philippines		
Rubiaceae	*Hymenodictyon excelsum* (Roxb.) Wall.	Bhudkul, Lati Karma	150-300	Himalaya, India, Burma, Indo-China, Malaysia	T	Chaudhary http://efloras.org
Cupressaceae	*Juniperus recurva* Buch.-Ham. ex D. Don	Dhupi	3300-4600	Chitral, Himalaya (Kashmir to Bhutan), Assam, Burma, W. China	S	Chaudhary http://efloras.org
Juglandaceae	*Juglans regia* L.	Sano Okhar			T	Chaudhary
Cupressaceae	*Juniperus indica* Bertol.	Dhupi	3700-4100	Karakoram, Himalaya (Kashmir to Nepal), S. E. Tibet, W. China	S	Chaudhary http://efloras.org
Malvaceae	*Kydia calycina* Roxb.	Pulia	150-900	Himalaya (Kashmir to Bhutan), India, Burma, Thailand, Yunnan	T	Rijal, 2011
Lythraceae	*Lagerstroemia parviflora* Roxb.	Bot Dhaiyanro	200-800	Tropical Himalaya (Kumaun to Sikkim), India, Burma	T	Chaudhary http://efloras.org
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Jhingat, Halunde	100-1400	Himalaya (Swat to Bhutan), Assam, Burma, Indo-China, Ceylon, Andaman Isl., China, Malaysia	T	Chaudhary http://efloras.org

Family	Latin Name	Nepali Name	Elevation ranges	Distribution	Habit	Source
Sapotaceae	*Madhuca longifolia* (Koenig) Macbride	Mahuwa	150	Tropical Himalaya, India, Ceylon	T	Rijal, 2011
Euphorbiaceae	*Mallotus nepalensis* Mull. Arg.	Phirphire	1700-2400	Himalaya (Nepal to Bhutan), Assaln, S.W. China (Yunnan)	T	Rijal, 2011
Anacardiaceae	*Mangifera indica* L.	Amp	300-700	Tropical Himalaya, India, Ceylon, Burma, Indo-China, Malaysia, widely cultivated and often naturalised in Tropics	T	Chaudhary Rijal, 2011 http://efloras.org
Anacardiaceae	*Mangifera sylvatica* Roxb. ex Wall.	Taksai	450-1000	Himalaya (Nepal, Sikkim), Assam, Andaman Isl., Burma, Thailand, Indo-China	T	Rijal, 2011
Meliaceae	*Melia azedarach* L.	Bakenu	700-1100	Iran, Himalaya, east to China. Cultivated	T	Rijal, 2011
Magnoliaceae	*Michelia champaca* L.	Aule Champ	600-1300	Nepal, India, Burma, Thailand, Indo-China, S. Yunnan; commonly planted in SE. Asia	T	Chaudhary http://efloras.org
Rubiaceae	*Mitragyna parvifolia* (Roxb.) Korth.	Bhurkul	150-200	Himalaya, India, Ceylon	T	Chaudhary http://efloras.org

Family	Latin Name	Nepali Name	Elevation ranges	Distribution	Habit	Source
Bignoniaceae	*Oroxylum indicum*(L.) Kurz	Tatelo	400-1400	Tropical Himalaya, India to Indo-China, Malaysia, W. & S. China	T	Chaudhary http://efloras.org
Pinaceae	*Pinus roxburghii* Sarg.	Khote salla	1100-2100	Afghanistan, Himalaya (Kashmir to Bhutan)	T	Chaudhary http://efloras.org
Pinaceae	*Pinus wallichiana* A. B. Jacks.	Gobre salla	1800-3300	Afghanistan, Himalaya (Kashmir to Nepal)	T	Chaudhary http://efloras.org
Fabaceae	*Pterocarpus marsupium* Roxb.	Bijaya Sal			T	Chaudhary
Fagaceae	*Q. lanata* Sm.	Banjh	460-2600	Himalaya (Kumaun to NEFA), Burma, Indo-China	T	Chaudhary http://efloras.org
Fagaceae	*Q. leucotrichophora* A. Camus	Banjh	1500-2400	Pakistan, Himalaya (Kumaun to Nepal), Ceylon, ?Burma	T	Chaudhary http://efloras.org
Fagaceae	*Q. semecarpifolia* Sm.	Khasru	1700-3800	Afghanistan, Himalaya (Chitral to NEFA), S. Tibet, Burma, S. China	T	Chaudhary http://efloras.org
Fagaceae	*Quercus glauca* Thunb.	Falant			T	Chaudhary
Theaceae	*Schima wallichii* (DC.) Korth.	Chilaune	900-2100	Himalaya (Nepal to Bhutan), Assam. S. Tibet, east to W. China	T	Chaudhary Rijal, 2011 http://efloras.or

Family	**Latin Name**	**Nepali Name**	**Elevation ranges**	**Distribution**	**Habit**	**Source**
						g
Sapindaceae	*Schleichera oleosa* (Lour.) Oken	Kusum	200-300	Tropical Himalaya (Punjab to Nepal), India, Ceylon, Burma, Thailand, Indo-China, Malaysia	T	Chaudhary Rijal, 2011 http://efloras.or g
Dipterocarpaceae	*Shorea robusta* Gaertn.	Sal, Sakhuwa	150-1500	Subtropical Himalaya (Garhwal to Assam), India	T	Chaudhary Rijal, 2011 http://efloras.or g
Myrtaceae	*Syzygium cumini* (L.) Skeels	Jamun	300-1200	Subtropical Himalaya, India, Ceylon, Malaysia, Australia	T	Chaudhary Rijal, 2011 http://efloras.or g
Combretaceae	*T. bellirica* (Gaertn.) Roxb.	Barro	300-1100	Nepal, India, Ceylon, Burma, Thailand, Indo-China, Malaysia	T	Chaudhary http://efloras.or g
Combretaceae	T. chebula	Harro			T	Chaudhary
Combretaceae	*T. myriocarpa*	Pani Saj			T	Chaudhary
Fabaceae	*Tamarindus indica* L.	Amili	200-400	Pantropics in cultivation, possibly native in tropical Africa	T	Rijal, 2011
Taxaceae	*Taxus baccata*	Dhengra		Broad	T	Chaudhary

Family	Latin Name	Nepali Name	Elevation ranges	Distribution	Habit	Source
		salla/Lauth salla				http://efloras.org
Combretaceae	*Terminalia alata* Heyne ex Roth	Asna, Saj	200-1400	Himalaya, India, Ceylon, Burma, Thailand, Indo-China	T	Chaudhary http://efloras.org
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Barro	300-1100	Nepal, India, Ceylon, Burma, Thailand, Indo-China, Malaysia	T	Rijal, 2011
Combretaceae	*Terminalia chebula* Retz.	Harro	150-1100	Kumaun, Nepal, India, Ceylon, Burma	T	Rijal, 2011
Meliaceae	*Toona ciliata* M. Roem.	Tooni	200-1700	Afghanistan, Himalaya, India, Ceylon, east to China, Malaysia, Australia	T	Chaudhary Rijal, 2011 http://efloras.org
Euphorbiaceae	*Trewia nudiflora* L.	Pithara, Gurel	150-1800	Himalaya (Kumaun to Nepal), India, Ceylon, Burma, Indo-China, S. China, W. Malaysia	T	Chaudhary http://efloras.org
Pinaceae	*Tsuga dumosa* (D. Don) Eichler	Thingre salla	2100-3600	Himalaya (Kumaun to Bhutan), N. Burma	T	Chaudhary http://efloras.org

Note: Abbreviations in life form: S = shrub; T = tree.

Annex 5. List of Major Fuelwood species, edible and non-edible oil plants in Dhading District, C. Nepal

Date	Name of V.D.C.	No. of Households surveyed	No. of Resource map preparation and Meetings		Case studies	Sample collections
			Maps	Meetings		
May 8-10, 2014	Budathum	0	3	1	2	4
June 10-17	Budathum, Baseri	11 & 13 = 22	0	0	3	40
May 19- June 1	Fulkharka, Mulpani	40 & 16 = 56	6	2	3	55
August 8-11, 2014	Salyantar, Aaginchowk	0	4	2	0	19
Total		78	13	5	8	118

Major Fuelwood plants		
Common name	**Scientific names**	**Family**
Chilaaune	*Schima wallichii* (DC.) Korth	Theaceae
Salla	*Pinus roxburghii* Sargent	Pinaceae
Siris	*Albizia* sp.	Leguminosae
Uttis	*Alnus nepalensis* D.Don	Betulaceae
Kaafal	*Myrica esculenta* Buch.-Ham. ex D.	Myricaceae

	Don	
Khanaayo	*Ficus semicordata* Buch.-Ham. ex Sm.	Moraceae
Kutmero	*Litsea monopelata* (Roxb.) Pers.	Lauraceae
Saal	*Shorea robusta* Gaertn.	Dipterocarpaceae
Gurash	*Rhododendron arboreum* Sm.	Ericaceae
Katush	*Castanopsis indica* (Roxb.) Miq.	Fagaceae

Major edible oil plants		
Common name	**Scientific names**	**Family**
	Anethum sowa Kura.	Umbelliferae
Sarsyu	*Brassica campestris* L. var. *sarson* Prain	Brassicaceae
Raayo	*Brassica juncea* (L.) Czern	Brassicaceae
Tori	*Brassica rapa* L.	Brassicaceae
Bhatmaas	*Glycine max* (L.) Merr.	Leguminosae
Jhuse til	*Guizotia abyssinica* (L.f.) Cass	Asteraceae
Mula	*Raphanus sativus* L.	Brassicaceae
Til	*Sesamum orientale* L.	Pedaliaceae
Goldhari	*Camellia* sp.	Theaceae

Major non edible oil plants		
Common name	**Scientific names**	**Family**

Chiuri	*Aesandra butyracea* (Roxb.) Baehni	Sapotaceae
Amala	*Phyllanthus emblica* L.	Euphorbiaceae
Amphi	*Alangium salviifolium* (L.f.) Wangerin	Alangiaceae
Titepaati	*Artemisia indica* Willd.	Asteraceae
Dhasingare	*Gaultheria fragrantissima* Wall.	Ericaceae
Sajiban	*Jatropha curcas* L.	Euphorbiaceae
Anderi	*Ricinus communis* L.	Euphorbiaceae
Aakha taare	*Trichilia connaroides* (Wight & Arn.) Bentvelzen	Meliaceae
Bakaino	*Melia azederach* L.	Meliaceae
Bhalaayo	*Semecarpus anacardium* L.f.	Anacardiaceae
Thulo khirro	*Sapium insigne* (Royle) Benth. & Hook.f.	Euphorbiaceae
Paangraa??	*Entada phaseoloides* (L.) Merr.	Fabaceae

REFERENCES :

Abatzoglou, N. and Boivin, S. 2009. A review of biogas purification processes. *Biofuels, Bioproducts and Biorefining*. **3** (1), pp. 42-71.

Acharya, D.R., Bell, J.S., Simkhada, P., van Teijlingen, ER. And Regmi, R. 2010. Research Women's autonomy in household decision-making: a demographic study in Nepal. *Reproductive Health*. **7** (15), pp. 1-12.

Ahn, S.Y. Eom, S.Y., Rhie, Y.H., Sung, Y.M., Moon, C.E., Choi, G.M. and Kim, D.J. 2013. Utilization of wood biomass char in a direct carbon fuel cell (DCFC) system. *Applied Energy*. **105,** pp. 207-216.

Ale, B. and Bade Shrestha, S. O. 2009. Introduction of hydrogen vehicles in Kathmandu Valley: A clean and sustainable way of transportation. *Renewable Energy*. **34** (6), pp.1432-1437.

Andersson, T. et al. 1999. *Rural Energy Services: A Handbook for Sustainable Energy Development*. London: ITDG Publishing.

Andersson, T., Doig, A., Rees, D., Khennas, S. 2012. Ethanol Production, Food and Forests. *Environmental and Resource Economics*. **51** (1), pp. 1-21.

Subedi, B. P., Ghimire, P.L., Koontz, A., Khanal, S.C., Katwal, P. Sthapit, K.R. and Khadka-Mishra, S. 2014. *Private Sector Involvement and Investment in Nepal's Forestry: Status, Prospects and Ways Forward*. National level study report submitted to the Multi Stakeholder Forestry Programme - Service Support Unit. Kathmandu: Asia Network for Sustainable Agriculture and Bioresource (ANSAB).

Axaopoulos, P., Panagakis, P. Tsavdaris, A. and Georgakakis, D. 2001. Simulation and experimental performance of a solar-heated anaerobic digester. *Solar Energy*. **70** (2)**,** pp. 155-164.

Bailis, R., Berrueta, V., Chengappa, C., Dutta, K. Edwards, R., Masera, O., Still, D. and Smith, K.R. (2007) Performance testing for monitoring improved biomass stove interventions: experiences of the household energy and health project. *Energy for Sustainable Development*. **11** (2), pp. 57–70.

Basu, P. 2010. Biomass Gasification and Pyrolysis: Practical Design and Theory, London: Elsevier.

Bhusal, P., Zahnd, A., Eloholma, M., Halonen, L. 2007. Energy efficient innovative lighting and energy supply solutions in developing co9untries. *International Review of Electrical Engineering*. **2** (5), pp. 665–670.

Birol, F. 2007. Energy economics: a place for energy poverty in the agenda? *The Energy Journal*. **28** (3), pp 1-6.

Boswell, M.J. 1998. Exploration and Utilisation of the Indigenous Renewable Oil Resource in Nepal: *Jatropha curcas* a Low Altitude Species. In: *Proceedings of International Conference on the f Renewable Energy Technology for Rural Development. 24-25 November 1998, Kathmandu.* Kathmandu: International Conference on the f Renewable Energy Technology for Rural Development , pp. 98-106.

Bruce, N., Perez-Padilla, R., and Albalak, R. 2000. Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization*. **78** (9), pp. 1078-1092.

CBS. 2011. *Nepal Living Standards Survey (2010/11). Kathmandu:* Central Bureau of Statistics - Government of Nepal.

Cecelski, E. 1999. *The Role of Women in Sustainable Energy Development*. Bolder Colorado: National Renewable Energy Laboratory.

Choi, G.H. and Bell, S.R. 1994. Investigation of coal-water slurry fuel combustion in reciprocating, internal combustion engine. *KSME Journal*. **8** (4)**,** pp.356-363.

Clancy, J., Skutsch, M. and Batchelor, S. 2003. The Gender - Energy- Poverty Nexus: Finding the energy to address gender concerns in development. London: Department for International Development._

Costa, R. C. and Sodre, J.R. 2010. Hydrous ethanol vs. gasoline-ethanol blend: Engine performance and emissions. *Fuel*. **89** (2)**,** pp.287-293.

Di Blasi, C. 2009. Combustion and gasification rates of lignocellulosic chars. *Progress in Energy and Combustion Science*. **35** (2) pp.121-140.

Diesel, R. 1895. Method of and Apparatus for Converting Heat Into Work. Berlin-Germany.

Du, Z. 2007. A state of the art review on microbial fuel cells: A promising technology for wastewater treatment and bioenergy. *Biotechnology Advances*. **25** (5)**,** pp. 464-482.

Dwivedi, G. and Sharma, M.P. 2014. Potential and limitation of straight vegetable oils as engine fuel – An Indian perspective. *Renewable and Sustainable Energy Reviews*.**33**, pp. 316-322.

Ezzati, M. and Kammen, D. M. 2001. Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: an exposure-response study. *The Lancet*. ***358*** (9282), pp.619-624.

Foley, G. and Barnard, G. 1983. *Biomass Gasification in Developing Countries*. London: Earthscan.

Foley, G. 1992.Rural electrification in the developing world. *Energy Policy*. **20** (2), pp. 145–152.

Foley, G. (2000) Photovoltaic Applications in Rural Areas of the Developing world, ESMAP Technical Paper. ESMAP (Energy Sector Management Assistance Programme): Washington: World Bank, p. 79.

Furuta, M. and Salway, S. 2006. Women's Position Within the Household as a Determinant Of Maternal Health Care Use in Nepal, *International Family Planning Perspectives*. **32** (1), pp. 17–27.

Gyawali, D. and Dixit, A. 2010. The construction and destruction of scarcity in development: Water and power experiences in Nepal. In Mehta, L. ed. *The Limits to Scarcity. Contesting the Politics of Allocation*. London: Earthscan, pp. 233-251.

Haile, F. 1991. *Women fuelwood carriers in Addis Ababa and the peri-urban forest*. Geneva: International Labour Office.

Hoogwijk, M. 2004. On the Global and Regional Potential of Renewable Energy Sources. Netherlands: Department of Science, Technology and Society, Utrecht University.

Hsieh, W.D., Chen, R.H., Wu, T.L. and Lin, T.H. 2002. Engine performance and pollutant emission of an SI engine using ethanol–gasoline blended fuels. *Atmospheric Environment*. **36** (3), pp. 403-410.

Ives, J.D. 2004. *Himalayan Perceptions: Environmental Change and the Well Being of Mountain Peoples*. London: Routledge.

Kirubi, C., Jacobson, A., Kammen, D. M. and Mills, A. 2009. Community-based electric micro-grids can contribute to rural development: evidence from Kenya. *World development*. **37** (7), pp. 1208-1221.

Kowalewicz, A. 1993. Methanol as a Fuel for Spark Ignition Engines: A Review and Analysis. *Journal of Automobile Engineering*. **207**, pp. 43-52.

Kruse, A. 2008. Supercritical water gasification. *Biofuels, Bioproducts and Biorefining*. **2** (5), pp. 415-437.

Kruse, A. and Dinjus, E. 2007. Hot compressed water as reaction medium and reactant: 2. Degradation reactions. *The Journal of Supercritical Fluids*. **41** (3), pp. 361-379.

Kurmi, O. P., Semple, S., Simkhada, P., Smith, W. C. S., and Ayres, J. G. 2010. COPD and chronic bronchitis risk of indoor air pollution from solid fuel: a systematic review and meta-analysis. *Thorax*. **65** (3), pp.221-228.

Lin Y. T., S. (2005) Ethanol fermentation from biomass resources: current state and prospects. *Applied Microbiology and Technology*. **69** (6), pp.627-642.

Lu, Y., Zhao, L. and Guo, L. 2011. Technical and economic evaluation of solar hydrogen production by supercritical water gasification of biomass in China. *International Journal of Hydrogen Energy*. **36** (22), pp. 14349-14359.

Masud, J., Sharan, D., Lohani, B.N. 2007. Energy for all: addressing the energy, environment, and poverty nexus in Asia. Manila: Asian Development Bank.

Milne, T.A., Abatzoglou, N., Evans, R. J. and Laboratory, N. R. E. 1999. *Biomass Gasifier "tars": Their Nature, Formation, and Conversion*. Colorado: National Renewable Energy Laboratory.

Munnings, C., Kulkarni, A. Giddey, S. and Badwal, S.P.S. 2014. Biomass to power conversion in a direct carbon fuel cell. *International Journal of Hydrogen Energy*. **39** (23), pp. 12377-12385.

Naliathambi Gunaseelan, V. 1997. Anaerobic digestion of biomass for methane production: A review. *Biomass and Bioenergy*. **13** (1/2)**,** pp**.** 83-114.

NEA 2014. A Year In Review: Fiscal Year 12/13. Kathmandu: Nepal Electricity Authority.

Pachauri, S., Mueller, A., Kemmler, A., and Spreng, D. 2004. On measuring energy poverty in Indian households. *World Development*. **32** (12), pp. 2083-2104.

Piriou, B., Vaitilingom, G., Veyssiere, B., Cuq, B. and Rouau, X. 2013. Potential direct use of solid biomass in internal combustion engines. *Progress in Energy and Combustion Science*. **39** (1), pp. 169-188.

Pokharel, S. 2003. Promotional issues on alternative energy technologies in Nepal. *Energy Policy*. **31** (4), pp. 307–318.

Rabinowicz, E. and Mutis, A. 1965. Effect of abrasive particle size on wear. *Wear*. **8** pp**.** 381-390.

Rajbhandari, M. M. S. 2011. Hurdle towards Education Decentralization: An Ontological Paradigm of Community Participation in India and Nepal. Available from
from http://files.eric.ed.gov/fulltext/ED518022.pdf cited 18 September 2014.

Reddy S.N., Nanda, S. Dalai, A.K., and Kozinski, J.A. 2014. Supercritical water gasification of biomass for hydrogen production. *International Journal of Hydrogen Energy*. **39** (13), pp. 6912-6926.

Rehfuess, E. 2006. Fuel for life: household energy and health. Geneva: World Health Organisation

Rogner, H.H. 2000. Energy resourcesand technology options. In: *World Energy Assessment (WEA)*. New York: United Nation Development Programme.

Rosch, C., Skarka, J. and Wegerer, N. 2012. Materials flow modeling of nutrient recycling in biodiesel production from microalgae. *Bioresource Technology*. **107**, pp.191-199.

Rothchild, J. 2006. *Gender Trouble Makers: Education and Empowerment in Nepal*. London: Routledge.

Sharma, P. 2005. Distance education and online technologies in India.. *In:* Alison A. Carr-Chellman, A. ed. *Global Perspectives on E-learning: Rhetoric and reality*. London: Sage. pp. 52-66.

Smith, K. R., Samet, J. M., Romieu, I., and Bruce, N. 2000. Indoor air pollution in developing countries and acute lower respiratory infections in children. *Thorax*. **55** (6), pp. 518-532.

Srivastava, L., and Rehman, I. H. 2006. Energy for sustainable development in India: Linkages and strategic direction. *Energy Policy*. **34** (5), pp. 643-654.

Turkenburg, W.C. 2000. Renewable energy technologies in J. Goldemberg (Ed.), *World Energy Assessment*. Washington D.C.: UNDP, pp. 220–272.

Udall, L. 1995. Arun III Hydroelectric Project In Nepal: Another World Bank Debacle?, available from http://www.internationalrivers.org/files/attached-files/lori_udall_on_aruniii.pdf cited 18 September 2014.

UNDP (1997) *Energy After Rio: Prospects and Challenges*. New York: UNDP.

Vancoillie, J. et al. 2013. The potential of methanol as a fuel for flex-fuel and dedicated spark-ignition engines. *Applied Energy*. **102**, pp.140-149.

Wang, X. 2004. A Review of the ESMAP Rural Energy and Renewable Energy Portfolio. New York: World Bank and UNDP p. 75.

Wagner, T. W. and Wyszynski, M. L. 1996. Aldehydes and Ketones in Engine Exhaust Emissions–a Review. *Journal of Automobile Engineering*. **210** (24), pp. 109-122.

WECS (2010) Energy Sector Synopsis Report 2010. Kathmandu: Water and Energy Commission, Secretariat. Government of Nepal.

Xue, J. 2013. Combustion characteristics, engine performances and emissions of waste edible oil biodiesel in diesel engine. *Renewable and Sustainable Energy Reviews*. **23,** pp. 350-365.

Yenigun, O. and Demirel, B. 2013. Ammonia inhibition in anaerobic digestion: A review. *Process Biochemistry*. **48** (5/6), pp. 901-911.

Zahnd, A. and Kimber, H.M. 2009. Benefits from a renewable energy village electrification system. *Renewable Energy*. **34** (2), pp. 362–368

GIZ. 2011. The potential of sustainable liquid biofuel production in Rwanda. A study on the agricultural, technical and economic conditions and food security. Berlin: Deutsche Gesellschaft fürInternationale Zusammenarbeit, GmbH.