ALTERNATIVE ENERGY AND EFFECTIVE IMPLEMENTATION OF ENVIRONMENTAL IMPACT ASSESSMENT

TAPENDRA CHAND

DaayitwaSummer Fellow 2015 with HONORABLE GOKARNA RAJ BISTA

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Abstract

In the present context of Nepal, there is huge energy deficit that is jeopardizing our national economy. We are compelled to import conventional fossil fuels worth billions, which is considered as a leading factor for huge trade deficit. Thus, Government of Nepal must focus on alternative energy to address such a man-made disaster. One of the tools namely environmental impact assessment (EIA) has proved beneficial for sustainable development of any development project and is commonly practiced in many countries including Nepal. This research focuses on finding the possibilities of available resources and endowments in the entire geography of Nepal and production cost of different alternative energy. Consequently, comparative analysis of solar and wind were made with hydro whereas that of bio-diesel was made with conventional diesel. On the other hand, general methodology for EIA and initial environmental examination (IEE) in Nepal were elaborated. Different qualitative and quantitative methods were used for this research. Meeting, telephone and e-mail conversation were conducted with various experts. Furthermore, various national and International journals (exe: 'science direct'), newspaper articles, books were used for desk research. Finally citation was done using citation tool namely 'End Note'. It was found that among various alternative form of energy found in Nepal; solar, wind, biodiesel and biogas seems promising and pragmatic. Comparative analysis of both solar and wind with hydro-power confirmed that the earlier two technologies can largely contribute towards compensating power deficit, specifically in all seasons of Nepal excluding monsoon. Government of Nepal is focusing only on Hydro policy which is hindering other renewable technologies like solar and wind to penetrate in the Nepalese market. It was found that public hearings are never conducted during EIA report preparation and also Nepal has not introduced the concept of accrediting the experts and consulting firms to prepare the EIA report. So, in order to develop renewable energy technologies (RETs) as a viable and sustainable option for developing countries like Nepal, it is important to educate the people about the potential economic, health and environmental merits of renewable energy. In addition to this, Government of Nepal can also experiment with consumption based subsidies like 'Net metering system' together with the existing investment based subsidies to encourage the consumption of energy from renewable resources. For an effective implementation of EIA, there should be one window approach ("Ek dwar pranali") where different ministry can collaborate effectively and efficiently. Furthermore, there should be decentralization process of environmental administration at district development committee (DDC) via formation of Environmental unit (EU) and Environmental Sub-committee (ESC).

Keywords: Environmental impact assessment, Sustainable development, Endowments, Bio-diesel, Desk research, Power deficit, Initial environmental examination, Accrediting, Renewable energy technologies, Net metering system, Investment based subsidies, One window approach, Decentralization, District development committee, Environmental unit, Environmental sub-committee.

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Executive Summary

In the present context of Nepal, there is huge energy deficit that is jeopardizing our national economy. We are compelled to import petroleum products, manufactured as well as food products, electricity, etc. worth billions which are considered as leading factors for huge trade deficit of more than six hundred billion Nepali Rupees. Therefore, it's time for us to think about an alternative that could save our country from such a man-made disaster. Recently, this artificial disaster was accompanied by a natural disaster entitled 'earthquake.' The earthquake has destroyed the majority of privately owned and some state owned hydropower plants, which has resulted into disruption of electric power that nearly equals to 200 MW. This is a devastating scenario for Nepal as it is generating electricity below 1000 MW, mostly from hydro power plants. So, it's time for us to think about renewable energy that could positively offset the energy demand of our country. Our small effort and effective policies promoting green source of energy could save our country from such paucity of Energy.

EIA and IEE are two major tools that needs to be prepared before executing any development projects and is commonly practiced in many developed, developing and under-developed countries including Nepal. These tools have proved extremely beneficial for sustainable development and have benefited both local community and ecosystem. Ironically, EIA that are prepared in Nepal have many fallacies like ineffective communication with the local people, reports in technical English, obsolete non-strategic policies, inadequate and inefficient manpower, unaccredited agencies and experts responsible for preparing report, etc. Thus, revolutionary change in the entire methodology of EIA preparation needs to be addressed so that different ongoing development projects in Nepal could be executed sustainably.

Different quantitative and quantitative methods were used for this research and to prepare this report. Meeting, telephone conversation and e-mail conversation were conducted with various experts working in the field of wind energy, solar energy, hydro-power, Bio-diesel and environment. Furthermore, various national and International journals (exe: 'science direct'), newspaper article (exe: Kantipur, The Kathmandu post, The Himalayan times, etc.), books were used for desk research. Finally citation was done using citation tool namely 'End Note'.

Key Findings

- Nepal electricity authority (NEA) has monopoly in the Nepalese energy market.
- Initial investment of Renewable energy technologies (RETs) is high but its operation cost is minimal.
- After the completion of wind mapping in Nepal (2015-2018), there is a possibility of noticeable investment in the field of wind energy.
- The cost of both solar and wind power is in decreasing trend; mainly because majority of equipment's are imported from china.
- Government of Nepal is focusing only on Hydro policy which is hindering other renewable technologies to penetrate in the Nepalese market.
- Financial Institutions are not readily motivated to invest in Renewable energy technologies (RETs) because of immature business models, market insecurity and implementation and usage risks.
- Public hearings are never conducted during EIA report preparation.
- Nepal has not introduced the concept of accrediting the experts and consulting firms to prepare the EIA report.
- Unlike air, water and noise quality, which can be assessed against established standards; the socio-economic impacts do not have standard scale and are difficult to rank.
- Main problem for initial phase of EIA is consultation with different departments which is time consuming and cumbersome procedure.

Key Recommendations

- The implementation of a cooperative concept could be an excellent option for Nepal for developing and implementing renewable energy resources in rural parts.
- To develop RETs as a viable and sustainable option for developing countries like Nepal, it is important to educate the people about the potential economic, health and environmental merits of renewable energy.
- Government of Nepal can also experiment with consumption based subsidies like 'Net metering system' together with the existing investment based subsidies to encourage the consumption of energy from renewable resources.
- Wasteland suitable for Jatropha plantation should be officially declared by the local authorities with the support of GIS (Geoinformation system) maps and local expertise in a participatory and transparent matter.

- Homeowners should be encouraged to install battery with capacity to handle at least four hours of house load which can shift peak load demand significantly to solve power shortage problem.
- Differential pricing of electricity according to demand and supply ability can dramatically shift load demand.
- For an effective implementation of EIA, there should be one window approach ("Ek dwar pranali") where different ministry can collaborate effectively and efficiently
- There should be decentralization process of environmental administration at district development committee (DDC) via formation of Environmental unit (EU) and Environmental Sub-committee (ESC).

1 Introduction

1.1 Background

Topographic elevation of Nepal changes from 60 m at the southern plains to 8848 m at Mount Everest in the north, with a horizontal distance of less than 200 km. However, the north-south distance is less than 100 km in some instances, which clearly indicates the steepness of its topography and variation in physiographic regions. Furthermore, the physiographic region ranges from tropical forest in the south to the permanent ice-covered arctic in the north. [1] Nepal is a country gifted with natural resources other than conventional resources of energy like coal, gas, oil and nuclear fuels. Hence, we are supposed to fulfill our energy needs mostly form non-conventional form of energy specifically fuel wood, agricultural residues, animal waste, hydro-electric power, solar, bio-diesel and potentially wind energy. Nepal's energy system needs to be adapted into a more sustainable one, based on a diverse mix of energy sources, addressing the pressing challenges of security of supply and climate change. In accordance with the fact that there is sharp increase in oil and natural gas prices, renewable source of energy can be used as a substitute for fossil fuels and may reduce the dependence on imports and/or the greenhouse gas emissions. Nevertheless, different forms of renewable energy other than hydro-power are not yet commercially successful because of various limitations and discrepancies. For example: Fuel wood can also be used for producing syngas or producer gas ($CO+H_2$) which can be used for fuelling gas turbines that can generate electricity after necessary cleaning mechanisms. However, this type of application is still in the research phase even in developed countries because of various limitations and thus its application in Nepal would take many years. Furthermore, other sectors like solar, wind, geo-thermal, bio-diesel needs higher capital cost that does not justifies the economic benefit unless it is heavily subsidized.

Environmental Impact Assessment (EIA) is one of the major instruments integrated with a goal of making economic development project, environmentally sound/friendly and sustainable. [2] In other words, EIA is a process that analyses and evaluates the impacts that human activities can have on the environment. Its purpose is to guarantee a sustainable development that is in synchronization with human welfare and the conservation of ecosystem. [3] In the planning history of Nepal, the sixth plan (1980-1985), for the first time recognized the need for EIA integration for major infrastructure projects. The government of Nepal then initiated environment conservation related policies in the seventh plan (1985-1990). Environmental assessment Guideline 1993 was the first "lesson learnt" document in

Nepal which has played facilitation role in the EIA process. With an inspiration from oversees, Nepal government has established EIA system for development projects with the formulation of environmental protection rules 1997 as well as sectorial policy, laws and guidelines. Based on the formulated Act, regulations, and guidelines, criteria for (Initial Environmental examination) IEE/EIA (Environmental impact assessment) has established that the development projects certainly require environmental assessment study as per the nature of the projects unless they cross the threshold for the disruption of the environmentally sensitive areas and their natural environment. [2] Nepal has been a party of 16-environmental related international legal instruments, the treaties, conventions and agreements. Furthermore, Nepal has signed other four conventions and treaties, which Nepal should implement based on moral obligation but not on legal ground. Besides the international legally binding instruments, there are other instruments such as Stockholm declaration, Rio declaration and Agenda 21 – a blue print of action-for the 21st century, which obliges the UN member states to adopt necessary measures on EIA application so as to minimize potential environmental impacts. Hence, these obligations bind Nepal to follow EIA for majority of development projects. In the past, the implementation of EIA in the project planning used to be a closed door approach. However, with the enforcement of EPR (Environmental protection rules) 1997, the opportunity for the involvement of stakeholders has increased. Experiences from review of earlier EIA reports shows that any person can prepare such report and hence, the reliability of report is still in doubt. Furthermore, the agencies responsible for environmental monitoring are not adequately addressed with the importance of EIA study, so monitoring aspect is totally neglected. [4] The use of EIA is reasonably recent in Nepal, but its implementation has already raised eyebrows among people from many sectors, including the general public and experts in different fields. It has been said that EIA reports are merely rhetoric in Nepal because the reports lack further guidelines and monitoring, fail to win public support, and neglect the development of project alternatives, as well as incompetence, lack of political will and ill preparedness on the part of government. [5]

1.2 Objectives

The objectives of this project are to:

- To discover the existing available resources and endowments in the entire geographical Nepal and proposing state-of-the-art technology to make use of endogenous alternative source of energy.

- To determine the cost of different alternative source of energy namely photovoltaic Solar, wind power and bio-diesel and accordingly comparative analysis with hydro-power and other conventional source of energy.

- To explore/review the provisions on EIA in place currently, and find ways for the upcoming projects to strike a balance between achieving both prosperity and sustainability possible.

2 Methodology

2.1 Research Questions

The research questions to be answered by this project are:

1. What are the existing available resources and endowments in the entire geography of Nepal?
2. What is the production cost for per kW of electricity generated from Photovoltaic solar panels and wind power? How can it be compared with hydropower?
3. What is the production cost of 1 litre of biodiesel derived from Jatropha plant? How can it be competitive with conventional diesel?
4. What are the challenges for Renewable energy (Solar, wind and Bio-diesel) development in Nepal?
5. What are the necessary recommendations for renewable energy development in Nepal?
6. How is environmental impact assessment (EIA) as well as initial environment examination (IEE) prepared in Nepal?
7. What are some misconceptions about EIA?
8. What are the different fallacies within EIA and IEE for various development projects and how can those discrepancies be addressed via various innovative approaches?

2.2 Research Design

The project will use both qualitative and quantitative methods to answer the above mentioned research questions. The following table summarises the methods used to answer each question:

Table 1: Methods used to answer research questions

Research Question	Method Used to Answer Question
1. What are the existing available resources and endowments in the entire geography of Nepal?	-Research via various national and international Journals. -Meeting with Gayatri Sharma who is Daayitwa summer fellow 2015.
2. What is the production cost for per kW of electricity generated from Photovoltaic solar panels and wind power? How can it be compared with hydropower? 3. What is the production cost of 1 litre of biodiesel derived from Jatropha plant? How can it be competitive with conventional diesel? 4. What are the challenges for Renewable energy (Solar, wind and Bio-diesel) development in Nepal? 5. What are the necessary recommendations for renewable energy development in Nepal?	-Research via various national and international Journals. -Research on various Renewable energy technology (RET) policies. -Telephone conversation and meeting with honourable Gokarna Raj Bista. -Telephone conversation with wind engineer of AEPC namely Rajeev shrestha. -Telephone conversation with meteorologist of AEPC namely Aruna Awali. -E-mail conversation with project engineer of Gham power Pvt. Ltd.namely subash pandey. - Both e-mail conversation and meeting with Chief executive officer of wind power Nepal pvt. Ltd. namely Kushal Gurung. -Meeting with program officer of people, energy and environment development association (PEEDA) namely Shalabh poudel who is also former Daayitwa fellow. -Telephone conversation with various private solar companies. -Via access of library of Water and energy commission secretariat.
6. How is environmental impact assessment (EIA) as well as initial environment examination (IEE) prepared in Nepal? 7. What are some misconceptions about EIA? 8. What are the different fallacies within EIA and IEE for various development projects and how can those discrepancies be addressed via various innovative approaches?	-Research via various national and international journals and book namely "Environmental Impact Assessment; methods, process, procedures in south Asian countries published by school of environmental science and management (SchEMS)." - Meeting as well as e-mail conversation with Prof. Dr. Ram Bahadur khadka who is principal of SchEMS and is a renowned environmental expert of Nepal. - Meeting with Sangeet Lal karna who is Mechanical engineer at Upper Tamakoshi hydropower Limited. - Meeting as well as e-mail conversation with Mikesh Joshi who is design engineer at Upper Tamakoshi hydropower Ltd. -Research on various environmental acts and policies. -Meeting with Er. Bikrant Bikram Chand who is managing director of Eco Nepal consultancy and formerly worked as an environmental monitoring expert at International non-governmental organization namely SEAM-N (strengthening of environmental administration and management in Nepal).

2.3 Instruments

Different Interviews, telephone and e-mail conversations were conducted with the concerned authorities. Both national and international journals relevant to the particular topics were vigorously studied and cited using citation tool namely 'End Note'.

See Appendix 1, Appendix 2 and Appendix 3 for detail of Interviews, telephone and e-mail conversations.

2.4 Data Collection

The data was collected by the Daayitwa summer fellow 2015 namely ‘Tapendra chand’ via face-to-face interview, phone and e-mail conversations. The language used for such data collection was both English and Nepali.

3. Existing available resources and endowments in entire geographical Nepal

3.1 Fuel Wood

Forests cover 14.4 million acres (22388 square miles) of land with total available biomass resources being 429 million dry metric tons. Forest biomass is a crucial resource for rural livelihoods in Nepal and 75% of energy is in the form of fuel wood, which is commonly harvested from forest. [[6], [7], [8]] Hence, fuel wood is a major biomass that is being used either for cooking or heating purpose mostly in different rural parts of Nepal.

3.2 Agricultural residues

In rural areas with limited supply of fuel wood, the energy for heating and cooking are fulfilled by available field and processing co-products from different cereal crops (paddy, maize, wheat, and millets), oil seeds, grain legume, and fiber crop (e.g. jute). Agricultural residues are the third largest biomass source of energy after fuel wood and animal dung. [9]

In combination with fuel wood and other agricultural residues like bagasse (sugarcane residue), corncobs, cow dung etc. can be used for producing biochar which is porous, light, dark byproduct after pyrolysis of biomass. This process uses limited amount of oxygen either via primary air or secondary air. The typical technical term used for such pyrolysis is called Top lit updraft gasification where fuel is burned on the top instead of burning it from the bottom which is commonly practiced. In addition to this, primary air is supplied from the bottom which will assist in the heating and slow burning of fuel which will consequently lead towards formation of high quality biochar. The top of the pyrolysis chamber is closed to limit the amount of oxygen which will assist in slow burning of fuel instead of burning it quickly which we can see commonly when they are heated with sufficient amount of oxygen. The idea here is to produce biochar that can be used for agriculture productivity. Furthermore, there are many advantages associated to it. For example: it can trap the carbon (acts as carbon filter) and thus reduces the emission of greenhouse gases like carbon-dioxide, methane and other particulates. It has been found that it increases the water holding or retention capacity of soil, acts as pesticide, traps nitrogen necessary for plants, can be used for cleaning up the environment during natural disaster or man-made disaster like chemical spill, mercury spill where these activated porous carbon can soak those harmful chemicals.

On the other hand, such pyrolysis chamber can be further elaborated to a gasification chamber or plant that can trap syngas or producer gas ($CO + H_2$) which after certain cleaning mechanism and reheating can be used as fuel in gas turbine to produce electricity. However, this type of application is still in the research phase even in developed countries because of various limitations and thus its application in Nepal would take many years.

3.3 Municipal solid waste

Waste generation per capita per day in Nepal is very less in comparison to other major Asian cities like Taipei, Singapore, New Delhi and Bangkok. However, waste management is a burning issue in Nepal which needs serious consideration. Open space dumping which is common in Nepal is considered harmful regarding release of methane gas (CH_4) which is 20 times more harmful than carbon-dioxide (CO_2) along with air pollution and water pollution. On the other hand, these wastes can be used for electricity generation as well as for biogas production which consequently could fulfil the demand of heat and electricity. However, wastes in Nepal consists considerable amount of moisture as we consume more cooked food rather than packaged food which necessitates significant amount of drying which in turn consumes energy. Thus, end product that is generation of electricity and heat is not cost-effective. On the other hand, waste incinerators that are used to burn wastes have demerits regarding release of harmful carcinogenic chemicals like dioxins and furans.

It has been found that biogas obtained from municipal wastes after necessary screening of organic wastes like remaining food, vegetable wastes etc. can be cleaned to remove impurities and upgraded to pure bio-methane. It can then be used in the vehicles designed to run on compressed natural gas (CNG) or liquefied natural gas (LNG) which consequently reduces emission of local pollutants including NOx and other particulates. It has been found that highest methane rate production occur at 60-80 % of humidity.[10] Moisture content of bhaktapur and kathmandu were 69.03 % and 72.83 % respectively. Thus, these values are within the limits that facilitates the highest production of methane. Furthermore, higher water contents are likely to affect the process performance by dissolving readily degradable organic matter which enhances production rate of methane. Average value of Moisture for bhaktapur, lalitpur, Kathmandu and kalimati are 69.03%, 85%, 82%, 72.82% and 82% respectively. [11]Hence, it can be concluded that the waste content of these major cities of Nepal promises higher possibility of biogas production which can be used as renewable fuel for smooth operation of vehicles.

3.4 Hydropower

Nepal is rich in water resources possessing about 2.2% of the world's total water resources. [12] About 6000 rivers and rivulets with total length of around 45,000 km and an annual discharge of 174 billion cubic meters are available in the nation. [13] The theoretical and commercial potentials of hydropower in Nepal are estimated to be around 83,000 MW and 42,000 MW, respectively whereas technical potential is about 45,000 MW. In a span of about 100 km, Nepali rivers provide a potential height of about 4 km, thus providing a high linear density (33 MW/km) and large hydropower potential. [14] On the basis of water resources per capita, Nepal rank's second in the world after Brazil. So, it is not to be misunderstood that Nepal ranks second in the water resources.

3.5 Solar Energy

On an average Nepal has 6.8 sunshine hours per day with the intensity of solar insolation ranging from 3.9 to 5.1 KWh/m^2/day whereas the national average is about 4.7 KWh/m^2/day. [15] In addition to this, Nepal receives more than 300 sunny days per year which is higher as compared to most of the European countries. Hence, use of solar power technologies can help mitigate the blackout problem as Nepal receives good solar insolation. Among many renewable energy technologies, photovoltaic solar power (PSP), with advancement in technology and decreasing cost, has become so popular that, it became the growing renewable energy technology in last decade. The photovoltaic solar power (PSP) capacity and potential of a particular urban area can be calculated using solar insolation and rooftop area of that area. The loss on inverter/converter and storage during battery backup needs to be considered while calculating total energy that the PV panels can convert into electricity, (given by conversion efficiency). Eq. (1) can be used to calculate the energy generated from PSP. [16] In this analysis, conversion efficiency was considered as the mean efficiency of PSP.

Solar energy (KW h) = insolation (kW h/m^2/day) * number of days * area (m^2) * conversion efficiency (k)……..Eq. 1

Installed capacity of PSP can be obtained by multiplying panel rating with the area covered by panel. If electricity is directly applied to distribution system or grid, d.c. (direct current) electricity generated in PV is converted into a.c. (alternative current) during which there is a

loss that needs to be considered. This loss can be explained by DC to AC derate factor. For this analysis, default loss factors equivalent to 0.77 is used for 0.5 to 1000 kW system as most of the households are considered to have solar system of this size. Furthermore, mean efficiency of PSP is considered to be 13.4% and average wattage in a meter area of solar panel is considered as 134 W/m^2. It was found that utilization of all rooftop space is enough to install 6126 MW PSP contributing almost 10,000 GW h or more electricity into the national grid. However, it needs to be understood that not all roof space can be utilized for solar panels as there are other things that accommodates the area and also not all structures can withstand such PSP installations. For example: total energy shortage in national grid was only 1278.45 GW h in 2013/2014. [17] It means tilted PSP installed in only 10% of rooftop space will be enough to produce deficient energy. Hence, it can be concluded that only one tenth utilization of total capacity will be enough to produce deficient energy.

On the other hand there is huge potential of solar thermal devices such as solar water heaters (SWH), solar dryers (SD), and solar cookers (SC). However, solar thermal devices are not suitable in those areas where the temperature falls below freezing. In the case of solar cookers, it takes longer time for cooking and is not time efficient.

3.6 Wind Energy

As of now, wind energy is an unharnessed energy resource in Nepal. Due to its diverse topography and variation in meteorological conditions, it is difficult to generalize wind patterns in the country. The solar and wind energy resource Assessment (SWERA, 2002-2007) project reported a potential area of about 6074 sq. km with a wind power density greater than 300 W/m^2, and total commercial potential of 3000 MW wind power. In addition, although available data are limited, collected data (at height of 10 – 20 m) in a few candidate sites for wind power development show that enough wind is available to generate electricity from 10AM to 10PM having possibility to supply more electricity in the evening peak hours. [18] However, most of the potential areas are very site specific in mountainous locations without infrastructure support. [9] The Kagbeni wind power project was one of the biggest projects with installed capacity of 20 KW built in 1987 under the support of the Danish government. However, within three months of operation, blade and tower of the wind generator were broken. It has been found from recent studies of AEPC that, mustang district solely have total wind energy generation capacity of 1000 MW. However, consistency of wind speed is a matter of question and thus a solution like hybrid system (combination of wind and solar) or detailed feasibility study with minimum observation of wind patterns for minimum 1-2 years needs to be implemented. According to Ram Prasad Regmi, if a larger

wind turbine is installed for wind extraction in Mustang, it can be operated for maximum four hours a day only and if small turbine is installed, it will be damaged by high winds[1]. The western and far-western regions of the country have vast wind energy resources that could be extracted commercially, according to a study. A preliminary study conducted by the National Atmospheric Resource and Environment Research Laboratory at the Central Department of Physics, Tribhuvan University (TU), showed Dadeldhura, Darchula in the Far-Western region and Mustang, Palpa and Gulmi in the Western region have an immense potential to generate hundreds of megawatts of power through wind farms. According to Ram Prasad Regmi, an associate professor, wind power can only be extracted during the dry season to generate electricity and the Chisapani area located north-east of Shivapuri has a relatively better wind but it is not commercially viable. [19]

3.7 Animal Manure

Even though livestock manure is often used as fertilizer in hilly and many parts of the plain (the Terai) region of the country, it is widely used as an energy source in the southern part of the Terai areas where forest resources are not easily available. Manure is used in both dried cake and gaseous form (biogas) commonly known as "gobar gas" for energy. [9] There is a growing use of biogas technology in Nepal with an annual increase of about 15.0%. [20] Livestock is an integral component of Nepalese farming system. The total households with cattle and buffalo in Nepal were estimated to be 1.2 million in 2001. Based upon the study, technical biogas potential of the country is estimated to be 1.0 million household level plants, out of which 57.0% in the Terai (plains), 37.0% in hills and rest 6.0% in remote hills or in mountain region. [21]

3.8 Geothermal Energy

It is one of the important resources of renewable energy in Nepal and it is recorded that more than 33 hot springs are available containing temperature ranging from 21°C to 73 °C and flow of 0.2 to 8.0 liters per second. [22] These hot water springs are currently being used for the therapeutic purposes. However, hot water of this temperature in combination with other secondary fuel can be used for electricity generation via steam turbine. Furthermore, end product like less saturated steam via heat exchangers can be used for thermal applications like space heating, heating biogas digester etc. It has been found that geothermal energy provides roughly 2.1 MW of energy with further development and investigation of the resource

[1]Wind becomes stronger during 12pm to 4pm in Mustang area.

ongoing. [23] Geothermal Mapping is shown in figure 1 whereas Table 2 indicates the surface and discharge enthalpy at different locations denoted by alphabets like A, B, C etc.

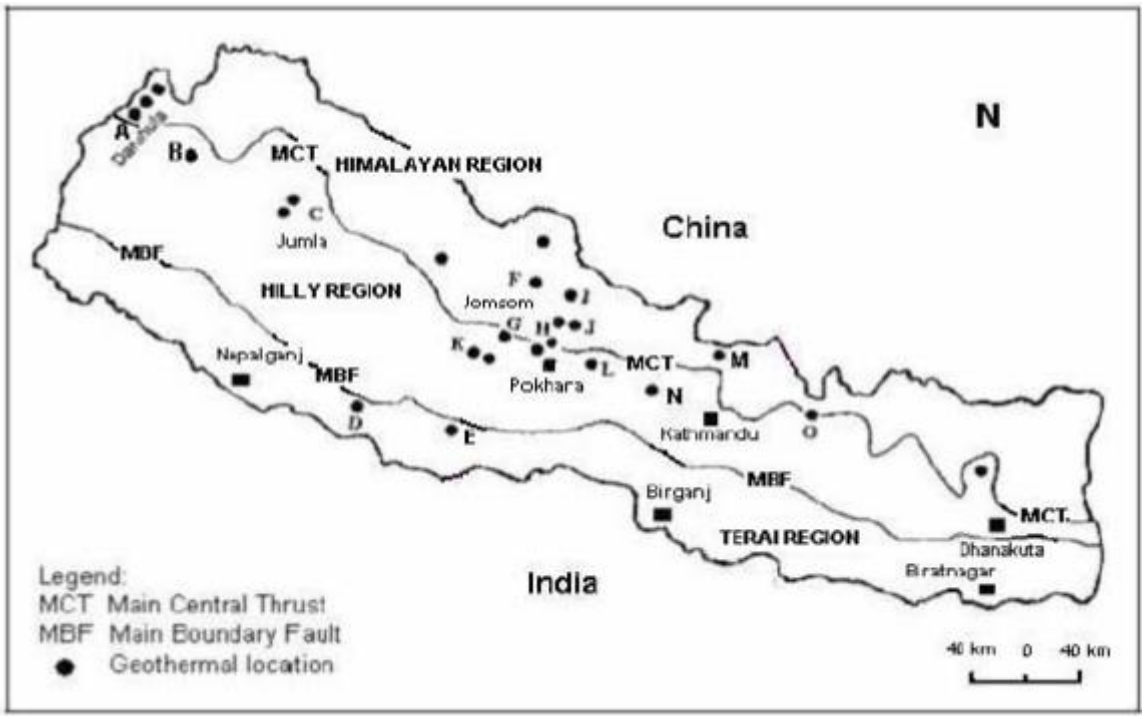

Figure 1: Map of Thermal locations in Nepal [24]

Table 2: Geothermal localities and general information [24]

Locality	Symbol	Flow rate (l/s)	Surface Temperature (°C)	Discharge Enthalpy (KJ/kg)
Darchula	A	0.6	44.33	264.3
Tapoban	B	0.3	31	126
Jumla	C	1.05	33	456
Riar	D	1.5	33	227
Suraikhola	E	1.7	36	210
Muktinath	F	3	22	211
BhurungTatopani	G	1.8	72	484
Sadhu khola	H	1.5	68	460
Kharpani	I	0.4	49	-
Mayangdi	J	2	40	376
SinghaTatopani	K	6	54	452
Bhulbhulekhar	L	1.2	34	-
Chilime	M	0.9	48	386
SyabriBesi	N	0.4	34	365
kodari	O	5.5	42	17

3.9 Biodiesel

Bio-diesel is a renewable transport fuel made by reacting triglyceride oils, usually of vegetable origin, with alcohols in the presence of base catalyst. This converts the triglyceride molecule into three molecules of alkyl ester (the biodiesel) and one molecule of glycerol via a series of three equilibrium reactions. In almost all processes, methanol is used as it is the least expensive and results in most rapid reaction.[25]

Triglyceride + Methanol ↔ Methyl Ester + Diglyceride

Diglyceride + Methanol ↔ Methyl Ester + Monoglyceride

Monoglyceride + Methanol ↔ Methyl Ester + Glycerol

In the context of Nepal, the most promising source of bio-diesel is the plant namely Jatropha derived from the Greek word 'Jatros' means 'Doctor' and 'trophe' means 'Nutrition'. Botanically this is known as Jatrophacurcas L. and belongs to the family Euphorbiaceae. It is a shrub with smooth gray bark, which exudes whitish colored, watery, latex when cut. Normally, it grows between three and five meters in height, but can attain a height of up to eight or ten meters under favourable conditions. It has large green to pale-green leaves. It flowers during May-June with light yellow color and produces fruits. More female flowers give more number of seeds. The fruits are green in color and turns into yellow when matures and black when it dries. The seeds become mature when the capsule changes from green to yellow, after two to four months from fertilization. Oils can be extracted from the seeds and used as fuels for burning lamps and to run diesel engines. In addition to this, the remaining residue or pressed cake after oil extraction can be used as organic fertilizer. In the past, Jatropha seeds were eaten as a remedy for constipation and food poisoning and also used for purposes like as cooking oil, ointment, and soap making. [26] However, on an average calculation, it requires 5 kg of seed to produce 1 liter of bio-diesel and thus the end price of bio-diesel is more than that of its counterparts like diesel and kerosene. It has been found that Jatropha is found in the districts namely Panchthar, Okhaldhunga, Dolakha, Sindhuli, Makawanpur, Dahading, Gorkha, Tanahu, Pyuthan, Salyan, Doti and Dadeldhura. It has various local names like kadam in the eastern region, Baghandi in terai, Sajiwan in mid region, Ratanjyoti in western region. In general two scenarios for jatropha plantations are considered for Nepal. The first scenario is concentrated on Terai region where jatropha plantation can be done on waste lands and former flooding land. The other scenario is

focused on hilly region where plantation can be done as a fence, along the roads, against erosion or around the leasehold forestry areas. [27]

4. Cost Analysis of different alternative source of energy

In the present context of Nepal, solar power, wind power and bio-diesel from 'Jatropha' seems promising and pragmatic. Thus, cost analysis of the above mentioned renewable form of technology is discussed and comparative analysis of solar and wind have been made with hydropower whereas that of biodiesel with conventional diesel. Furthermore, for both solar and wind, the cost per Kilowatt (KW) i.e. $/KW of electricity production have been calculated. On the other hand, for biodiesel, production cost per litre i.e. Rs/Litre has been calculated.

4.1 Cost analysis of solar power

The initial investment for solar PV (Grid connected solar PV) in Nepal is high but is paid off by a high production and by a cost of 19.6NRs/kWh of the final energy that is by far less than the one produced by the systems at use in households during load shedding periods (inverter: batteries: 54.0 NRs/kWh): genset: 55.4 NRs/kWh), or by thermal power plant (Ca. 30 NRs/kWh). The common understanding that PV systems are expensive is mainly because of high initial investment cost. But in terms of energy costs, PV systems are very economic when compared to other alternatives because of the long lifespan of the technology which is more than 25 years. In addition to this, these systems are clean source of energy and drastically reduce emission of harmful green-house gases, responsible for global warming. Even though inverter-battery systems present low investment cost, they have very high energy production costs because of their relatively short lifespan and low efficiency. Most importantly, they consume more energy from national grid in comparison to its uses in order to compensate losses in its back-up system, thus proving detrimental to national energy crisis. Even the genset systems, which have a short lifespan and high running costs due to fuel and regular maintenance is expensive in comparison to PV system. [28] The declining cost factor in solar PV and inflation of cost as well as at least double variation in estimated cost, time taking for construction and installation and socio-economic hurdles in development in Hydropower making solar power as option and alternative to Hydropower electricity. The cost of electricity generated by PV systems is determined by the capital cost, the discount

rate, subsidy rate, the variable cost, the level of solar irradiation and efficiency of the solar cells. Among these parameters, the capital cost, the cost of finance and efficiency are the most critical and improvements in these parameters provide the largest opportunity for cost reductions. PV system costs for residential systems are projected to decline from USD 4200 to USD 6000/Kw in 2010 to between USD 1800 to USD 2700/Kw by 2020 and to USD 1500 to USD 1800/Kw by 2030. [29]

There is another way to make comparative analysis of different energy generating technologies. It is called levelized cost of electricity (LCOE) which represents the per-kilowatthour cost (in real dollars) of building and operating a generating plant over an assumed life and duty cycle (for example: service life of solar PV and wind is 30 years). [30] In other words, the basic thought is that one forms the sum of all accumulated costs for building and operating a plant and comparing this figure to the annual power generation. [31] Key inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance costs, financing costs, and an assumed utilization rate for each plant type. The importance of these factors varies among the technologies. For technologies such as solar and wind generation that have no fuel costs and relatively small variable O&M costs, LCOE changes in rough proportion to the estimated capital cost of generation capacity. For technologies with significant fuel cost, both fuel cost and overnight cost estimates significantly affect LCOE. Furthermore, availability of various incentives, including state or federal tax credits, can also impact the calculation of LCOE. The typical formula for calculating the LCOE of renewable energy technologies is [32],

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{t,el}}{(1+i)^t}}$$

Where,

I_o = Investment expenditures

A_t = Annual total costs in year t

M_t,el = Produced quantity of electricity in the respective year in KWh

i = Real interest rate or discount rate in %

n = Economic operational lifetime in years

t = Year of lifetime (1, 2, ...n)

In the context of Solar PV it is dependent on the following factors:

a. The capital and installation costs of PV modules and BoS[2]

b. The average annual electricity yield (Kwh) which is a function of the local solar irradiation and the solar cells technical performance (i.e. efficiency of solar cells)

c. The cost of capital for PV system

When the LCOE of PV system is the same or less than residential electricity tariff, then the PV electricity is considered economically competitive for residential users. The IEA (International Energy agency) in its PV technology road map (IEA, 2010) projects that "In 2020, the LCOE of PV system will range between USD 0.105 and USD 0.21/KWh for large utility scale plants and between USD 0.16 and USD 0.315/KWh for residential PV systems". Since, Hydro Power is also capital intensive like solar, has low O&M costs, and no fuel costs, the LCOE is very sensitive to investment cost and interest rates rather than to life time. Furthermore, it is non-dispatchable technologies whose output cannot be varied to follow demand. So, LCOE of PV system and Hydro-power can be compared. It has been found that even though LCOE of Hydro-power is less than PV system, there are other complications in hydropower like EIA (environmental impact assessment) which is highest among the renewable energy technologies. In addition to this, hydropower is mature technology and it cannot be expected to gain more efficiency neither cost reduction in construction but the cost is expected to inflate by 10 % every year. So, the cost of production is expected to increase in the forthcoming days. In 2014, the cost of installation of hydro-power in Nepal was averaged to $3000/KW. However, in case of solar PV system the cost for urban area is around $1950/KW for battery less system and about $3750/KW for battery based system (In case of rural area, add extra 1$ per watt)[3]. So, the cost for solar PV is equivalent to hydro-power. Other factors, like longer construction time of hydropower project[4], runoff type hydro-power

[2]The BoS cost includes items like of the structural systems, the electrical systems and battery or other storage Systems cost.
[3]Based on the information provided by Subash Pandey, project engineer at Gham Power Pvt. Ltd
[4]It takes 1 year to complete commercial PV system whereas it takes 4-5 years to complete commercial hydro-power system.

plant that shows fluctuation in power production, huge transmission loss, and increase in peak demand thrice of base load and adverse environmental effect necessitates importance of both residential and commercial solar PV system. [29]

4.2 Cost analysis of Wind power

As far as wind is concerned, it could be an alternative to hydropower because it has been found that during dry season river flow is less which consequently leads to lower hydropower generation (most of the hydropower plant is run-off type in Nepal which is dependent on the flow of water). On the other hand, during dry season the wind potential has been high and thus wind power could be an effective option for power production. [33] In the present context of Nepal, the cost of wind power production is $5400 - $5900/KW which is in decreasing trend and will decrease in the upcoming days as the equipment's for wind power production are imported from china[5]. According to Kushal Gurung (CEO of wind power Nepal Ltd.), his company's latest bid for a 31kw wind-solar micro-grid project (with battery and transmission line), submitted to AEPC, the cost was Rs. 385/watt, i.e. $3850/kW. Furthermore, china is the fourth largest producer of Wind power and it is supposed to increase significantly in the years to come which will eventually leads to the reduction of cost. Another interesting fact is that it is easier to construct and install wind turbines faster than hydropower. The hydropower project cycle is big and a single project doesn't complete even in 10 years at times. But if the road and transmission line is available, one can install a wind turbine in three to nine months. [34]

In total, it has been found that wind and solar energy can potentially compensate the deficiency in energy production during winter (December-February) and spring (March-May) in Nepal when there is less production by hydropower plant. The comparative analysis among solar, wind and hydro can be shown from the figure 2 in which monthly patterns of wind speed (m/s), solar radiation (KWh/m^2/day), and river discharge (m^3/s) is shown in the same graph.

[5]Based on the telephone conversation with ArunaAwali (Meteorologist at Alternative energy promotion center).

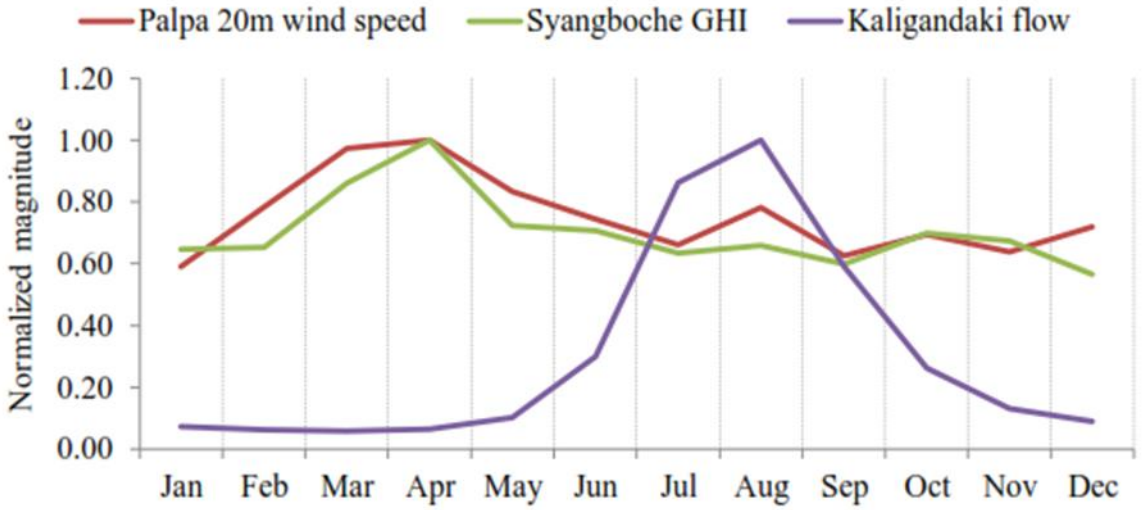

Figure 2: Comparison of the three energy resources-wind, solar, hydro- on a monthly basis [33]

Note:*since the magnitude and units are different for wind speed, Global horizontal irradiation (GHI), and river discharge, each will be normalized by its respective peak value occurring in the monthly charts just to make comparison in one chart easy. *Wind speed at Palpa was measured from September 2005 – August 2006. *GHI was measured at Syangboche from January 2002 – December 2002. * River flow was measured at Kaligandaki which is run off type hydro-power plant of capacity equivalent to 144 MW.*

Hence, it is clear from figure 2 that other than monsoon season the power production in Nepal is dramatically reduced. Thus, wind and solar energy can compensate the huge gap in power production and can be an effective option or alternative specifically for Nepal. [33] One option could be wind-solar hybrid system where one can compensate deficiency of each other simultaneously.

4.3 Cost analysis of Biodiesel

In the present context, Nepal is suffering huge energy crisis which is compelling us to import petroleum products worth 114 billion Nepali Rupees. There is huge trade deficit in which import of petroleum products comprises 18.5 % of total trade deficit (617 billion Nepali Rupees) that is detrimental to our economy[6]. Thus, bio-diesel could prove as an effective alternative source of fuel which can be used in different blended form like B15 (15 % biodiesel + 85 % conventional Diesel), B20 (20 % biodiesel + 80 % conventional Diesel), B25 (25 % biodiesel + 75 % conventional diesel) etc. or it can be used entirely as bio-diesel in the modified diesel engines. It is estimated that on top of the 10 % blending, with every 5 % increment on the blending proportion, area required for cultivation takes increases by a factor of 1.3. [35]

[6]Retrieved from http://www.ekantipur.com/kantipur/2072/3/19/full-story/349701.html

The detailed cost of bio-diesel production from 'Jatropha' (commonly used in Nepal for bio-diesel production) can be breakdown into the following components as per the following reference: [[35], [36]]

a.) Price of Jatropha seed in local market: Rs. 15/Kg
b.) 5 Kg of Jatropha seed produces 1 Liter of bio-diesel
c.) On the basis of Mustard oil average cost of extraction is Rs. 10/Kg
d.) Commonly the price of mustard pressed cake is Rs. 12/Kg. So, the price of Jatropha pressed cake is estimated to be the same.
e.) Transesterification cost of Jatropha oil is Rs. 10.5/Kg
f.) 1.2 percent of glycerin is produced after transesterification and the selling price of glycerin produced is Rs. 82/Kg.

Table 3: Cost of Bio-diesel per liter [[35], [36]]

Activities	Rate (Rs/Kg)	Quantity (Kg)	Cost (Rs.)
Seed	15	5	75
Extraction	10	5	50
Less cake produced	14	3.12	-43.68
Cost of oil per liter			81.32
Transesterification	10.5	1	10.5
Less glycerin produced	82	0.062	-5.084
Cost of Bio-diesel per liter			86.73

The cost of Transesterification per kg is shown in Table 4:

Table 4: Transesterification cost per 1000 kg of bio-diesel [36]

	Unit	Amount	Price	Total (Rs.)
Methanol	Kg	100	60	6000
Catalyst	Kg	10	150	1500
Electricity	hour	160	8	1280
Labour	Man-day	2	500	1000
		1	800	800
Total cost				10,580
Transesterification cost per Kg				10,58

Note: This cost varies as per the custom duties put for the transesterification plant unit during import.

Hence, from table 3 it can be found that, the costs for 1 Liter of bio-diesel costs around Rs. 86.73 which is nearly equal to present day cost of conventional diesel (Rs. 86.50 per liter[7]). It has been found that, the investment cost in the second year of plantation is high because it involves additional labour cost as 50 % of yield is expected to be available from the 2nd year and followed by 80 % of the yield from 3rd year and onward. On the total of cultivation of the Jatropha, estimated shares of labour inputs is 79 %, fertilizer inputs (9 %), cost of seedlings including plant protection measures is 9 % and irrigation input has a stake of 4 %. These entire shares are without considering the interest to the investment and without contingencies and returns from by-products. [35]

5. Challenges for Renewable energy development in Nepal

There are many challenges in Nepal for renewable energy technology (RET) development. Among different alternatives the challenges are specifically focused on solar, wind and biodiesel in the following discussion summarized in table 5.

Table 5: Challenges for Renewable energy technology (RET) development

Particulars	Solar	Wind	Bio-diesel
Policy barrier	-Recently published Urban Solar Delivery Guideline 2072 by AEPC for PV solar is not executed properly. There is concept of Net metering system[8] written on subsidy program but it has not been practiced[9]. Furthermore, most of the companies authorized by AEPC for such subsidy programs are not aware of the entire policies. So, lack of monitoring and inspection from government authorities.	-Lack of proper subsidized program.	-Lack of proper co-ordination in between public and market regulatory mechanism. [37]
Technical barrier	-Lack of proper storage capacity or efficient battery system.	-Higher wind speed i.e. cut off speed of 35-40 m/s could cause damage to rotor blades. Thus, power supply will fluctuate	-Higher viscosity and flash point of bio-diesel in which the first problem leads to blockage of fuel supply and the other leads to

[7] Retrieved from http://www.nepaloil.com.np/previous-selling-price-16.html
[8] Net metering allows residential and commercial customers who generate their own electricity from solar power to feed electricity they do not use back into the grid.
[9]Based on Telephone conversation with some private companies which are authorized by AEPC for implementation of Net Metering system.

		periodically depending upon the wind speed.	ignition problem especially during cold season.
Human resource barrier	Energy technologies have not received much coverage in most of the engineering and technical courses currently taught at universities and colleges in the country. There is no technical/vocational school that trains manpower in various aspects of renewable energy. At the local level, rural communities lack minimal level of technical knowledge to operate and maintain established renewable technologies. In addition to this, most of the skilled, semi-skilled manpower are going abroad for better future and opportunities.		
Infrastructure barrier	-As, land availability in urban areas is scare and land price is high, development of Photovoltaic solar power in open space will be very difficult and expensive.	-poor road and transport facilities to carry heavy equipment's to rural areas of Nepal having highest possibility of wind power.	-Lack of trans-esterification plant as well as seed collection centers at various locations of Nepal.
Political barrier	Political instability in the country has greatly constrained the development of renewable energy technology in Nepal. During the past three decades, Nepal has experienced huge political turmoil with more than dozens of government. These frequent changes in government and political system have adversely affected the long term planning and policy formulation for the development of nation.		
Institutional Barrier	Alternative energy promotion center (AEPC), the single governmental agency for the promotion of renewable energy technologies, is mainly focusing in the dissemination of the proven technologies through subsidy via central renewable energy fund (CREF). However, the government has yet to establish institution with the sole responsibility of research and development of renewable technologies.		
Financial or Investment barrier	-Financial Institutions are not readily motivated to invest because of immature business models, market insecurity and implementation and usage risks. -Managing Liquidity issues is vital for Institutional Investors like banks, insurance companies, retirement or pension funds, unions or trusts, Citizen Investment Fund, RastriyaBimaSansthan, Employee Provident Fund, and Nepal Army Welfare Fund which are few examples of Institutional Investors in Nepal. .Maintaining liquidity of an investment portfolio — that is, ensuring that across all potential time periods there will be enough cash available to meet the institution's needs — is critical to the success of an investment team. Valuing the cost of illiquidity is difficult and uncertain. Most institutional investors try to be on the side of caution; many avoid all investments they deem illiquid. The result is that institutional investors often limit or avoid direct investments in projects and smaller companies, even if the risk adjusted returns seem more attractive, reducing the overall potential for institutional investors in the renewable energy space. In other words, the increasing liquidity requirements and increasing the cost associated with investing in illiquid assets is likely to continue to be a major stumbling block to getting institutional investors to invest in renewable energy project debt or equity.[10]		
Lack of awareness and program in rural areas	Rural communities are unaware of the Renewable energy technologies and the adverse impact of existing practices on health, economy and the environment. Although, they often have access to renewable energy technologies, they lack the understanding of these technologies. Thus, they lack knowledge of successful replicable projects, government subsidies, potential financial partners, and the means for establishing renewable energy systems.		
Lack of affordability	Even with the current level and modality of government subsidy, services from major renewable energy technologies are unaffordable to the majority of the poor in rural areas. Comparatively higher initial cost of alternative energy options e.g. solar, wind and bio-diesel and lower affordability of low-income households are the major barriers for establishing such technologies in the rural areas.		

[10] Retrieved from http://energy4livelihood.net/institutional-investors-in-renewable-energy/

Monopoly in the market	Nepal electricity Authority (NEA) is not willing to implement Net metering system.	AEPC is flexible to give license to private companies for wind power development but NEA is reluctant to buy electricity.	Even though the price of bio-diesel is almost similar to conventional diesel, Nepal oil corporation (NOC) is unwilling to develop this technology. It could be invisible pressure from Indian oil corporation (IOC).

6. Recommendation for renewable energy development

There are many ways which can be prioritized and executed for the development of different renewable energy technologies. However, here the recommendations have been made focusing on solar, wind and biodiesel.

i) Decentralized energy resources

Due to the rugged mountainous terrain and scattered nature of human settlements, the national grid extension to these areas is very difficult and uneconomical. Hence, decentralized energy sources could be the most effective alternative for such remote locality. Rural populations need to be encouraged to participate in the construction of integrated as well as isolated grid for solar and wind power technology in combination with small-scale hydropower schemes. Due to Nepal's topography cost is high and local governments need to diversify the use and management of resources. [38] For example: If an improved water mill is installed in the village then it can be used for electricity generation, grinding of local grains, expelling of oil and also for irrigation.

ii) Energy cooperatives

The implementation of a cooperative concept could be an excellent option for Nepal for developing and implementing renewable energy resources in rural parts. Financial, technical and legal supports could certainly facilitate the development of RETs. Also, the formulation of a cooperative model provides the effective platform for the mobilization of local resources in the development and dissemination of RETs.

iii) Increment in funding and subsidy for wind power development

After the completion of wind mapping in Nepal (2015-2018) which is being done in collaboration of World Bank, AEPC, Technical university of Denmark, Wind power Nepal

Pvt. Ltd., government of Nepal should invest heavily in wind power development. GOV. of Nepal should work in combination with World Bank as it is willing to develop wind power equivalent to 100 MW in possible areas having highest possibility of wind in terms of wind speed, air density, humidity, pressure and wind direction.

iv) One solar panel for single citizenship

Government policy of one PV solar for one house is the main obstacle. The main reason behind it is; there are many families residing in the same house where they are not divided socially but are separated legally or vice-versa. Thus, one of the families would like to have solar panel but other is not willing to do so or both of them are willing to install solar panel. However, according to the rules and regulations of government of Nepal there can be only one solar panel in one house, if a particular house owner wants to be eligible for subsidy program. So, there could be rapid development of PV solar if government of Nepal implements the policy of "One solar panel for single citizenship."

v) Micro Financing

In order to improve everyone's access to renewable energy technologies, provision for financing services (soft loans) should be made available. To fulfill the credit requirement of the rural people with fewer hassles, micro finance institutions should be established in target areas which will reduce the time needed for debt management. Furthermore, poor people who usually hesitate to deal with big financial institutions may find it easy to deal with micro finance institutions like cooperatives. [39]

vi) Awareness Program

To develop RETs as a viable and sustainable option for developing countries like Nepal, it is important to educate the people about the potential economic, health and environmental merits of renewable energy. There is a need to develop programs that bring awareness and disseminate knowledge to a wide audience through a variety of mass media and multi-stakeholder dialogues.

vii) Augmented effort for Biofuel

Nepal has limited arable land which has been aggressively utilized for food, feed and other commercial crop cultivation. So, it is not possible to allocate arable land for large scale cultivation of energy crops like 'Jatropha' as practiced in neighboring countries like India and China. To avoid any kind of conflict from the beginning, wasteland suitable for Jatropha plantation should be officially declared by the local authorities with the support of GIS maps and local expertise in a participatory and transparent matter. [36] Such biofuels could serve as the best alternative to kerosene or diesel in villages and can be used for running a

generator for lightning or irrigation pumps or agro-processing mills in average for 2-3 hours per day.

viii) Cost assessment of Renewable energy technologies

Comparative analysis of cost should be made on the basis of levelized social costs of electricity. [40] The levelized cost of electricity includes the negative externalities (external costs) such as the costs of greenhouse gas emitted. While levelized social costs provide a level playing field for cost comparisons; a potentially complicating factor would be the right price of carbon which tends to vary across studies. [41]

ix) Designing cautious subsidies

The Nepalese subsidy scheme for solar PV is quite attractive when compared against direct subsidies provided in other growing economies like China, Sri Lanka and Indonesia. [42] As a step further, the government can also experiment with consumption based subsidies together with the existing investment based subsidies to encourage the consumption of energy from renewable resources. Experiences from the US and Europe (in particular Germany and UK) demonstrate that feed-in tariffs (FIT) (i.e. paying consumers for the green energy they generate) can be an attractive cash-back mechanism for local and national governments to spur development of renewable energy. [43]

x) Efforts for development for roof top Photovoltaic solar panels

a.) Government support to grid connected solar PV without battery backup should be limited to maximum daytime shortage only. Any other additional incentives will not be productive because most of daytime electricity will be wasted.

b.) Encouraging homeowners to install battery with capacity to handle at least four hours of house load can shift peak load demand significantly to solve power shortage problem. It will reduce peak time household load demand significantly.

c.) Differential pricing of electricity according to demand and supply ability can dramatically shift load demand.

7. Environmental Impact Assessment (EIA) In Nepal

As shown in Figure 3, as soon as the EIA is deemed necessary for any particular project; different steps such as scoping, terms of reference up to final EIA document submission is done with an active public participation along with other relevant stakeholders. Review of EIA is done both by public and EIA expert and the final decision is made by Ministry of Science, technology and environment (MOSTE). If EIA is approved, then the project is implemented otherwise EIA needs to be redesigned. Finally, monitoring and evaluation will be done by the allocated auditors which will provide necessary feedback to the proponent which will serve as input for initiation of new proposal.

According to Environmental protection rules, 2054 (1997), some of the projects under water resource and energy sector that does require EIA are as follows:

- Supply of electricity through installation of transmission lines of more than 66KV capacity.
- Operation of more than 6 MW (mva.) Rural electrification.
- Operation of electricity generation projects with a capacity of more than 50 MW.
- Generation of more than 1 MW diesel of heat electricity.
- Any water resources development activity which displaces more than 100 people with permanent residence.
- Construction of multipurpose reservoirs.
- Inter-basin water transfer and use.

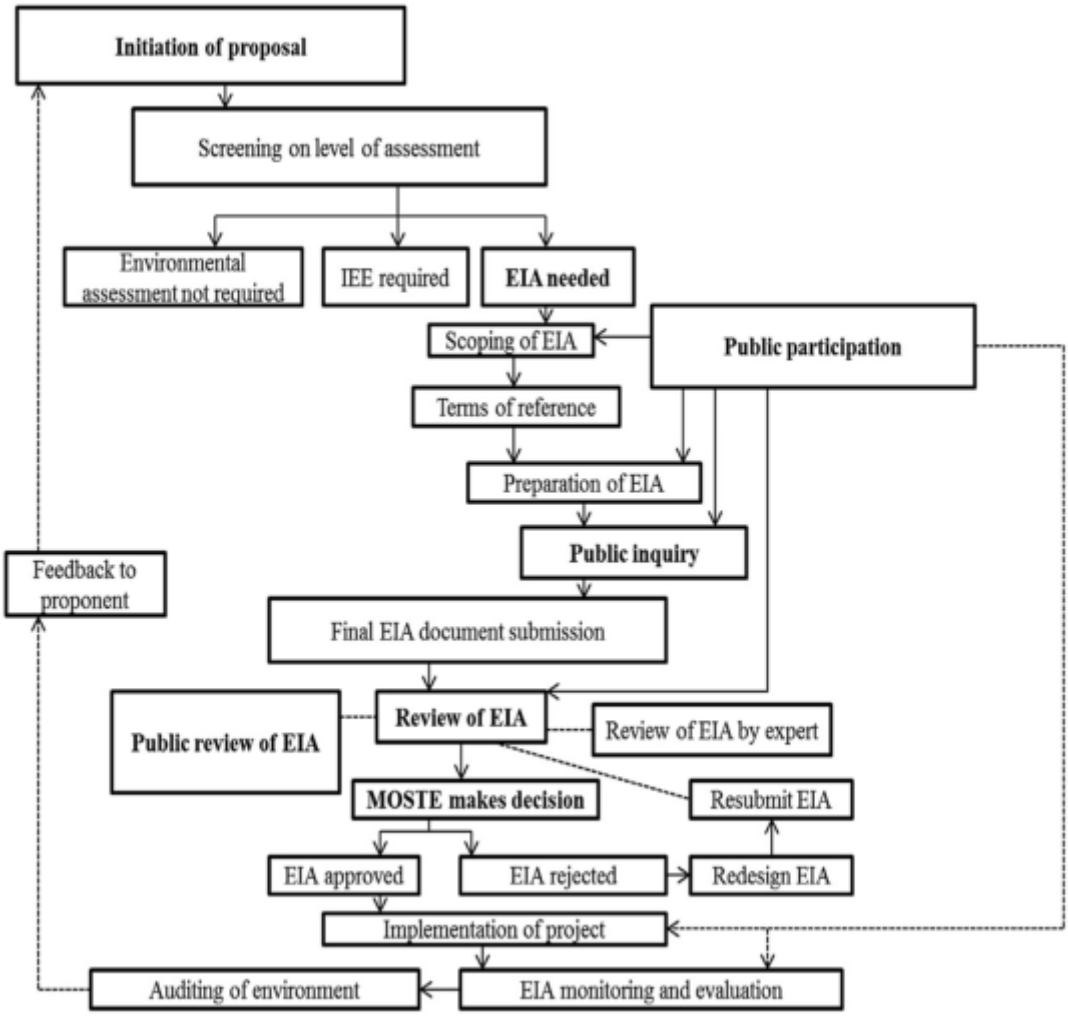

Figure 3:Schematics of EIA Process in Nepal [44]

7.1 Misconceptions about EIA

There are various misconceptions about EIA which is shown in figure 4. It is in fact very effective tool for sustainable development and acts as preventive tool for forthcoming damages. There are various examples of hydropower projects in Nepal that has been cancelled because of outcomes depicted by EIA. So, it can be concluded that it does delay projects but proves extremely beneficial for socio-economic development of local community as well as for the local ecosystem and environment.

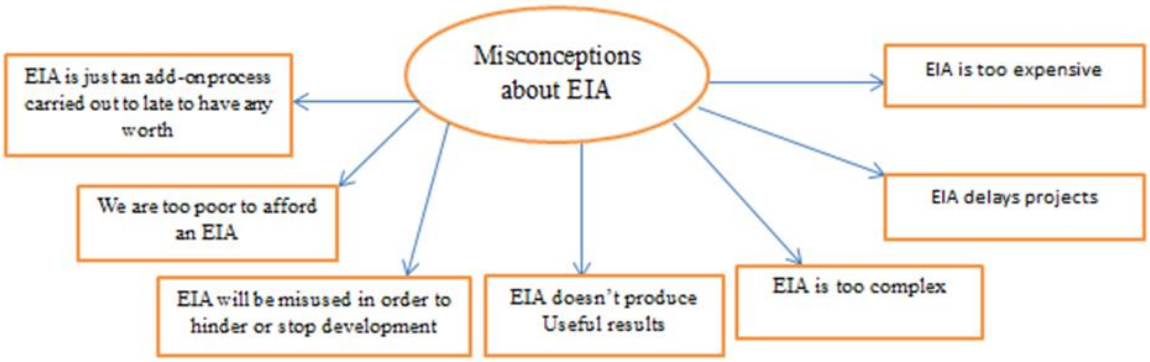

Figure 4: Misconceptions about EIA[45]

7.2 Initial Environmental Examination (IEE) in Nepal

Usually Ministry of science, technology and environment (MOSTE) is the responsible authority for approving EIA, whereas the relevant agency or line ministry is in in charge of making decisions regarding IEE. [5] Thus, IEE is comparatively simpler than EIA. As shown in figure 5, for a project that requires IEE; there is announcement of 15 days public notice by the proponent which is followed by determination of scoping report by MOSTE. Terms of reference is then approved for IEE by the relevant agency which is then used to prepare IEE report. This report is open for public for 15 days and a report is then submitted to the relevant agency with a recommendation letter from V.D.C or municipality as per necessity. Finally, IEE report is approved by the relevant agency within 21 days after its submission.

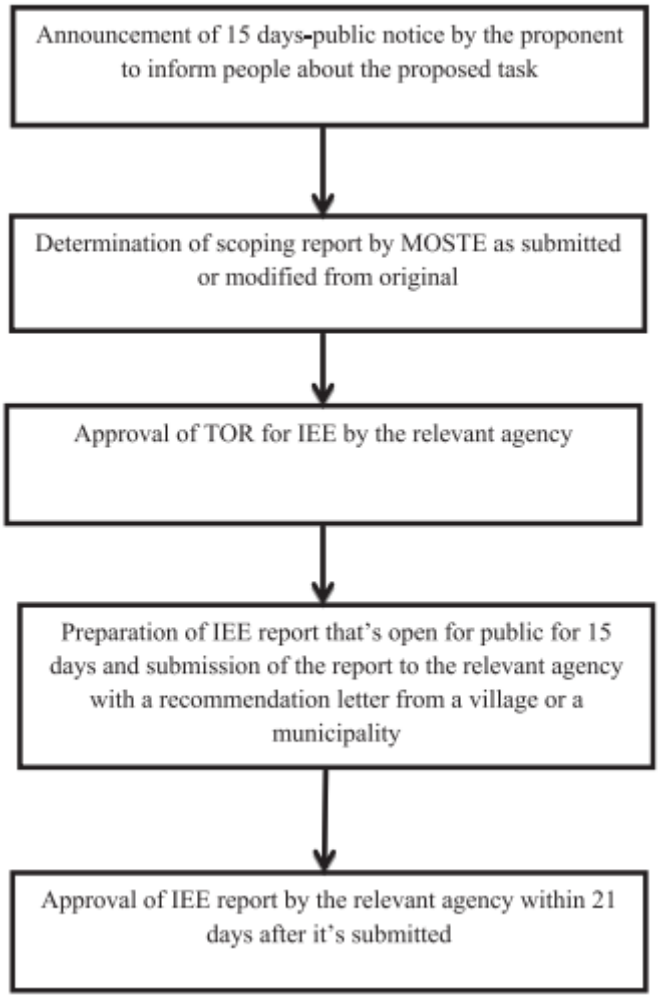

Figure 5: IEE process in Nepal [46]

8. Challenges In EIA

i) Nepal has not introduced the concept of accrediting the experts and consulting firms to prepare the EIA report. Experiences from review of various EIA reports reveals that any person can prepare such report and hence, the quality of EIA report is still in doubt.

ii) The relevant agencies responsible for environmental monitoring are not adequately addressed with the importance of EIA study, so monitoring aspect is totally neglected.

iii) Ineffective incorporation of recommendations from EIA report into design and contract documents.

iv) Public hearings are never conducted during EIA report preparation. Any hearings that may be conducted are held after the completion of the reports to seek letters of support from village officials, which have created obstacles for affected stakeholders to contribute in an EIA study. [46]

v) Main problem for initial phase of EIA is consultation with different departments which is time consuming and cumbersome procedure. For example: In case of hydropower, main departments that are involved in the preparation of EIA are Ministry of science, technology and environment (MOSTE), Ministry of Energy, Ministry of Forest, Nepal electricity authority etc.

vi) Unlike air, water and noise quality, which can be assessed against established standards; the socio-economic impacts do not have standard scale and are difficult to rank. Thus, importance weighting of socio-economic impacts are commonly determined by the consensus obtained from the interaction with the local people, agencies, NGOs and experts which can easily be manipulated. [2]

vii) In the process of EIA of a development project, many impacts are usually identified; some of them are significantly detrimental or beneficial but most of them are insignificant in terms of their severity, albeit, they are equally treated and wrongly predicted. In such circumstances, the project proponent faces dilemma as to where to place more resources and efforts in order to minimize the detrimental effects or to enhance beneficial effects of project implementation. Therefore, categorization of impacts in terms of severity is more desirable. [47]

vii) Impact prediction is done tentatively and may not be true every time and may prove wrong. Unlike IEE, in which impact and mitigation are already known, there are unseen problems for EIA within the project that could be beyond our imagination and most of the things are unknown[11].

viii) EIA reports are written in the English language which local people cannot understand. Thus, this prevents local people to have their opinion on the development projects at different steps of EIA preparation. [48]

[11] On the basis of meeting with Prof. Dr. Ram bahadur khadka.

9. Recommendation for effective Implementation of EIA

All possible impacts of the project activities caused environmental stress which could be properly managed or mitigated as per the nature, magnitude and duration of the impacts by adopting policy and legal instruments in EIA practices. The major point to be highlighted in the policy and legal instruments towards effective implementation of EIA system are highlighted as follows:

- In the context of Nepal, every ministry should have environment commission, similar to Bhutan so that EIA procedure is less cumbersome[12].

- For an effective implementation of EIA, there should be one window approach ("Ek dwar pranali") where different ministry can collaborate effectively and efficiently[13].

- There must be strategic EIA in Nepal which necessitates amendment in the obsolete policies responsible for directing plans and programs. Thus, there should be some changes in environmental policies like environmental protection rules, 2054, environmental protection act, 2053 etc.

- Recently, there is a provision of recruiting 'environmental inspector' at Department of environment who could play significant role in the monitoring and evaluation aspects of different development projects. Thus, strengthening human capacity at such departments and ministries like Ministry of Science, technology and environment (MoEST) could be beneficial for effective implementation of EIA.

- There is a committee in India that monitors EIA and IEE and the responsible authorities are experts in their respective fields. Thus, similar kind of National accreditation board or committee should be formed in Nepal[14].

- There should be decentralization process of environmental administration at district development committee (DDC) in Nepal. Capacitating the DDCs in terms of both technical and financial resources is of paramount tasks to be addressed at first. The establishment of *Environmental Sub-Committee (ESC)* and the *Environment Unit (EU)* at DDCs is a key for effective and proper implementation of environmental

[12,14] On the basis of meeting with Prof. Dr. Ram bahadur khadka.
[13] On the basis of meeting with Mikesh joshi who is design engineer at Upper Tamakoshi hydropower Ltd.

powers allotted by Ministry of Science, Technology and Environment (MoEST). [49] The interrelationship among DDC, EU and ESC has been illustrated in figure 6.
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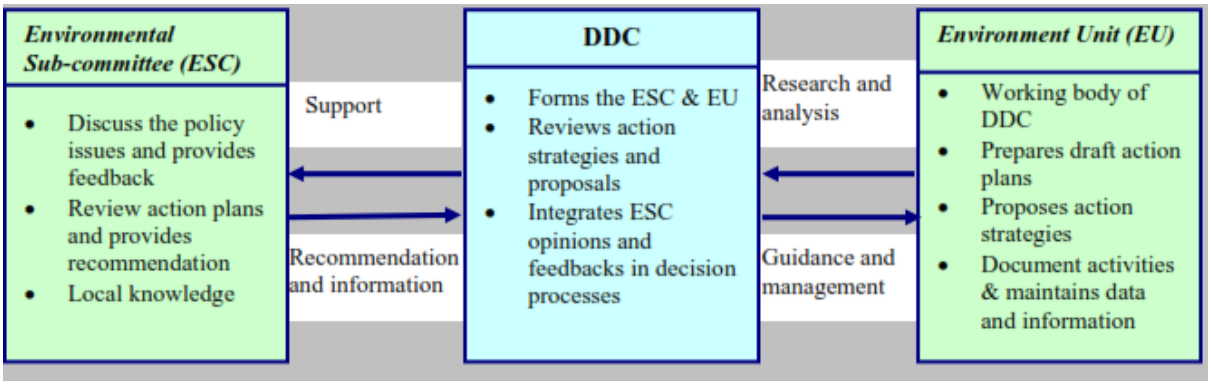

Figure 6: Interrelationship among DDC, EU and ESC [49]

Furthermore, the role of both ESC and EU has been clarified in figure 7. As depicted in figure 7, the role of ESC shall be of advisory nature whereas the role of EU is to implement all the environmental activities and programs at DDC. For example, in case where the environmental complaints are received by DDC, the EU of DDC shall be responsible for the documentation and verification of the particular complaints and it prepares the plan of action for DDC. Next, the DDC, by seeking the opinion of ESC on the matter, shall take the necessary action.

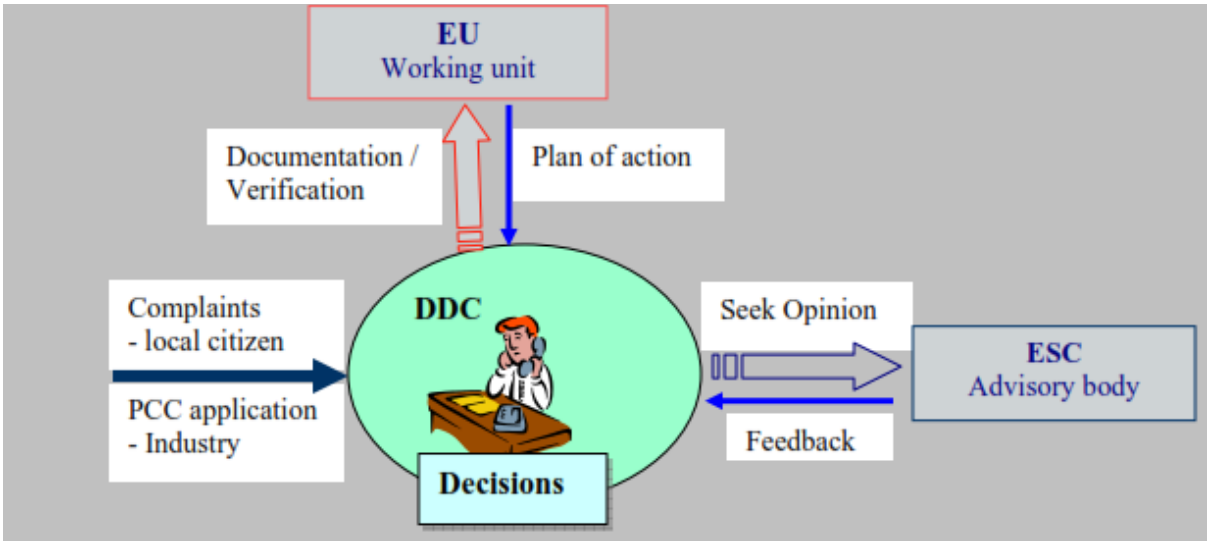

Figure 7: The role of EU and Esc at DDC [49]

An overview of DDC environmental administration has been shown in figure 8. As shown in figure 8, MoEST directs Ministry of Local development (MLD) which then provides provision to form committees at DDC according to Local self-governance act 1999. Thus, at first, DDC addresses public concerns as per rule 16 to rule rule 20 of environmental protection regulation 1997, and consequently performs verification and assessment via support of EU. Finally, actions are executed by DDC after necessary advices and recommendations from ESC. This system has already been implemented in six districts of Nepal namely Morang, Sunsari, Ilam, Jhapa, Panchthar and Dhankuta and needs to be replicated in other districts as well. This will drastically reduce the ambiguity for EIA.

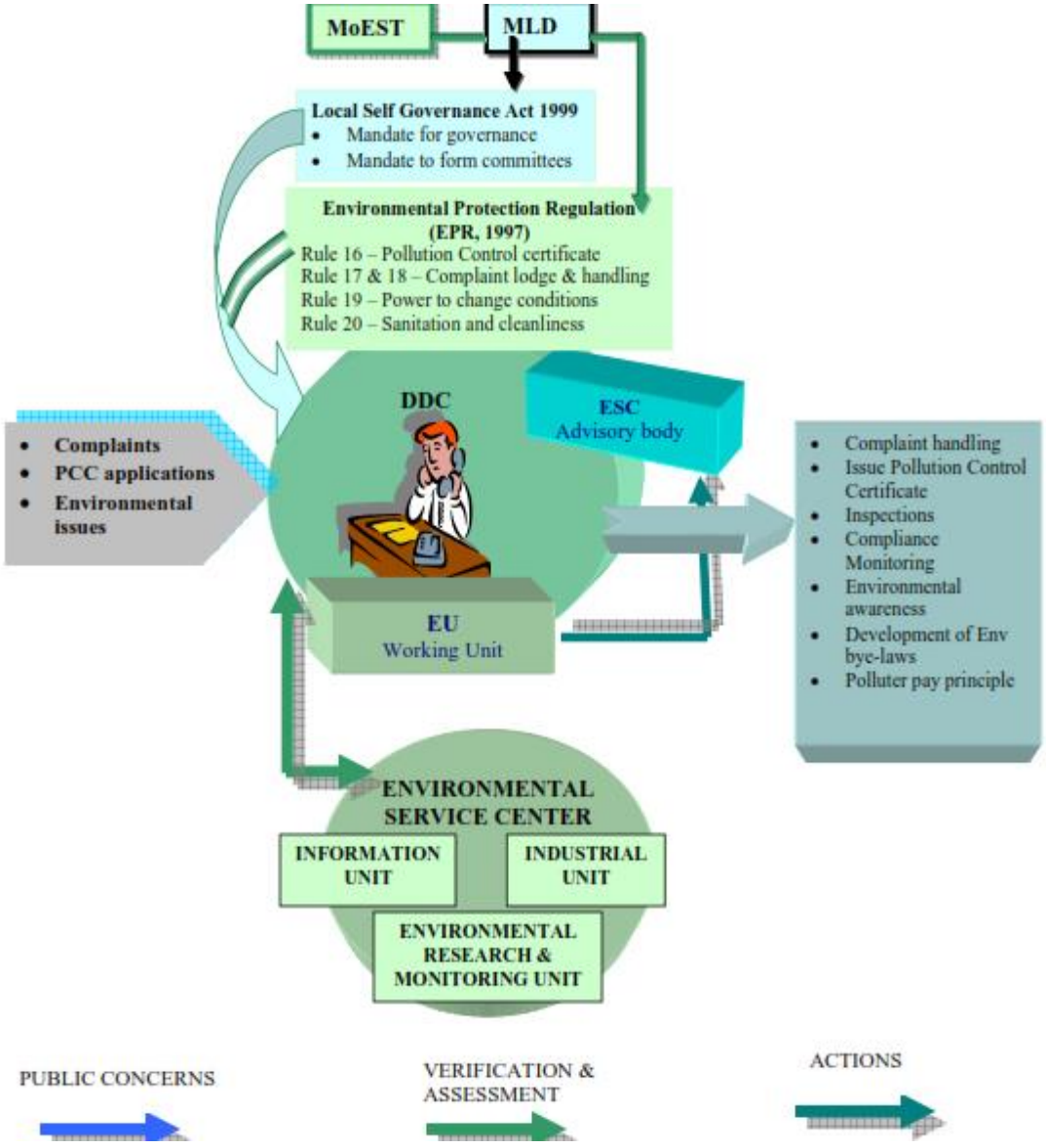

Figure 8: DDC Environmental Administration Overview [49]

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Appendix 1: Summarization of Meeting

1. Meeting (Date: 29/06/2015)
   Name of the person: Mikesh Joshi
   Position: Design engineer at Upper Tamakoshi Hydropower Ltd.
   - The estimated cost of this project is approximately 8 Crore/MW i.e. around $800/KW. (The project once completed will generate 456 MW of Electricity)
   - The total cost of EIA was 2.5% - 5 % of total cost.
   - During the entire period of EIA, the deforestation was one of the main challenges and thus reforestation had to be done in the vicinity of the project. In addition to this, other areas of concern were vegetation, wildlife, aquatic life, displacement of village, compensation to the land owner etc.
   - Main problem is construction of Upstream and downstream dam that could create some problems which are as follows:
     a) Harm to aquatic life where the fish from downstream dam cannot go to the upstream dam and vice versa. Thus, solution is construction of fish ladder that could solve this problem and thus would eventually help the local fisherman whose livelihood is dependent on fishing.
     b) Possibility of Reduction in natural water flow from upstream dam to downstream dam. (There should be 10% environmental flow of water, if dam is constructed). Water dissipates through the cracks and goes to the agricultural land via rock which will assist for agricultural productivity. So, if this natural flow is disrupted then the local people in the vicinity will be affected.
     c) For example: In case of Kulekhani I (60 MW) and Kulekhani II (32 MW), there was humidity problem in the surrounding area because of Indrasarowar Dam. This is because of higher rate of water vaporization which consequently increases the humidity of the environment. Thus, end result was excessive fog formation and visibility problem.
     d) Main problem for initial phase of EIA is consultation with different department which is time consuming and cumbersome procedure. Main departments that are involved in EIA of hydropower are Ministry of science, technology and environment, Ministry of Energy and Ministry of Forest, Nepal electricity authority etc. Hence, for effective implementation of EIA, there should be one way approach (Ek dwar pranali) where different ministry can collaborate effectively for such methodology.

2. Meeting (Date: 06/07/2015)
   Name of Organization: People, Energy and Environment Development Association (PEEDA)
   Name of the person: Shalabh Poudel
   Position: Program officer, Former Fellow at Daayitwaa-Nepal
   Topic of discussion: Bio-diesel from Jatropha
   - His organization is doing research on Bio-diesel from jatropha at Okhaldhunga. The findings of research are positive and villagers seem satisfied as plantation of Jatropha at abandoned lands have reduced the possibility of landslides and had improved the water retention capacity of soil.
   - He has proposed me possible site visit most probably after 1 month.
   - There is no such transesterfication plant at Okhaldhunga.
   - The quality of seed seems comparatively good but needs to be dried before expelling.
   - Country like Nepal or in other words third world country is only place for experiments for International Donor agencies.

3. Meeting (Date: 09/07/2015)
   Name of the organization: Wind power Nepal Pvt. Ltd.
   Name of the person: Kushal Gurung
   Position: Chief executive Officer

   - According to him, US designed vertical wind-solar hybrid system will be introduced in Nepal in the upcoming winter season. It will be used for household applications.
   - For optimum output of wind turbine, wind speed of 12-15 m/s is essential whereas for commercial operation, wind speed greater than 6 m/s are necessary. However, for household application wind speed of 4-5 m/s is enough.
   - Wind mapping in Nepal is mainly done in three phases in which first phase includes mesoscale modeling using satellite which has already been started by Technical university of Denmark (one of the partner agencies) from March 2015 and will last till November 2015. After this initial phase, second phase will run for minimum 2 years that will include ground based data collection via various instruments like anemometer for wind speed and direction and many others like air density, humidity at different possible locations identified from first phase. Finally after 2 years, the data will be validated and matched which will consequently lead to the production of validated wind resource atlas.

- There will be higher possibility of wind power development in Nepal after this wind mapping. World Bank itself can invest for project of 100 MW in Nepal.

- Total wind power capacity of Nepal is 3000 MW in which Annapurna region i.e. Mustang area has possibility of 700 MW.
- "Energy policy in Nepal is only hydro policy". Alternative energy promotion center (AEPC) is flexible to provide license but Nepal electricity authority (NEA) is not willing to buy electricity generated from wind power. NEA has monopoly in power production, power purchase and its distribution. Thus, it's difficult for other renewable energy technologies to enter into the energy market of Nepal.

4. Name: Prof. Dr. Ram Bahadur khadka
   Position: Principal of School of Environmental science and management (SchEMS)
   Date of Meeting: 09/08/2015

   There are no accrediting agencies in Nepal related to EIA and IEE. Earlier when he was preparing EIA report of Indrawati III (7.5 MW), there was provision of EIA report preparation for hydropower project of more than 5 MW but at the moment, it is only necessary for project more than 50 MW. There are some investigations for determination of significance of socio-economic impact to some extent but is not followed entirely. There are physical, biological and socio-Economic impact analysis of different development projects where there are 100 of sectors to be considered and the screening is to be done at scoping phase. Impact prediction is done tentatively and may not be true every time and may prove wrong. However, after necessary significance analysis, different impact must be addressed. The one having adverse effect should be tackled with implementation of resources and the other having beneficiary effect needs to be enhanced. The total cost of EIA of different development projects ranges from 1-7% (International practice) of the total cost and that of Melamchi is 7% which is indeed more than average. He suggested me field visit to Bhotekoshi so that mitigation can be monitored. There are not remarkable improvements in the sector of EIA even after 17 years. Majority of countries in south Asia have similar kind of problems but India has comparatively better EIA system where both comprehensive (brief) and rapid EIA is done depending upon the project. In case of Bhutan, every ministry has environment commission and thus the process is simple and less cumbersome whereas in Bangladesh initially IEE is done and then only EIA is executed if it is thought to be necessary. The projects having red mark are directly implemented for EIA. However, the one having green undergoes IEE and later it is determined whether EIA is necessary or not. There is a committee in India

that monitors EIA and IEE and the responsible authorities are experts in their respective fields.

There must be strategic EIA in Nepal. There must be change in the policy level because plans and programs are directed by policy. There are some voices being raised to change environmental protection act as well as environmental protection rules. For example: 10 % water discharge in the downstream of hydro-power project is perfect example in the policy level that ensures that the vegetation, irrigation in the downstream remains unaffected. So, he focuses if there are some provisions in the policy level then it becomes easier in the execution as well as monitoring level. In case of IEE, impact and mitigation are already known whereas in case of EIA, there are unseen problems within the project that could be beyond our imaginations and most of the things are unknown. Recently, there is a provision of environmental inspector which could play significant role in the monitoring and evaluation aspects of ongoing project. In case of upper tamakoshi, there is possible danger that cho-rolpa Taal might burst thereby destroying entire hydropower project.

5. Name: Er. Bikrant Bikram Chand
   Former Position: Environmental Monitoring expert at Strengthening of environmental administration and management in Nepal (SEAM-N)
   Current Position: Managing director at Eco Nepal Consultancy
   Date of Meeting: 16th of August, 2015

   - He told me that, there are no criteria and standards for impact analysis of EIA. Majority of reports are copied from other report. For example: If EIA for any road construction project needs to be prepared then the reports are copied from EIA of hydro-power plant and vice-versa.
   - In the context of Nepal, there must be decentralization process of environmental administration at district development committee (DDC) via formation of environmental unit (EU) and environmental sub-committee (ESC). This system has already been implemented in six districts of Nepal namely Morang, Sunsari, Ilam, Jhapa, Panchthar and Dhankuta and needs to be replicated in other districts as well. This will drastically reduce the ambiguity for EIA.
   - There are no accrediting agencies for both EIA and IEE.

Appendix 2: Summarization of Telephone Conversation

1. Telephone conversation (Date: 30/06/2015)

   Name of the person: Aruna Awali
   Position: Meteorologist at Alternative Energy promotion center (AEPC)
   - In the present context, it costs around 5.5 lakh-6 lakh/KW for wind power generation in Nepal.
   - For wind turbine < 1 MW, it is not necessary to study wind pattern at certain locality for 10 years (normally required for wind turbine >1 Mw), rather data of 1-2 years is more than enough.
   - For wind turbine < 1 MW, it is also not necessary to do EIA and IEE. However, certain risk assessment can be done but it is not obligatory. Thus, ongoing and already finished projects are deprived of such provision.
   - One of the projects is on the research phase at Tanda of Mustang where 50 m tower has been established.
   - One of the difficulties that Nepal is currently facing is inaccessibility to the potential sites that promises higher possibilities of wind power generation is because of poor infrastructure development and extreme geography.

2. Telephone conversation (Date: 30/06/2015)
   Name of organization: Wind power Nepal
   - Nepal wind mapping is ongoing project which will start from November 2015 and will last till 2018. This is a project that will choose different locations in Nepal and will measure wind velocity with the help of anemometer. Furthermore, they will measure weather pattern on regular basis. The data thus collected will be reviewed by technical university of Denmark which is funding this project.
   - Rooftop wind-solar hybrid system is in research and experimental phase. They are planning to commercialize this system only for large scale projects rather than focusing on small scale residential projects.

3. Telephone conversation (Date: 01/07/2015)
   Name of the person: Rajeev Shrestha (Wind engineer at Alternative energy Promotion center)
   Position: Wind Engineer at Alternative energy Promotion center (AEPC)
   E-mail: rajeev.shrestha@aepc.gov.np

- With an initiative of Nepal Government and AEPC, there are three ongoing wind-solar hybrid projects specifically 31 KW at Kamalbazar (Achham), 7 KW at Surkhet and 12 KW at Dhaubadi VDC (Nawalparasi) in which the earlier two projects are on the process of bidding and are expected to complete within 4-5 days.
- One of the projects of 26 KW has been completed recently at Tatopani of Jumla which was executed by AEPC.
- Another ongoing project is also hybrid system (10 KW wind and 15 KW solar) which is funded by Asian development bank (ADB).
- Wind mapping in Nepal was done from 2006 – 2007 which was named as SWERA Project (The solar and wind energy resource assessment), done in collaboration by AEPC with the government of Denmark.
- The new project on wind mapping in Nepal will be implemented from November 2015 till 2018 in collaboration of wind power Nepal, AEPC and Technical University of Denmark. Methodology for such wind mapping includes installation of tower (80m high) which will collect data of parameters like wind speed, wind direction, air pressure, humidity etc. over the estimated time period. The data thus obtained will help concerned authorities to decide further about the wind power project. Government of Nepal is thinking of constructing large wind power projects (>= 1 MW) after the completion of this wind mapping project. Thus, future of wind power in Nepal looks promising and pragmatic.
- He told me that during the dry season in Nepal (Mangshir to Chaitra); wind speed is higher and continuous. The main reason being cold air denser than hot air which will consequently increase the rotation of turbine blades (Power of wind = $\frac{1}{2} \rho A V^3$). Thus, wind power can be an effective alternative to hydro power especially during dry season as the water flow in the river is low which in turn has been producing lower hydroelectric power.

4. Telephone conversation (Date: 07/07/2015)
   Name of the company: Dibya Urja Pvt. Ltd., Narayangopal Chowk
   Topic of the conversation: subsidy program on Roof-top Photovoltaic Solar by Gov. of Nepal

   One of the personnel told me that government of Nepal (AEPC) is providing subsidy of Rs. 15,000 on installation of solar panels even in urban areas and also loan without any mortgage with minimum interest. Furthermore, the loan can be repaid on installment for 5 years. According to him, the cost of solar panels (mostly imported from China) is in decreasing trend but other components like battery, charge controller etc. is in increasing trend.

When I asked him about the problems that are hindering development of PV solar in Nepal, he told me that government policy of one PV solar for one house is the main obstacle. The main reason behind it is, there are many families residing in the same house where they are not divided socially but are separated legally. Thus, one of the families would like to have solar panel but other is not willing to do so or both of them are willing to install solar panel. However, according to government of Nepal there should be only one solar panel in one house. That is why, he suggests me that government should implement the policy of one solar panel for single citizenship which will flourish the development of solar power in Nepal.

What do you think about the Inverter and its excessive power consumption from the national grid in order to compensate its inherent losses which have been proving detrimental to load shedding?

- He told me that, Nepalese market has already introduced hybrid inverter system that do charges from solar when there is sunlight and when there is no sunlight, they do charges with the power from National grid. This system is designed for minimum inherent losses and is thus more expensive than the local inverters with higher losses. Hence, people are reluctant to invest on such hybrid inverters but in reality they are paying more electricity bills because of higher power consumption (charging) by the local inverter in comparison with discharging.

Appendix 3: Summarization of E-mail conversation

1. Company: Wind power Nepal Ltd. (July 2, 2015)

Name: Kushal Gurung

Position: Chief executive officer

Specialization: carbon trade

The detail e-mail with questions and answers is shown below:

-What is the cost of wind power production in Nepal in terms of Per KWh?

This depends on location (e.g. how windy, how isolated or far, labour charge). Per KW wise it would be around 1.5 lakhs to 3 lakhs per KW, depending on standalone captive generation or microgrid for community electrification. (This information is in controversy with the

information provided by Aruna Awali of AEPC because she told me that it costs around 5-6 lakh per KW for wind power production. So, need to be discussed.

- Can you please explain in brief about the Nepal wind mapping that is

supported by Technical university of Denmark? (2015, November-2018)

Please find attached the ToR. For further discussion you may visit our office next week. Please give me two days prior notice.

-What are the possibilites of CDM for Wind power technology in Nepal?

CDM is sort of dead, i.e. Cost of CDM project development outweighs the cost of CERs generated. However, there could still be market for Voluntary Carbon Market.

-What will be the possibility of Rooftop wind-solar hybrid system in Nepal?

Yes, we believe there is good possibility, esp in certain pockets like Nagarkot, Bhedetar, Ilam or any Hill top resorts or villages, even high raise buildings in Kathmandu. We are planning to introduce a latest US designed vertical wind-solar hybrid system.

- Are there provision for Environmental assessment for wind power technology in Nepal?

None that I am aware of.

Last but not the least, I would like to know whether there is training for low carbon development or not? I would be grateful if you could provide information and would be happy to meet personally if necessary.

No we don't run standard training; we only provide bespoke training on demand.

2. Company: Gham Power Pvt. Ltd. (Date: June 25, 2015)

Name: Subash Pandey

Position: Project Engineer

According to him, solar installation cost is generally measured at per watt of solar panels installed. The cost for urban area would be around at 1.8 $ to 2.1 $ per watt for battery less system and around 3.5 $ to 4 $ for battery based system. For rural area add 1$ per watt on all cost. I met him at GIZ office in khumaltar where there was meeting of return experts from Germany and was held at 12th of June, 2015.

3. Name of Institution: School of Environmental Science and Management (SchEMS)

(Date: June 23, 2015)

Name of the person: Dr. Ram Bahadur Khadka

Position: Principal of SchEMS

Dear chand ji,

You can consult my book entitled

Environmental Impact Assessment; methods, process, procedures in south Asian countries published by SchEMS. We can meet, if you call me on 9851051457.