WATER RESOURCE POTENTIAL AND SOCIO-ECONOMIC IMPACT ASSESSMENT OF THE PROPOSED UPPER KARNALI HYDROELECTRIC PROJECT, NEPAL

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LETTER OF RECOMMENDATION

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The thesis bears the candidate's own effort and is not submitted for any other degree before.

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LETTER OF APPROVAL

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ABSTRACT

Karnali river has the largest potential for hydropower generation in Nepal with an estimation of economically exploitable potential of 24,000MW. There are seven mega projects in the pipeline of feasibility study and construction. Among them, the proposed Upper Karnali Hydroelectric Project is the one. GMR-ITD Consortium has been awarded the project on BOOT basis for a period of 30 years from the issue of generation of license (2008). It is an export oriented project for power transmission to India.

The secondary data of daily discharge and precipitation of latest 33 years (1978-2010) at hydrological station no. 240 (Asaraghat) were processed and flow duration curve for the proposed dam site was constructed. The theoretical hydropower potential with $Q_{40\%}$ design discharge, 85% overall efficiency and 150.11m net rated head was calculated as 549.63MW. This much of capacity will be produced only for four months i.e. from June to September when the project is operated 24 hours daily. However, the developer proposed to harness firm capacity of 900MW from the project. It is only possible when the developer design the project with $Q_{29\%}$ design discharge and 92% overall efficiency. In that case also, such amount will be produced only for two months. The developer applied optimization with peaking provision for 3.26 hours daily.

General physico-chemical parameters were found in normal range for aquatic lives. In fact, the river is snow-fed with high turbulence and there is no any industry and ore extraction site in the upstream. However, pH value recorded in post-monsoon was abruptly increased to 9.7. Similarly, the concentration of DO was found greater than that in other normal rivers reaching up to 12.89 mg/l during post-monsoon. The density of microbial organisms such as *E. coli* and normal coliform were found significantly (*E. coli* $\geq$98cfu/100ml and normal coliform >300cfu/100ml) in all sampling sites during post-monsoon.

For socio-economic data analysis, 70 households of the project affected families (PAFs) were randomly selected. Field observation, key informant interviews and group discussion with the severely project affected families (SPAFs) were conducted for primary data collection while the secondary data were collected from published and unpublished documents. Impact evaluation was carried out in accordance with the National EIA Guidelines, 1993. The project would directly affects 236 HHs out of which, 55 HHs would lose their houses and other physical infrastructures and 184 HHs would completely lose their agricultural lands. There would be changed the land use pattern of about 254.8 ha. Since the river flow pattern from the dam site to the powerhouse site alters after construction of the dam, the fisheries communities such as Majhi, Badi and other marginalized groups would face hardship in their livelihood.

Key words: *firm capacity, water quality, PAFs, SPAFs, impact evaluation*

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ABBREVIATION

AD -	Anno Domini (Christian Calendar to show particular no. of year)
APHA -	American Public Health Association
BOD -	Biological Oxygen Demand
BOOT -	Build, Own, Operate and Transfer
CBS -	Central Bureau of Statistics
CDES -	Central Department of Environmental Science
cfu -	Colony forming unit
cumec -	Cubic meter per second
DDC -	District Development Committee
DEM -	Digital Elevation Model
DFS -	Detailed Feasibility Study
DoED -	Department of Electricity Development
DPR -	Detailed Project Report
EIA -	Environmental Impact Assessment
EL -	Elevation
EMP -	Environmental Management Plan
EPR -	Environmental Protection Rules
GMR -	Gandhi Mallik Arjuna Rao
GoN -	Government of Nepal
GIS -	Geographical Information System
GPS -	Geographical Positioning System
GWh -	Giga Watt-hour
ha -	Hector
HEC -	Hydrologic Engineering Centre
HEP -	Hydroelectric Project
HMG -	His Majesty's Government of Nepal (Now GoN)
HMS -	Hydrologic Modeling System
ITD -	Italian Thai Development Public Company Limited
IUCN -	International Union for Conservation of Nature and Natural Resources (Now World Conservation Union)
KIRDARC -	Karnali Integrated Rural Development and Research Centre
KWh -	Kilo Watt-hour
masl -	Mean average sea level

MCM - million cubic meters
MDDL - Minimum draw down level
MHSP - Medium Hydropower Study Project
MoE - Ministry of Energy
MoSTE - Ministry of Science, Technology and Environment
MoU - Memorandum of Understanding
MoWR - Ministry of Water Resources
MU - Mega unit
MW - Mega Watt
NAST - National Academy of Science and Technology
NDWQS - National Drinking Water Quality Standard
NEA - Nepal Electricity Authority
NEPAP - Nepal Environmental Policy and Action Plan
NESS - Nepal Environmental and Scientific Services
NHPC - National Hydropower Corporation
NPC - National Planning Commission
NTU - Nephelometric Turbidity Unit
PA - Phenolphthalein Alkalinity
PAFs - Project Affected Families
PDA - Project Development Agreement
pH - Potentia hydrogenii (Chemical unit for acidity and alkalinity)
ROR - Run-of-River
SPAFs - Severely Project Affected Families
T.U. - Tribhuvan University
TA - Total Alkalinity
TDS - Total Dissolved Solids
TS - Total Solids
TSS - Total Suspended Solids
UKHEP - Upper Karnali Hydroelectric Project
UNDP - United Nations Development Program
USD - US Dollar
VDC - Village Development Committee
WECS - Water and Energy Commission Secretariat
WHO - World Health Organization

CHAPTER: I
INTRODUCTION

1.1 Background

Nepal is endowed with abundant fresh water resources from the availability point of view. It has vast network of water bodies consisting of about 6,000 rivers and streams with an estimated total length of some 45,000 km (CBS, 2008). These rivers flow through the high mountains to plain terrain and thus have turbulent and rapid flows. The total drainage area of all rivers that flow through Nepal is about 1, 94,471 km^2, out of which 76% is contained within the country. Among 6000 rivers, 33 rivers have drainage area greater than 1,000 km^2 (WECS, 2002).

In Nepal, there exist three types of rivers based on the nature of their source and discharge. Perennial rivers are in the first category and they originate from the Himalayas and carry snow-fed flows with significant discharge, even in the dry season. These include the Koshi, Gandaki, Karnali, and Mahakali river systems. Mechi, Kankai, Kamala, Bagmati, West Rapti and Babai rivers are in the second category which originate from the Mahabharat Range of mountains and are fed by precipitation as well as groundwater regeneration, including springs. Although these rivers are also perennial, they are commonly characterized by a wide seasonal fluctuation in discharge. The third category of river system includes a large number of small rivers in the Terai, which originate from the Southern Siwalik Range of hills. These rivers are seasonal with little flow during the dry season, but characterized by flash floods during the monsoon (Sharma, 1977; WECS, 2002).

There are four major river systems in Nepal based on the catchment boundary that drain out the country. They are Sapta Koshi river system in the east, Sapta Gandaki system in the central, Karnali system in the west and Mahakali system in the far-west.

1.2 Water Resource Potential

Since the early 20th century, the term water resource potential is exclusively used in conjunction with the modern development of hydroelectric power. In general, falling water is channeled through a turbine, which converts the water's energy into mechanical power. The rotation of the water turbines is transferred to a generator, which produces electricity. The amount of electricity, which can be generated at a hydroelectric plant, is dependent upon two factors. These factors are (1) the vertical distance through which the water falls, called the "head", and (2) the flow rate, measured as volume per unit time. The electricity produced is proportional to the product of the head and the rate of flow. The following is an equation, which may be used to roughly determine the amount of electricity that can be generated, by a potential hydroelectric power site (Dixit, 2002):

$P = \eta\rho Qgh$

Where,

P = power in watts

η = dimensionless efficiency of the turbine

ρ = density of water in kilograms per cubic meter

Q = flow in cubic meters per second

g = acceleration due to gravity

h = height difference between inlet and outlet i.e. head

The water flow in a stream can vary widely from season to season. Development of a hydropower site requires analysis of flow records, sometimes spanning decades, to assess the reliable annual energy supply. Dams and reservoirs provide a more dependable source of power by smoothing seasonal changes in water flow (Dixit, 2002).

1.3 Hydropower in Nepal

Due to steep topography, abundant precipitation and perennial nature of most of the rivers, which originate from the Himalayas and Tibetan plateau, there exists a tremendous hydropower potentiality in Nepal. As per the estimates made by Water and Energy Commission (WECS) based on doctoral thesis of Dr. Hariman Shrestha, the theoretically, technically and economically feasible hydropower potential classified within the major river system in Nepal is summarized as follows:

Table 1.1: Theoretical hydropower potential of Nepal

River basin	Potential in MW		Total
	Major river courses having catchment area above 1000 km^2	Small river courses having catchment areas between 100-1000 km^2	
Sapta Koshi	18,750	3,600	22,350
Sapta Gandaki	17,950	2,700	20,650
Karnali and Mahakali	32,680	3,500	36,180
Southern rivers	3,070	1,040	4,110
Total in MW	**72,450**	**10,840**	**83,290**

Source: NEA report, 2012

Table 1.2: Technically feasible hydropower potential in Nepal

River basin	No of feasible project sites	Technically feasible hydropower potential in MW
Sapta Koshi	53	11,400
Sapta Gandaki	18	6,660
Karnali	30	25,410
Mahakali	41	1,160
Southern rivers	9	980
Total in MW	**114**	**45,610**

Source: NEA report, 2012

Table 1.3: Economically feasible hydropower potential in Nepal

River basin	No of feasible project sites	Technically feasible hydropower potential in MW
Sapta Koshi	40	10,860
Sapta Gandaki	12	5,270
Karnali	7	24,000
Mahakali	2	1,125
Southern rivers	5	878
Total in MW	**66**	**42,133**

Source: NEA report, 2012

The above estimates were prepared on around 1960's period which requires to be updated based on the more accurate present data level.

Despite having a century long history of electricity generation and consumption, half of the population is still deprived from use of electricity and other half is facing long hours of power cut. The 500KW Pharping Power Plant which was commissioned in 1911 is the first hydropower installation in Nepal. The 640KW Sundarijal Hydropower Plant was commissioned in 1936, and the 2.4MW Panauti Hydropower Plant was installed in 1965. The total 92MW Kulekhani (I and II) Hydropower Plant was commissioned in 1982, which is the only project offering seasonal water storage in Nepal. The 144MW Kali Gandaki-A Hydropower Project commissioned in 2003 is the biggest hydropower project in Nepal so far. Most of the Hydropower Plants in Nepal are owned by the governmental agency, the Nepal Electricity Authority (NEA), and most of the projects are designed, constructed and financed by international consultants, contractors with the support from international assistants. However, in the later stage, local capacity is also getting competence on planning, design and construction of hydropower projects. For example, the 22.10MW Chilime hydropower project and 3MW Piluwa project which were designed and constructed by Nepalese engineers and was commissioned in 2003. The projects fund was managed from local financial institutions. A private hydropower developer has started financing in this sector after 1992, when the Government adopted new Hydropower Development Policy and Electricity Act. The total of 174.52MW electricity has been produced by the private sectors and they sell it to Nepal Electricity Authority (NEA report, 2012).

Till now, The Integrated Nepal Power System (INPS) has installed capacity of 705.42MW of which 652MW is hydro and 53MW is thermal. Similarly, out of the current total installed capacity, 555.51MW electricity is produced by the Run-of-River (ROR) system and the rest 92 MW is produced by the Storage type. It has been observed that the average annual growth in peak power is 6.87% and annual energy demand is 10.67%. The system peak demand for fiscal year 2011 was around 1,000MW (NEA report, 2012). As a predominant hydro system, the generation capacity falls to one third of its installed capacity during winter triggering severe imbalance between supply and demand. To meet the deficit demand, Nepal is importing around 100-120MW of power from India from different interconnection points based on bilateral power exchange agreement, under river treaty provisions and under commercial terms.

1.4 The Characteristics of Karnali River Basin

The Karnali river originates from the snow covered glacier near Lake Mansarovar in Tibet, surrounded by high Himalayas with peaks in the basin rising about 7,043 m. The main stream of the Karnali drains the southern flank of the Himalayan range and the central part of the Karnali catchment. It begins as the Humla Karnali in Tibet and flows southeasterly in Nepal until it is joined by the Mugu Karnali which flows in from the east. The river up to this reach is nearly 140 km long and generally flows in a steep gradient of 1:60. It then flows south until it is joined by the Tila river flowing in from the east. The Karnali river in this 82 km stretch between Mugu Karnali confluence and Tila confluence flows with a gradient of 1:170. After Tila confluence, the river flows for 27 km in southwest direction and then turns southeast to traverse 38 km up to the southern end of the Karnali bend at the Lohare khola confluence. The grade of Karnali in the stretch between Tila and Lohare khola confluences is nearly 1:400 (Pun, 2008).

The river makes a big loop in its lower reach starting from a place called Asaraghat. From here, the river flows in the south-east direction for about 25 kilometers, after that it turns 180 degree through a 5 km wide loop to flow northwest traversing about next 29 km to Tallo Balde. The Karnali then turns west to the Seti river confluence and loops back to the east where it is joined by the Bheri river. It then flows south via. Chisapani (from that point, the river flows to the plain area) and joins with Sarada river at Bramhaghat in India where it is known as Ghagra river, a tributary of the river Ganges (Pun, 2008).

The Karnali river Basin is the second largest river system in Nepal after the Koshi basin. The watershed divide of the Karnali river is marked by the international boundary with China and India. The total catchment area of the river is 1, 27,950 km^2 out of which 57,500 sq. km^2 is in India, 68,000 km^2 in Nepal and remaining 2,450 km^2 in Tibet. The catchment area includes snow-fed area of 5,608 km^2 and rain-fed area of 15,850 km^2.

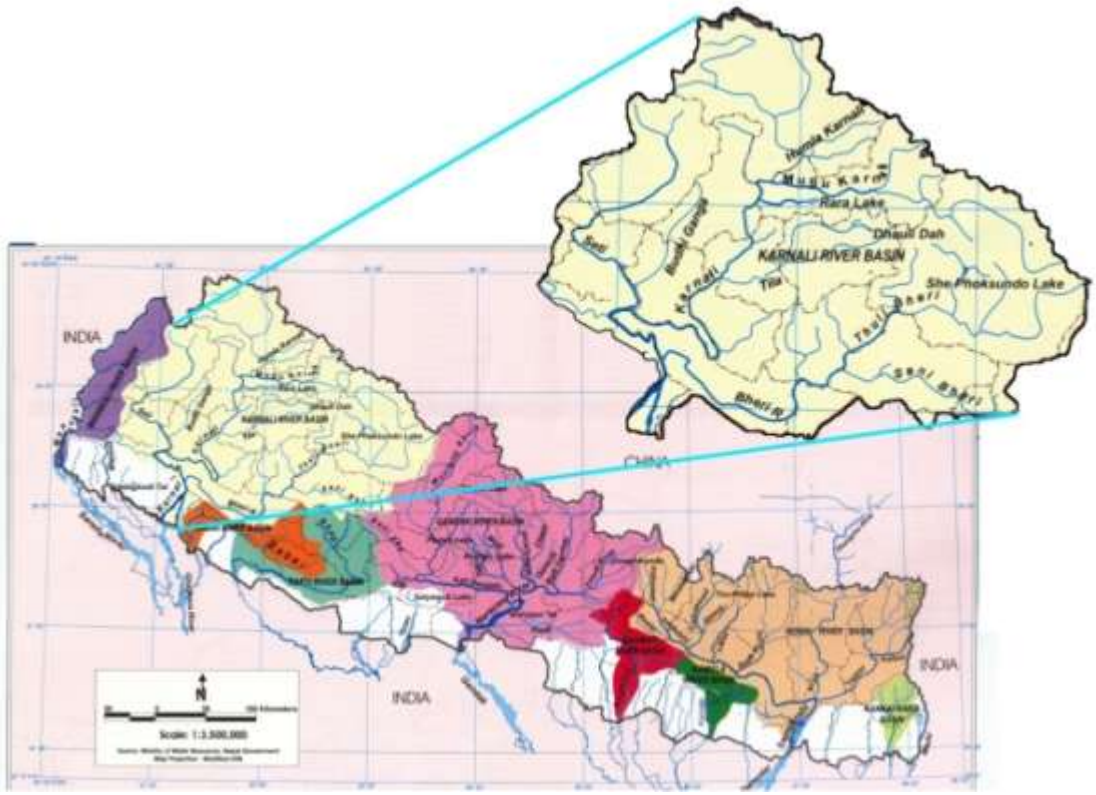

Figure 1.1: *Map of Nepal showing Karnali river basin*

1.5 Previous Study about Hydroelectric Potentiality of Karnali river:

Karnali river has the largest potential for hydropower development among the four major river systems in Nepal. It is estimated to have an economically exploitable hydro potential of 24,000MW. However this river has been kept on the least priority for a long period just because it still embraces the most remote and underdeveloped Karnali region. But the situation is gradually being changed and the hydro potentiality of the Karnali river attracts the eyes of Nepal Government and national and international private developers.

In December 1962, Nippon Koei of Japan was awarded the contract by UNDP to ascertain the hydropower capabilities of the Karnali river with the most desirable site for the hydroelectric project. Its investigations revealed ten projects with a total capacity of 68,000MW ranging from 1,800MW to 18MW based on capacity factors of 55% for storage and 90% for run-of-river plants. In 1966, Nippon Koei submitted the feasibility study report of the 1,800MW Chisapani high dam project with an arched gravity concrete dam of 207 m height, a gross capacity of 15,000 cubic meters, a firm annual

energy of 8,350 million KWh at an average cost of 3.28 million per KWh with 2,350 million KWh secondary energy at a cost of USD 302.3 million (Pun, 2008).

Norconsult/Electrowatt, under a UNDP fund, conducted the second feasibility study of Chisapani high dam and submitted its report in 1977. After conducting a range of studies on alternative schemes with installed capacities from 1500MW to 4500MW, Norconsult/Electrowatt selected the scheme of 3,600MW capacity having a dam height of 210 m from its foundation at Chisapani. With a firm energy of 8,505GWh and secondary energy of 6,567GWh, the average annual energy of the Chisapani project shot up to 15,072GWh (Pun, 2008).

In December 1989, the Canadian-led Himalayan Power Consultants completed their Detailed Feasibility Study (DFS) of Karnali Chisapani in accordance with the terms of references jointly prepared and agreed upon by Nepal and India. The DFS recommended a 270 m high gravel fill dam that would have a live storage of 16.2 billion cubic meters with the reservoir extending 100 km upstream. The 10,800MW powerhouse located on the left bank would have 18 units each of 600MW size generating an annual average energy of 20,842GWh. The re-regulating dam 8 km downstream would generate 84MW-six number of 14MW units. The 1988 capital cost of the project was estimated at USD 4,890 million. The DFS further noted that the Chisapani project generates substantial social and environmental impacts with the need to resettle about 60,000 people (Pun, 2008).

Pre-feasibility Study of Upper Karnali HEP in 1988 by NEA:

Nepal Electricity Authority (NEA) commenced the pre-feasibility of the Upper Karnali Hydroelectric Project in January 1988. Pre-feasibility report was prepared by Himalayan Power Consultant in December 1989. Then the feasibility study was carried out by NEA as a part of Medium Hydropower Study Project (MHSP) during October 1996 to June 1998.

The diversion site was identified on the Karnali river about 600 m downstream of Ramgad confluence and the power house area was proposed on the right bank terrace of western arm of Karnali river downstream of Lekhpani khola (GMR, 2010).

India's National Hydropower Corporation Limited (NHPC) prepared the initial groundwork of the development of Upper Karnali. On February 2004, NEA and NHPC agreed to jointly develop the 300MW Karnali Hydroelectric project. In the joint venture company, NHPC was proposed to be a 49% shareholder in the project which involved a total estimated capital cost of USD 500 million. The two sides had to prepare the detailed Project Report (DPR). India was supposed to buy the power generated from UKHEP in 1998; the World Bank undertook the feasibility study through Delta Pacific Consortium. An agreement was signed by the then Ministry of Water resources (MoWR) and the Delta Pacific Consortium in 2000. But the survey license was cancelled on January, 2002 due to insufficient progress in the project.

Government of Nepal (GoN) solicited the Expression of Interest (EOI) to select the developer to implement the UKHEP with a minimum installed capacity of 300MW and associated transmission system for evacuation of power. Among various potential developers, GMR-ITD Consortium was selected and was thereby invited by GoN to enter into a Memorandum of Understanding (MoU) in January 2008.

It was agreed that for the purpose of developing the project, GMR-ITD shall enter into an agreement with NEA to establish a joint Venture Company (JVC) with 27% free equity to NEA. The JVC so formed "GMR Upper Karnali Hydropower Ltd.", got the survey license for the project from Department of Electricity Development (DoED), under the guidance of the Ministry of Water Resources, GoN, in May 2008.

The JVC was awarded the Upper Karnali Hydroelectric Project on Build, Own, Operate and Transfer (BOOT) basis for a period of 30 years from the issue of generation of license. The project is to be developed as an 'Export' project for power transmission to India, with 12% free power to Nepal in addition to the royalty and export tax as applicable. The company has also agreed to give USD 500 per MW to the GoN for the project survey and deposit USD 12,500 per MW before commencing construction.

A detailed feasibility study was commenced by GMR Upper Karnali Hydropower Ltd. in 2008/09 to assess the design feasibility of the 300MW run-of-river (ROR) scheme. During this study a better site for a hydroelectric scheme was found on the Karnali river, approximately 7 km upstream of the previously identified site, 600 m downstream of

Ramgad confluence. The main advantage of this site was the possibility to avoid high socio-economic risk, allowing less environmental risk and increasing the installed capacity of the project to its most optimized level of 900MW. The first license for a minimum of 300MW was issued to the company on 2065-2-5 BS while the second license for 900MW was issued on 2066-9-5 BS.

1.6 Justification of Study

Implementation of any hydropower project degrades the environment. It is a vivid fact that developmental activities are mounting every day and environmental problems are increasing simultaneously. It has to assess the adverse and beneficial impact of project on environment for sustainable development.

In Nepal after the implementation of National EIA Guidelines in 1993 and Environment Protection Act/Regulation in 1997, it is mandatory for conduction of environmental assessment before the implementation of project. Following the National EIA guideline, Nepal Environmental and Scientific Services (NESS) has recently completed the EIA study of the proposed 900MW UKHEP and it is now in pipeline for approval in the Ministry of Energy (MoE) and the Ministry of Science, Technology and Environment (MoSTE).

There are very few studies found on the water quality of the Karnali river and the socio-economic status analysis of the Karnali region made by some experts and NGOs like KIRDARC related to the region. But the superficial level of study did not provide in depth knowledge of the Karnali river system. Moreover, besides the EIA made by NESS, there cannot be found any scientific study report yet made by the third party. In this context, this study will be a key reference for GMR, NESS, NEA and other concerned bodies to mitigate the adverse impact of the project. This study has attempted to generate databases in theoretical potential of hydroelectricity generation from the proposed dam site using Q_{40}% as design discharge and overall efficiency of 85%. The database of Karnali river's physico-chemical parameters is secondary information for measuring pollution level at present. As a whole, the study will be an important referenced document for the future project that will be launched within the same site.

1.7 Objectives:

Broad Objective:

Broad objective of this study is to estimate the theoretical hydropower potential of the proposed Upper Karnali Hydroelectric Project and assess the water quality and socio-economic impact after implementation of the project.

Specific Objectives

The specific objectives of this study are given below;

- To estimate the theoretical hydropower potential of the proposed UKHEP on the proposed dam site of the project.
- To study physico-chemical parameters of Karnali river's water in terms of temperature, pH, conductivity, secchi disc transparency, turbidity, alkalinity, hardness, chloride, CO_2, DO, phosphate, nitrate and iron.
- To study microbiological parameters of Karnali river's water in terms of *E. coli* and normal coliform.
- To study socio-economic status of the proposed project affected communities.
- To identify positive and negative impacts after implementation of the proposed project.
- To suggest mitigation measures for reducing the adverse effects due to implementation of proposed UKHEP.

1.8 Limitation of Study

- GIS software and hydropower model were not used in estimating the theoretical hydropower potential.
- The study was completed in limited duration of 11 days field work in post-monsoon (November 17-27, 2012). Water quality was tested by the researcher at that time, while the data of related physico-chemical parameters in pre-monsoon were taken from NESS that completed EIA of the project.
- The study had to be completed with limited economic resources.

CHAPTER: II

LITERATURE REVIEW

The following literatures were consulted during the study period and are presented in different sub heading.

2.1 Water Resource Potentiality

Adhikari, 2009 studied energy mapping using GIS and hydropower model in Karnali, Mahakali and West Rapti river basins. He processed monthly discharge data of 10 years (1997-2006) and calculated design discharges at different percentile. The SRTM (Satellite Radar Topographic Mission), Digital Elevation Model was used as basic input to GIS software. The hydropower model took the input of DEM, river network, elevation of river, flow accumulation and stream order in ASCII format. The model calculated the head, i.e. the height difference between the intake site where water is diverted from the river and the powerhouse where electricity is generated, and discharge using the monthly normalized discharge and catchment area and finally calculated the potential power as well as energy. He found that the gross installed power potential and total annual energy of West Rapti, Karnali and Mahakali are 438MW, 15,661MW and 2,261MW; and 2,951GWh, 1, 02,324GWh and 14,980GWh respectively.

Shah, 2009 studied energy mapping using GIS and hydropower model in Koshi, Narayani, Bagmati and Kankai Basins. He processed monthly discharge data of 10 years (1997-2006) and calculated design discharges at different percentile. The SRTM (Satellite Radar Topographic Mission), Digital Elevation Model was used as basic input to GIS software. The hydropower model took the input of DEM, river network, elevation of river, flow accumulation and stream order in ASCII format. The model calculated the head and discharge using the monthly normalized discharge and catchment area and finally calculated the potential power as well as energy. He found that the gross installed power potential and total annual energy of Kankai, Koshi, Bagmati, Narayani are 241MW, 17,008MW, 424MW, 17,800MW; and 1,517GWh, 1,08,816GWh, 2,574GWh, 1,13,373GWh respectively.

Jha, 2010 studied the total run-of-river type hydropower potential of Nepal. The study used mainly the hydro-meteorological data of DHM for hydrological analysis of all the rivers in Nepal. Incorporating GIS and the hydropower model that has specifically been developed by the author, the power potential and annual energy estimate on a run-of-the-river (ROR) basis of the entire country has been worked out. The result showed that the power potential and annual energy estimates of Narayani, Saptakoshi and Karnali river basins at Q_{40}% (flow excedence) and 80% efficiency are 17,800MW, 17,008MW, 15,661MW and 1,13,373GWh, 1,08,817GWh, 1,02,324GWh respectively. The Mahakali River would yield only 2,262MW of hydropower and 14,981GWh of energy annually. The other water sources in Nepal would have a total power potential of 1,105MW and a combined annual energy of 7,043GWh. Thus, the total hydropower potential and corresponding annual energy capacity of Nepal on a ROR basis at Q_{40}%, and 80% efficiency is 53,836MW and 3, 46,538GWh respectively.

Prajapati, 2011 studied the theoretical assessment of hydropower potential of Karnali basin using GIS and hydrological modeling technique. He used calibration and validation of the rainfall-runoff simulation model (HEC-HMS) along with GIS software. The hydropower potential was calculated by considering the flow and the head only. After obtaining the discharge, the power was calculated at every junction with 40% dependable flow which is according to the design guideline of DoED. The study revealed that at 40 percentile design flow, the theoretical power of Karnali basin was 14,150.80MW with total annual energy generation capacity 64,229.93GWh. He also calculated the theoretical hydropower potential of Upper Karnali river at Pather khola confluence and found that the total power potential was 647.36MW.

2.2 Water Quality

Some of the literatures reviewed for the river water quality are depicted below:

Khadka, 1983; Napit, 1988; Pradhananga *et al.* 1988 and Vaidya *et al.* 1988 studied water quality in Pashupati area. Khadka, 1983 studied major ions in the Bagmati river near Pashupatinath temple on the day of Mahashivaratri festival and found that the concentration of major ions, specially Na and Cl, was higher in sample collected downstream of the temple than upstream. The ion imbalance resulted from many people

bathing in the Bagmati at the temple site during the festival. Napit, 1988 investigated pollution of the Bagmati river in Pashupati area. He found that physical characteristics such as color, turbidity and suspended particles exceeded desirable levels. However, the chemical parameters tested did not exceed the WHO standards. Pradhananga *et al.* 1988 tested water samples of the Bagmati river at different sites in the Pashupati area and found parameters such as pH, Conductivity, DO, PO_4 and NH_3-N within the permissible value for water supply, fisheries and industry. However, the values for suspended solids and BOD exceeded WHO standards. Vaidya *et al.* 1988 studied pollution of the Bagmati river in the Pashupati area on the basis of a diversity index for macro-invertebrate fauna and found the level of pollution rising from low at upstream sites to moderate and high at downstream sites. The higher population of pollution-tolerant species in each sampling site during the month of May to August indicated that the pollution level increased in summer.

Shrestha, 1990 carried out a research on fisheries resource of Kali Gandaki river and its water quality. Altogether, 69 species of fishes were reported from Kali Gandaki River. Regarding the water quality, he reported that the pH value of the river water varied from 7.1 to 8.1, which was suitable for the growth of river carp. The water temperature was found in the range of 5^oC to 18^oC at the upper reaches, 15^oC to 22^oC at the middle reaches and 25^oC to 30^oC at lower reaches. The amount of dissolve oxygen was varied from 8.3 to 10 ppm (December to April) and 3 to 6 ppm (July to September).

Sagarmatha Power Company (P) Ltd., 2005 prepared final environmental impact assessment report of Upper Marsyangdi "A" (UM-O) Hydroelectric Project and revealed that the river was unpolluted. Turbidity was found to be very high during monsoon season (June to September) at powerhouse site. The suspended sediments were measured 2238 ppm. Similarly, iron content in all sampling sites was found in the range 7.65-13.59 mg/l which is very high. Except these two parameters, all other physico-chemical parameters were found within the permissible level of WHO for the purpose of drinking water.

NEA, 2005 studied environmental impact assessment of Chameliya Hydroelectric Project. Regarding water quality, the concentration of DO was found 11.8 mg/l which was very high. The river water was found slightly alkaline (pH 7.5) with very low

suspended solids (0.4 mg/l) at the weir site. Visibility was found 75.2 mg/l at the weir site. Similarly, iron, orthophosphate and TDS were found to be 0.12 mg/l, 0.5 mg/l and 85 mg/l respectively.

Sharma *et al*., 2007 studied on impact of Khimti-I hydropower project on water quality and found that the temperature was higher (18.6^{o}C) in recovery site which is 350 m downstream from bridge crossing Khimti at Khimti Besi than reference site (11.0^{o}C) and other parameters, conductivity 19µs/cm in reference site and 17µs/cm in recovery site, pH 7.93 in reference and 9.78 in recovery, phosphate 0.26 mg/l in reference and 0.01 mg/l in recovery and nitrate 0.1 mg/l reference and 0.18 mg/l in recovery sites.

WSHEP, 2007 studied the water quality parameters between the Gopghat and Budhi Ganga confluence and found that temperature was ranged from 17^{o}C-19.1^{o}C at this site and which was higher than the upstream of the dam site (10^{o}C-18.5^{o}C) due to lower altitude. Dissolve oxygen was lower in downstream site (8.8-9.5 mg/l) than upstream site (7.8-15.0 mg/l). Similarly, alkalinity was 7.2-8.7 mg/l and 29 mg/l as $CaCO_3$ and the pH from upstream site was recorded 8 to 8.7 at Gopghat site. Total hardness at upstream and downstream site was 80 to 260 mg/l and 60 to 96 mg/l as $CaCO_3$ and conductivity at Gopghat site was 100 to 160 µmhos/cm. Ammonia (NH_3-N) was found between 0.14 to 0.46 mg/l and total nitrogen ranged between 0.8 to 1.68 mg/l.

Water Resources Consult (P) Ltd., 2008 studied the environmental impact assessment of the Pancheswar Multi-purpose Project that includes the 6,480MW Pancheswar High Dam Project, 240MW Rupaligad Re-regulating Dam, and Poornagiri Dam. Regarding water quality of the project area, the result of various physico-chemical parameters is as shown below:

Pancheswar High Dam

- Results of water temperature and pH values for 24 sites showed gradual increase of temperature in the downstream of Mahakali river from Gauri-Mahakali confluence to Joljibi (19^{0}C in May-June) to 22.5^{0}C at Pancheswar Dam site, 23^{0}C near to Rupaligad dam site, 25^{0}C at Poornagiri dam site and 26^{0}C at Tanakpur Barrage (Brahma Dev). The pH level ranged from 6.5 to 7.5, between Gauri-Mahakali confluence at Joljibi and Poornagiri dam site and slight declination to 6.3 at

Tanakpur Barrage area. Big difference in pH level was observed between October-December (6.3-6.8) and May-June (8.0) from Rangoon khola-Mahakali confluence to Tanakpur Barrage area.

- In January 2007, samples of river water were collected at 11 sites in Pancheswar high dam site. Chemical parameters such as ammonia, iron, total hardness, chlorides and nitrate content was found in the range of 0.2 to .5 mg/l, 0.3 to 0.5 m/l, 40 to 144 mg/l, 11 to 25 mg/l and less than 0.3 mg/l respectively. Similarly, conductivity and dissolved oxygen was found in the range of 0.7 to 12.3 μs, 8.9 to 16 mg/l respectively. Total phosphate, nitrate, COD and BOD was in the range of less than 0.1 to 0.1 μg/l as PO_4, 0.1 to 0.2 μg/l as N and less than one respectively. Variation of total coliform and fecal coliform was in the range of nil to 1109 cfu/100 ml and nil to 151 cfu/100 ml respectively.

Water Quality in Settlements (Drinking Water)

No fecal coliform and ammonia contamination was found in the drinking water proposed for Pancheswar High Dam. River water was polluted but the drinking water source was safe. The pH value and iron content was in the range of 6.5 to 7.5 and 0.2 to 0.4 respectively. Spring water at Baku and Sera was free of iron content. Total hardness was 5-22 mg/l at Baku, Bet and Lali, 42-48 mg/l at Sera and Gokuleshwar and 100-112 mg/l at Joljibi and Jhulaghat. Except Jhulaghat (20 mg/l), chloride content was 1-5 mg/l and the nitrate content was <0.3 at Gokuleshwar, Bet, Joljibi and nitrate content at Sera was nil. Quality of drinking water in the settlements in within WHO limits and the water is safe for drinking.

Shrestha *et al.*, 2009 studied on Tamor river and found that water quality parameters i.e. air temperature (22^oC-26.3^oC), water temperature (16^oC-19^oC), DO (9.7-10 ppm), pH (7.3-7.5), alkalinity (17.1mg/l), total hardness (28.5-34.2 mg/l), CO_2 (5 mg/l) and conductivity (37.7-56.7 μs/cm) which were suitable range for the cold water fishes.

Acharya, 2009 studied the environmental assessment of Hewa-A Hydropower Project and he found all the physico-chemical parameters were within the WHO guideline values of drinking water. With low population and low developmental activities in the watershed area, the Hewa khola was found to be unpolluted with pH value of 6.7 and

free CO_2 in the range of (6-8.8) mg/l. The values of TS and TDS were found high i.e. (150-200) mg/l and (9.7-9.8)mg/l respectively. Nitrate and iron was found insignificantly and they varied from (0.25-0.3) mg/l and (0.4-0.46) mg/l respectively.

Singh *et al.*, 2010 studied on the river physico-chemical parameter of the Manipur river and found that temperature was ranged from 16^{o}C to 28^{o}C in winter and summer, pH in winter and summer lied between the WHO guideline values (6.5-8.5). The river water was alkaline in nature. River transparency was found to be lowest 0.8 cm in rainy season and highest 48.5 cm in winter and dissolve oxygen was recorded in the range of 4.43 mg/l to 13 mg/l which indicated the water was free from the pollution. Free CO_2 and chloride was found highest in summer.

Singh, 2012 studied the impact assessment of fishes and macro-invertebrates due to proposed high dam on Arun River. Regarding the physico-chemical parameters, the study revealed that all the parameters were within the range of Himalayan cold water. Concentration of DO was found high i.e. in the range of (9.28-10.1) mg/l in pre-monsoon and (10.13-10.54) mg/l in post monsoon. The pH value in the river was slightly acidic (3-6.5) in pre-monsoon whereas slightly alkaline (7.8-7.9) in post-monsoon. The chloride content was found in the range of (7.1-16.33) mg/l in both seasons. The total alkalinity varied from (60-65) mg/l in post-monsoon and (35-42) mg/l in pre-monsoon. The concentration of phosphate, nitrate and iron was found to be in the range of (0.299-0.376) mg/l, (0.039-0.2) mg/l and (0.26-0.27) mg/l in pre-monsoon; and (0.236-0.291) mg/l, (0.088-0.29) mg/l and (0.25-0.27) mg/l in post monsoon respectively.

2.3 Socio-economic impact assessment

2.3.1 Legal and policy framework for utilizing resources and institutionalizing EIA in Nepal

a. Constitution of Nepal

The "Interim Constitution of Nepal-2007" mentions in the Fundamental Right regarding environment as "Every person shall have the right to live in clean environment". It has mentioned in the state polices as "The state shall make necessary arrangements to maintain clean environment. The state shall give priority to the protection of the environment, and also to the prevention to its further damage due to physical development activities by increasing the awareness of the general public about

environmental cleanliness, and the state shall also make arrangements for the special protection of the environment and the rare wildlife. Provision shall be made for the protection of the forest, vegetation and biodiversity, its sustainable use and for equitable distribution of the benefit derived from it.

b. Plans, Policies and Strategies

Although planned development was started in 1957, Nepal recognized the importance of environment conservation in the mid 1970, and included policies since the fifth plan (1975-80). This plan accommodated land use related policies and expanded policies on natural resource management for the benefit of the society (NPC, 1975). The "Nepal Environmental Policy and Action Plan" (NEPAP) 1993 contains policies and programs to strengthen EIA system (EPC, 1993).

The "Industrial Policy 1992" has emphasized on adopting measures to minimize adverse impacts on the environment during the establishment, expansion and diversification of industries. The policy opens avenues to formulate guidelines and standards in order to check and minimize adverse effects of pollution associated with industrial growth. Industries that are likely to affect the environment have been categorized and a license is required to establish industries that affect public health and the environment (MOI, 1992).

The "Hydropower Development Policy 1992" incorporated the concept of EIA. It has a policy to make necessary arrangement in order to minimize the environmental impacts of hydropower projects and rehabilitation of displaced families. EIA could be extensively used for identification and minimization of adverse impacts. The policy clearly requires to maintaining minimum monthly downstream water release in the river and stream at 10 percent of the total discharge or as recommended by the EIA study (MOWR,1993).

The "Irrigation Policy 1993 (revision 1997)" made specific provision and urged to design and implement irrigation projects and programs based on the recommendations of EIA and IEE reports. The policy works to identify and select irrigation projects taking into account, the environmental balance. The working policy emphasizes on implementing projects by minimizing the adverse environmental impacts, conducting

IEE and EIA and organizing public hearing, ensuring biodiversity conservation by releasing minimum water to the downstream, and utilizing water for irrigation by avoiding/ reducing adverse environmental impacts (MOWR, 1992).

The "National Wetland Policy 2003" has also included the need for carrying out EIA in accordance with the provisions of the existing laws for development projects and actions, which are planned for implementation nearby the wetlands (MFSC, 2003).

The "National Conservation Strategy 1988" includes a number of programs to internalize EIA system in Nepal. The strategy underscores the need to ascertain the potential consequences of the development activities on the environment and urges to minimize detrimental effects. It proposed to establish an Assessment and Review Office (ARO), responsible for socio-economic and environmental assessment and review process (HMG/IUCN, 1988). It urged the proponents to prepare a statement concerning the potential socio-economic and environmental effects and review such projects based on the environmental guidelines.

The "Water Resources Strategy 2002" has recognized that Nepal has made good advance on EA legislation and procedure, but the proposed mitigation measures are not always implemented due to lack of capacity and/ or regular monitoring and follow-up. The strategy emphasizes to understand the environmental processes fully (e.g. soil erosion, landslides, sediment transport and deposition, floods etc) to avoid adverse impacts, improve conditions and/ or to reduce negative elements (WECS, 2002). The strategy underscores the need for effective implementation of EIA and SEA norms and recommendations. The strategy has clearly mentioned that the compliance with regulations and Environmental Management Plan (EMP) has been unsatisfactory due to lack of supervision, monitoring and enforcement, and inadequate follow-up of remedial actions.

c. Acts and Rules

The "Land Acquisition Act 1977" contains provisions to make land and house of any person available for the developers by the government making sure that compensation

shall be paid for the amount of land and house, either by the developer or by the government (MLR, 1977).

The "Forest Act 1992" opens avenues to carry out EIA of the development proposals if they are to be implemented in the forest areas and or pass through the forest areas. Section 68 of the act states that in case there is no alternative except to use the forest area for the implementation of the plan of national priority and if there shall be no significant adverse effect on the environment while conducting such plan, HMG may give assent to use any part of the government managed forests, community forests, leasehold forests or religious forests for the implementation of such plan (MFSC, 1993).

The "Water Resources Act 1993" contains provisions to maintain the quality standard of water while making use of it and prevent pollution due to the addition of the foreign agents, to minimize environmental impacts, including soil erosion, floods and landslides (MOWR, 1993). This provision calls for carrying out EIA prior to project implementation to identify likely impacts of the water resource projects on the environment (section 20). It also empowers HMG to frame standards while utilizing water resources (section 18) and to frame rules on the environment-related matters and pollution control (section 24).

The "Water Resources Rules 1993" oblige the proponent to analyze environmental impacts of a proposal and state that such a study should contain environmental control and safety measures and other necessary arrangements to resettle people during hydroelectricity development (MOWR, 1993),

The "Electricity Rules 1993" stresses environmental analysis, which should include environmental mitigation measures to minimize adverse impacts likely to occur while implementing hydroelectricity projects (Rule 12 and 13) (MOWR, 1993).

"Environment Protection Act (EPA) 1996", a framework and umbrella act commenced on 24th June, 1997 opens avenues to mainstream and institutionalize environmental assessment in Nepal (MOPE, 1996). In accordance with power conferred by Section 24 of EPA 1996, HMG has framed the Environment Protection Rules (EPR), 1997 and it entered into force on 26th June 1997 (MOPE, 1997). The rules elaborate approval process

of IEE and EIA. The schedule 1 of EPR 1997 includes a list of projects in the sectors of forestry, industry, mining, road, water resources and energy, tourism, drinking water, waste management and agriculture which require IEE level of assessment. In addition, this schedule includes an investment threshold criterion to streamline IEE study of any plan, project or programs. The plan, project or programs which will invest NRs. 10 to 100 million should undergo IEE process. Similarly, the projects requiring EIA study have been listed in schedule 2 of EPR 1997. This schedule includes health and sensitive area criteria in addition to the sectors outlined above. The investment criterion is also included and the plan, project or programs investing more than NRs. 100 million should undergo EIA process. The schedules 3 and 5 contain the format for TOR and IEE report, and the schedules 4and 6 include format for TOR and EIA report respectively. Out of 7 schedules included in EPR 1997, 6 schedules are related to either IEE or EIA.

d. National Standards and Guidelines

The "National EIA Guidelines 1993" has been the breakthrough in streamlining EA process in Nepal. This guideline was implemented at a point of tie where there were no legal requirements on the environmental matters and EA system (HMG, 1993).

2.3.2 Previous studies on hydropower and environment

Various studies related to hydropower and environment have been reviewed. Some of them relevant to this project are briefly described below:

LEDCO, 1991 prepared the environmental impact assessment of the Nyadi Hydropower Project. It was found that 24 ropanis of land would be permanently acquired of which 4 ropanis for access road and 20 ropanis for surge tank and power house. The beneficial impact of the project included electrification of the locality, construction of access road, transportation facilities to uplift economic condition of local fishermen, enhancement of cottage and small scale industries, facilitation quick health care services, employment opportunities to the local people, enterprise development and shareholding the project. The adverse effect included soil deposits from the tunnels which were excavated from four sites, landslides and demographic pressures due to influx of workers in local communities.

NEA, 1998 has carried out feasibility study of Kabeli Hydropower Project located in the area close to Hewa-A Hydropower Project. The study has covered environmental information and possible impact with appropriate mitigation measure of the area. According to the study, the lands to be utilized for various construction and pounding coverage area do not fall under unique natural habitat of narrow distribution in the country or ecologically sensitive area. Neither protected area nor historical religio-cultural and heritage area fall in the project site.

NEA, 2000 conducted the environmental monitoring of Modi Khola Hydroelectric Project. The monitoring reported removal of 417 trees of different species for site clearance and no water quality deterioration, no problem of air and noise pollution, no hunting/ poaching. The project implemented different eco-friendly activities such as river/ slope protection, proper dumping of spoil, avoiding use of forest resources for cooking, compensatory plantation at various places of the construction area. NEA (2002) conducted the environmental auditing of Modi Khola Hydroelectric Project. The study revealed that the proposed mitigation measures were implemented during the construction and operation phase. There was no deterioration on water, air and noise quality, no vibration, no sanitation related health hazards, no haphazard disposal of spoil, no encroachment of forest area and no trade on medicinal plants and wildlife products during construction. Most of the unstable slopes were protected. Negligible numbers of trees were felled in the project area for site clearance.

GITEC, 2000 prepared the scoping document of Upper Modi Hydro Electricity Project located at Kimchi Besi, Patichaur 6 km north on Pokhara-Baglung road. With regard to socio-economic aspects, the priority issues to be assessed during the EIA study include withdrawal of economic activities after project construction (boom and bust cycle), hydroelectricity generation and rural electrification program, employment generation to local people, economic upliftment due to the project, demolition of structures and restoration activities, possible township development and likely environmental impacts and future development potential and gender issues.

LEDCO, 2001 prepared the environmental impact assessment of the Khudikhola Hydropower Project located in Annapurna Conservation Area at Khudi VDC, Lamjung district which has been generating electricity since 2007. It is run of river type project

with an installed capacity of 3.45MW. The electricity generated from the project is synchronized in the national grid. The EIA study of the project had indicated beneficial and adverse environmental impacts, which are discussed below:

- By creating work opportunities, bringing new people into the area for the construction period and maintaining the road conditions to allow the good circulation of transport vehicles, the project is expected to positively influence the local market economy (agro-products, stores, restaurants, meat products etc.) and to momentarily reduce out-migration of men from the area.
- The project however was designed so that no involuntary displacement of people will be necessary and that only 3.3 ha of land will be permanently acquired and 4 ha will be rented for two years limiting impacts on the land and house holdings in the area. KHP recommends fair compensation for acquired land or rented lands plus compensation packages to help affected landowners bear the consequences of the losing their land.
- The two first months of the 4 months fishing seasons will probably be impacted by diversion of the river for power generation, which would leave one stretch (2.5 km stretch, the project will definitely have an impact on aquatic life downstream from the weir thus voluntary release of water by the project during the dryer months (10% of lean flow) is expected) of the river dewatered for those two months. Full time fishermen will be hired in priority by project during construction and operation period to compensate for their loss in revenue

KHC, 2001 prepared the final EIA report of Langtang Khola Hydroelectric Project of Rasuwa district. Social impacts primarily arising from land acquisition and labor employment had been considered as one of the primary environmental issues in its EIA final report. The others included the impacts arising from alternation of river hydrology, habitat destruction of flora and fauna, sedimentation, offsite impacts form access road and natural hazards related to landslide and erosion. In total, there are 14 families in project area that are likely to be affected due to land and other property acquisition. The affected families would be losing only a small portion of their land. This would be directly related to the loss of agricultural production creating a food scarcity in the region where food is already in deficit.

Roy, 2002 studied the environmental audit of Chilime Hydroelectric Project located in Rasuwa and Nuwakot districts. As the project implementer provided kerosene laborers, there was no illegal hunting and firewood collection. Slope stabilization along the road was not satisfactory since several landslides were observed. The project provided cash compensation for CFUGs for 3 years however compensatory plantation was not successful due to soil erosion, landslides and lack of technical guidance.

Pandey et al., 2002 studied the environmental impacts of hydropower development on vegetation and wildlife resources of Kali Gandaki 'A' Hydroelectric Project area. The prominent impacts were vegetation clearance and threatening of rare and endangered species, found more degraded at the dam site than at reservoir area. However most of the impacts were of temporary nature and expected to be reduced after the project completion. There was reasonable success in the implementation of mitigation measures for minimizing the adverse impacts on vegetation and wildlife.

NEA, 2003 studied the post construction environmental impact audit of Kali Gandaki 'A' Hydroelectric Project. 65 ha of cultivated land, forest land and other land have been submerged by reservoir and approximately 208.63 ha land was used for the project structures. Approximately 6.2 million tones o sediments were released in river and 6093 trees of Khair, Bakaino, Ipil Ipil, Simal, Sisso and Sal were removed during construction. No significant effect on fish population was reported. Altogether 1468 families lost their land or part of it. On the other hand, Sharma (2004) studied the post project evaluation of environmental mitigation measures of Kali Gandaki 'A' Hydroelectric Project and 132 KV transmission line. The study showed that around 97 ha of land was disturbed and 4.11 million cubic meters of excavated materials were generated during construction. 6093 trees of different species were felled down. Proper land restoration and bioengineering measures, appropriate disposal of muck and plantation of 338,000 seedlings were the major mitigation programs successfully implemented to minimize the impacts on natural vegetation and watershed.

Singh, 2003 studied the environmental auditing of Puwa Khola Hydropower Project of Ilam district. He found no deterioration of air quality and noise level, no change in wildlife habitat and biodiversity, no hunting, poaching and trade of wildlife products, no use of child labor, no increase in alcohol consumption, no ethnic impacts and no bad and

lethal events reported during rural electrification in absence of safety measures. Satisfactory sanitation condition and slope protection was reported from the project area. Land acquisition had been done through negotiation with landowners and compensation was provided timely.

Barnwal, 2004 studied the socio-economic impacts on the adjoining area of Kulekhani 1st Hydropower Project. He found that project provided the excessive drinking water facilities to the local and employment opportunities to both local and outsiders during construction and operation. Electricity supply had extended the social and recreation activities. Fisherman and fishes had been troubled since downstream side of river is significantly affected. Agricultural production was affected because fertile and hill land was utilized by project. Environmental mitigation measures were not completely implemented. He judged the impact of the project as moderate in absolute term and satisfactory in relative term.

Khadka, 2004 studied the environmental auditing of Modi Khola Hydroelectric Project and found that there was lack of close co-ordination between employer, proponent and stakeholder of the project during construction phase. Mitigation measures mentioned in the EIA report were not effectively implemented. Proper functioning of fish ladder and employments oriented trainings to locals and environmental education campaign were lacking. Limited and few monitoring were done during construction phase.

DoED, 2004 studied the environmental impact assessment of Mewa khola at Taplejung district and indicated beneficial and adverse environmental impacts and their mitigation measures, which are discussed below:

- The project will permanently acquire total area of 33 ha out of which 14.7 ha is agricultural and 15 ha forest.
- About 3.6 km of the river will be dewatered.
- The major impact on vegetation and forest resources includes the loss of more than 550 trees of various sizes and their standing volume.
- No households are expected to be directly affected in terms of relocation. However in terms of the loss of land during construction activities, 16 households will be affected due to impounding.

- Improper management of waste generated by the workforce and other people as well as muck disposal near the river bed may pollute the river water.
- Proper management of waste products and muck disposal has to be carried out.
- Proper dumping and disposal of excavated material, avoidance of clearing vegetation along the landslide areas.
- Proper land value will be given to compensate.

Sagarmatha Power Company (P) Ltd., 2005 prepared final environmental impact assessment report of Upper Marsyangdi "A" (UM-O) Hydropower Project and it was found that land acquisition for site clearance would directly affect 137 families. Altogether 21.15 ha of cultivated private land and 9.89 ha of government land would be acquired for construction of the project. Out of them 1 household is located in the powerhouse site, 17 in headwork site, 3 in surge tank site, 10 in workers' camp site, 7 in labor camp site and rest 99 households along the access road site. This loss would be compensated preferably the cash at replacement value as per the interest of the owners using the Land Acquisition Act, 2034 BS for compensation as applicable. Cash compensation would be provided for a year of agricultural production at the prevailing market price. In addition, the hardship and maintenance cost would be provided to 7 SPAFs who would be losing their house. Social service facilities and infrastructures such as school, health post, water supply pipes, taps and well and irrigation channels would not be demolished as a part of site clearance.

NEA, 2005 studied the environmental impact assessment of Chameliya Hydroelectric Project and regarding socio-economic impact, the project would acquire 15.94 ha private land and 33 households would be affected by the land acquisition. Similarly 41 households and 8 cowsheds would be directly affected due to acquisition of houses. 27 ha of land including cultivated land, kharbari and barren land would be affected due to construction of access road. 95% of the PAFs requested for cash compensation. So, compensation fixation committee as per rule 13 of the Land Acquisition Act, 2034 BS would be formed under the chairmanship of the Chief District Officer of Darchula. Besides, there were some positive impacts too. Among them, generation of employment was the one. Altogether 2100 people would be employed during construction period and

60 people would be employed during operation period as permanent job in administrative and technical works.

Pandey, 2005 studied the environmental impact of Middle Marsyangdi Hydroelectric Project during construction phase. The study revealed that the environmental situation of the project area was not deteriorated to great extent however certain issues like noise quality, disposal problem, and air pollution, apparently high amount of iron, arsenic and lead in Marsyangdi river water and presence of coliform in drinking water could not be avoided. The EMAP was not followed as effectively as it was expected. The impacts during the construction were inevitable so the efforts to minimize the impact through effective application of mitigation measures had to be made.

Magar, 2005 studied the socio-economic impact of Piluwa khola Small Hydropower Project of Sankhuwasava district. He found that the project brought about various socio-economic impacts on people and surroundings. Due to land acquisition of 23 households, the average land holding of 40.70 Ropanis per PAF before project construction changed to that of 39.38 Ropanis per PAF at the project completion. Money provided as compensation was used by PAFs to purchase better cultivable land, to pay debt, to invest on business etc. 52.17% of PAFs and 36.51% households of the study area were electrified before project but 73.19% of PAFs and the whole area were electrified after the project operation. The project provided employment to more than 200 people during the construction period and to 16 people (9-permanent job/ 7-seasonal job) after operation of the project.

Timsina, 2006 studied the implementation of the environmental mitigation measures in Khudi Hydropower Project. The study revealed that the proposed mitigation measures were not effectively implemented. Most of the solid and liquid wastes from construction sites and workforce camps were discharged directly into river. Poor management of solid and liquid wastes and high noise level were noticed in the construction site. Decline of fish population by more than half and firewood felling from ACAP was reported during the construction period. Mitigation measures for the conservation and protection of the forest area was not implemented properly.

Water Resources Consult (P) Ltd., 2008 studied the environmental impact assessment of the Pancheswar Multi-purpose Project that includes Pancheswar High Dam, Rupaligad Re-regulating Dam and Poornagiri Dam. Regarding the socioeconomic impacts, the study revealed following major points:

Pancheswar High Dam

- Submergence of 153 settlements in 23 VDCs with the implementation of Pancheswar High Dam and Poornagiri High Dam will be the major issues; affecting about 73,402 people living.
- In Darchula district altogether ten VDCs would be directly/indirectly affected by Pancheswar Multi-purpose Project. Total 23.82 percent households would be displaced as a result of project implementation.
- The range of affect is minimum 4.33 percent HHs (Ritha chaupata) and maximum 59.73 percent HHs (Gokuleshwar VDC). Gokuleshwar is highly affected VDC where nearly 60 percent households would be displaced.
- The implementation of Pancheswar Multi-purpose Project will require the displacement of 2943 households with 22,905 populations. Lose of land, psychological stress due to loss of ancestral property, food insecurity, and marginalization of affected households.
- Remains of Uku Palace has archaeological importance that lies in the submerge area of Pancheswar High Dam. This place is associated with the emotion of Thakuri Pal and history of ancient Nepal.
- Altogether 102 of temples and shrines (69 in Darchula and 33 in Baitadi) will submerge in Pancheswar High Dam. Some of the temples are very old and have internationally (Malika Arjun and Saipal of Uku and Jagannath temple of Lali) significant.
- Contractor requirement of manpower for this purpose of infrastructure planning has been estimated as 8000 out of this half of the personnel would be provided infrastructure facilities on the Indian side and half on the Nepalese side.

Rupaligad Re-regulating Dam

- Altogether 4 VDCs with six settlements of Baitadi and Dadeldhura districts will be affected by Rupaligad Re-regulating Dam. 140 households with 1144 population would be directly affected by the project.

- There are 140 families (SPAF) with a population of 1,144 in Direct Impact Zone of Rupal who will be displaced due to Rupaligad Re-regulating Dam construction. Similarly, 36 families (PAF) with a 252 population of Indirect Impact Zone of Rupal will be affected due to construction and influx of population

Patan- Pancheswar Access Road

- Patan-Pancheswar access road is situated in Baitadi district. It covers nine VDCs i.e. Melauli, Patan, Kulau, Basantapur, Salena, Shivnath, Pancheswar, Durgasthan, Maharudra VDCs. 32 settlements of ten VDC will be affected by the project.
- There may be increase of prostitution, alcohol abuse and crimes on the road side areas. In-migration of the population due to easier access and in search of job opportunities will cause more pressures on health, education and public safety services.

Acharya, 2009 studied the environmental assessment of Hewa-A Hydropower Project. Regarding socio-economic impact, the project would acquire 3.92 ha of land permanently and 5.26 ha temporarily. However, not a single household was affected in terms of relocation. By land acquisition and temporary land use, averagely 3.15 tones of paddy, 14.15 tones of millet and same amount of maize would be lost. No historical religio-cultural sites and protected areas lied within the project site and its immediate vicinity.

Shrestha, (2012) studied the social impact assessment of the proposed Arun III Hydroelectric Project and he revealed that there would be moderate impact due to implementation of the project because the project is confined in gorge like valley; vegetation clearance in the project area is minimum; there is significant flow or tributaries between dam and the powerhouse sites which increases the water flow downstream; and the amount of land and property needed to be acquired is minimum. The project will provide employment to a large number of people during construction. However, few negative impacts resulting from the implementation of the project can be reduced or mitigated using simple and inexpensive measures.

CHAPTER: III

MATERIALS AND METHOD

3.1 Study Area

The study area is Karnali river, the geographical boundary of mid-western and far-western development region. The river makes a big loop in its lower reach near a place called Asaraghat. From here the river flows in the south-east direction for about 25 kilometers, after that it makes a complete reversal in its direction. The river comes back flowing in the north-west direction for next 29 km to a point, called Tallo Balde, just 2.5 km away from its earlier position. The whole loop covers about 54 km river distance. There is a drop of 150 meters in the river bed elevations between these two positions merely two and half kilometers away from one another. The project to utilize this bend for power generation is known as the Upper Karnali Hydroelectric Project (GMR report, 2010). The dam site of the proposed Upper Karnali Hydroelectric Project is located at Tuinkuna, the eastern arm of the river bend, 1.5 km upstream from Ramgad khola confluence. Geographically, it lies on latitude 28 55'23" N and longitude 81 28'20" E (GMR report, 2010). There is a road access from Surkhet along the Karnali highway (Surkhet-Jumla highway). The dam site is 95 km away from Birendranagar, Surkhet.

The power house site is located at the western arm of the river bend on the right bank 1.25 km upstream of Tallo Balde of Bhairabsthan VDC-1, Achham district. Geographically, it lies on latitude 28 54'02" N and longitude 81 26'40" E (GMR report, 2010). There is no road accessibility to the power house site.

The catchment area of Karnali river up to the proposed dam site of UKHEP is 21,458 km^2 and it lies between latitudes 28 55' N to 30 36' N and longitudes 80 39' E to 83 31' E. The annual maximum temperatures in the project area occur generally in the month May and ranges from 25 C to 35 C. Likewise the minimum temperature generally occurs in the month January and February ranging from 5.5 C to 13 C (GMR report, 2010).

Figure 3.1: *Map of Project area showing the Project and the related VDCs (GMR report, 2010)*

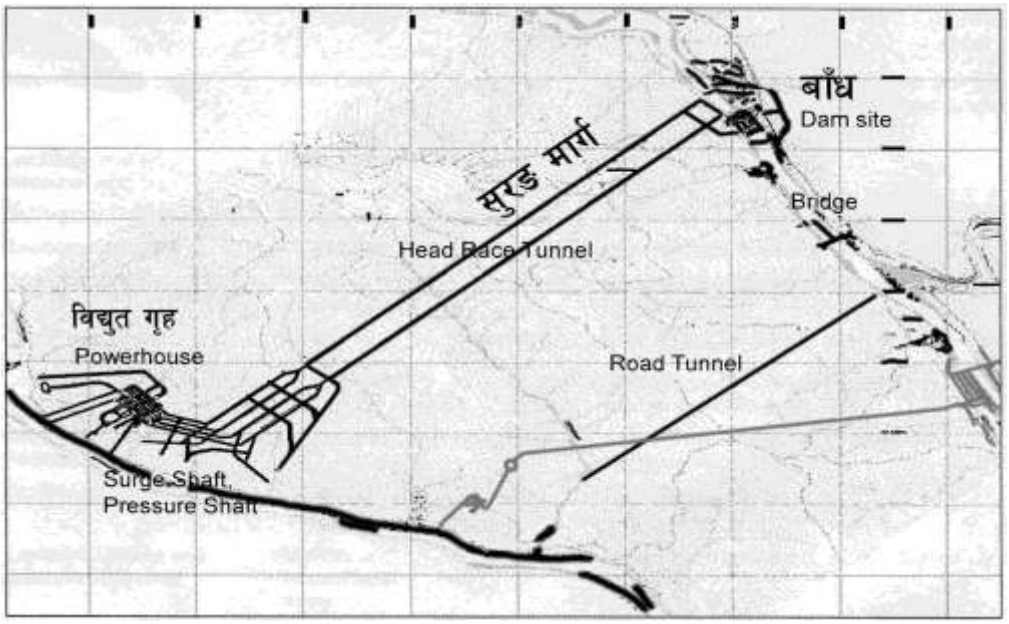

Figure 3.2: *Map of project area showing dam site, powerhouse site and headrace tunnel (GMR report, 2010)*

Table 3.1: Important salient features of the Upper Karnali Hydroelectric Project

LOCATION	
Country	**Nepal**
District	Surkhet, Dailekh and Achham
River	Karnali
Geographical location	Boundary of Mid-Western and Far-Western development regions of Nepal
Survey license boundary	Latitude 28 42'00"N to 28 58'00" N and Longitudes 81 25'00" E to 81 35'30" E
Dam location	Eastern arm of Karnali bend 1.5 km upstream of Ramgad khola confluence Latitude 28 55'23" N and longitude 81 28'20" E
Powerhouse location	Western arm of Karnali bend on right bank 1.25 km upstream of Tallo Balde khola Latitude 28 54'02" N and longitude 81 26'40" E
HYDROLOGY	
Catchment area	21,458 km²
Annual Average rainfall	920 mm
Max. average monthly flow	1384 cumec
Min. average monthly flow	117 cumec
1 in 1000 year flood	6700 cumec
1 in 10,000 year flood	8050 cumec
RESERVOIR	
Full reservoir level (FRL)	EL. 637.00 m
Min. draw down level (MDDL)	EL. 633.00 m
Gross storage	17.86 MCM
Live storage	6.66 MCM
Surface area at FRL	196 ha
Length of reservoir at FRL	8.9 km
RIVER DIVERSION WORKS	
Diversion discharge	600 cumec
DAM	
Type	Concrete gravity type
Dam top	EL. 640.00 m
Length at dam top	207 m

Max. height	64 m from deepest foundation level and 30 from river bed level
POWER INTAKE	
No. and size of openings	4 nos.; 15m×11.25m
Design discharge	744 cumec
Invert level	EL. 617.50 m
Length	146 m
Power house	
Type	Surface
Installed capacity	900MW
No. and capacity of units	8 nos.×112.5MW
Design discharge	664.32 cumec
Gross head	159.26 m
Rated net head	150.11 m
POWER GENERATION	
Design annual energy generation	3466 MU
PLF (Design)	43.96%
Min. peaking hours	3.26 hours

Source: NESS, 2012

Note: - The detail salient features of the proposed UKHEP is shown in Annex 3

3.2 Methodology for Water Resource Potential

The secondary data of daily discharge and precipitation at hydrological station no. 240 (Asaraghat) was obtained from Department of Hydrology and Meteorology (DHM). The data of latest 33 years i.e. from 1978 to 2010 were processed; and long term daily average discharge and average annual precipitation was calculated using MS-Excel 2007 program. As the watershed area of the hydrological station no. 240 (Asaraghat) is 21438 km^2 while that of the proposed dam site is 21458 km^2; 20 km^2 additional watershed area is covered by the proposed dam site. That's why; long term daily average discharge at proposed dam site was attained by multiplying the long term daily average discharge at Asaraghat station by the factor 1.00093. Thus obtained daily average discharge data was arranged in descending order of magnitude from highest to the lowest value, with each

flow value being assigned a rank. For each value the percentage of time/exceedence probability (P) was calculated as $P = (m/N) \times 100$

Where,

m = rank

N = Total no. of data in record

Then, flow duration curve was constructed plotting percentage of time on X-axis and discharge on Y-axis (Reddy, 2002). According to the design guideline of Department of Electricity Development (DoED), 40% dependable flow (Q_{40}%) was considered. To determine the theoretical power potential, the following were the design consideration:

a. The net head was considered as 150.11 m (GMR, 2011)

b. The overall efficiency of 84%.

c. The downstream release of 10 % was considered for environmental consideration.

Then, the power was calculated by using theoretical power potential as

$P = 9.81 \eta Q H$

Where,

η = overall efficiency

Q = design discharge at 40 percentile

H = head

3.3 Methodology for physico-chemical parameters

3.3.1 Sampling Sites

Four sampling sites were selected along the river such as upstream (site I), dam site (site II), dewatered zone (site III) and powerhouse site (site IV) on the basis of their structural impact importance.

Site I: Upstream of the proposed dam site

This site is upstream zone of the proposed dam site located at Sisne in Singaudi VDC-5, Dailekh. It is about 7.5 km north-west to the dam site. The site lies on latitude 28 57'29.9" N and longitude 081 25'53.9" E with elevation 613 m from masl which was fixed with the help of GPS. The width of the river at the site was found to be 99 m. The right bank (Bhairabsthan VDC of Achham) is gentle cliff with human habitation and few patches of farmlands while there is lowland area with cultivation and few no. of human habitation on the left bank (Singaudi VDC of Dailekh) (Field survey, 2012).

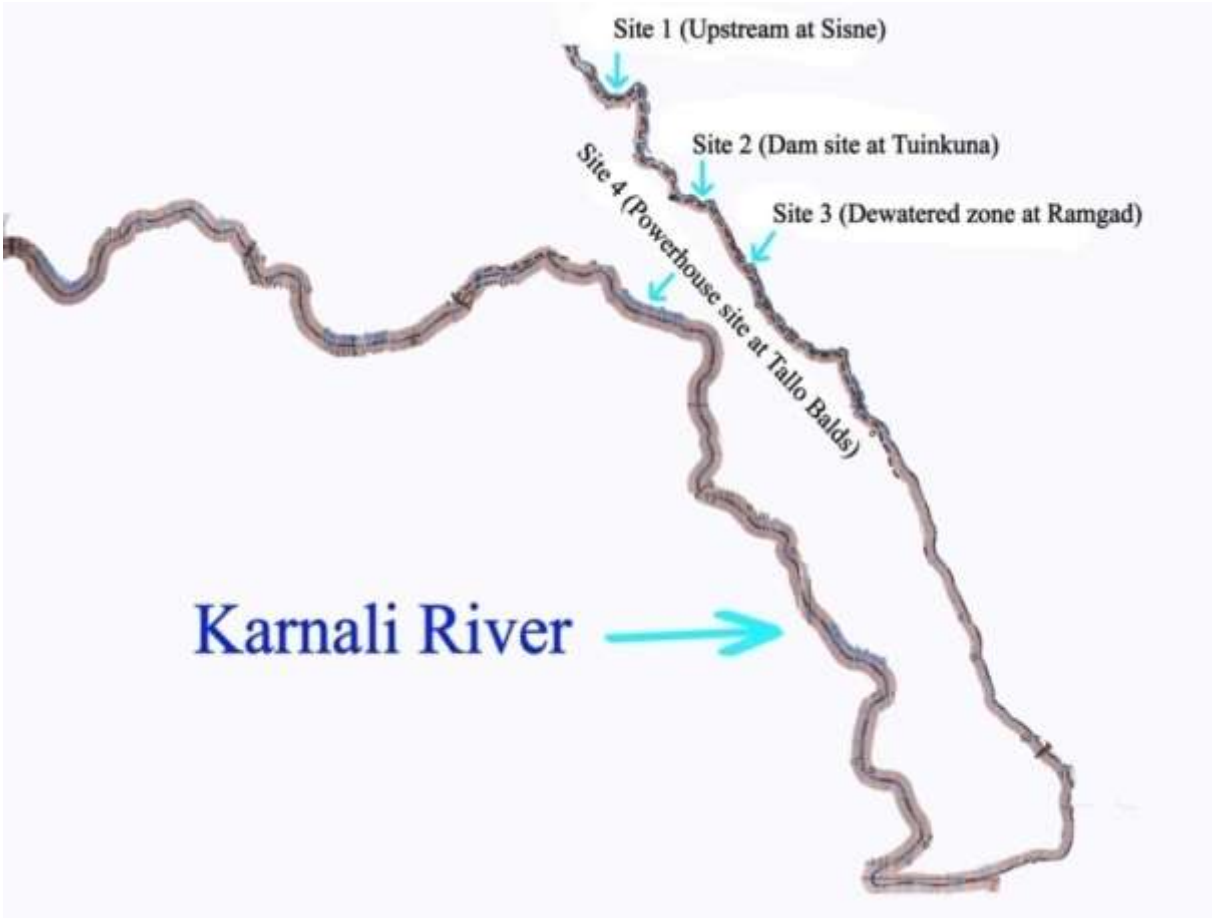

Figure 3.3: *Map showing the sampling sites in the Karnali river*

Site II: Proposed Dam Site

It is the proposed dam site located at Tuinkuna. The GPS reference point for this site is latitude 28 55'24.2" N and longitude 081 28'14" E with elevation 603 m. from masl. The river width at the time of data collection was found to be 69 m. There is vertical cliff on both side of the river. Karnali highway is passing through on the left bank (Sattala VDC-1, Dailekh) while the right bank (Bhairabsthan VDC-4, Achham) is covered with dense forest of Sal tree. Tunnels (Drift-1 on the right bank and Drift-2 on the left bank) were constructed by GMR for rock testing. An army camp was established about 500 m above the sample site (Field survey, 2012).

Site III: Downstream of the Proposed Dam site (Dewatered zone)

It is the dewatered zone located at Ramgad. The site was chosen just 155 m north-west to the confluence of Ramgad khola with Karnali river. The GPS reference point is latitude

28 54'48.2"N and longitude 081 28'36.2" E with elevation 601 m. from masl. This site is 1.5 km south-east to the proposed dam site. There is a Ramgad Bazaar with more than 100 households and shops alongside of the Ramgad khola on the left bank (Sattala VDC-1, Dailekh district) while the vertical cliff with dense forest of Sal tree on the right bank (Bhairabsthan VDC-4, Achham). The river width at the time of data collection was found to be 92 m (Field survey, 2012).

Site IV: Proposed Powerhouse Site

This site is located at the western arm of the river bend on the right bank of Tallo Balde in Bhairabsthan VDC-1, Achham district. The GPS reference point is latitude 28 53'59.3" N and longitude 081 26'34.6" E with elevation 456 m from masl. It is the point just 2.5 km tunnel distance from the dam site on the next face of the same hill while the river traversing distance from the dam site to the powerhouse site is recorded 54 km. The right river bank is a steep cliff with dense Sal forest situated at the boundary of Achham district while there is another steep cliff with dense mixed forest on the left river bank, the boundary of Surkhet district. The river width at the time of data collection was found 66 m (Field survey, 2012).

3.4 Time and Schedule for Research

The preliminary field visit was carried out in June 1-9, 2012 in pre-monsoon. At that time, consultation with the GMR officials (The project developer), informal discussion with the local political leaders and Pariyojana Sarokar Samiti were done. The proposed dam site and the powerhouse site were also visited.

The second field visit was carried out in November 17-27, 2012 in post-monsoon. In that duration, water quality sampling and detail socio-economic survey was done. General physico-chemical parameters were tested in the field by carrying the portable chemical box while other parameters were tested in lab of Central Department of Environmental Science (CDES), T.U. The water samples were also tested in the lab of National Academy of Science and Technology (NAST) for verification. After the field visit, calculation of field data and report writing was done. During this period literature was reviewed by visiting library and internet and by conferring with thesis supervisor.

3.5 Methods of analysis of Physico-chemical parameters

3.5.1. Temperature:

The temperature of water and air was measured by using a digital thermometer. The surface water was collected in a beaker. Soon after the collection of the water sample, the thermometer was dipped into the water sample and noted the reading.

3.5.2. pH

For the measurement of pH (Potentia hydrogenii) of water, water sample was taken in a clean beaker and electrode (rinsed with distill water & blot dried) of pH meter of model HI 8314 portable pH meter (Hanna instruments, Manufacturers with accuracy of ± 0.01 at 20 C/68 F) was dipped into the water sample. Equilibrium between electrodes and water sample was established by stirring water sample to ensure homogeneity. It was stirred gently to minimize CO_2 entrainment. Then, the reading of pH meter was noted. On each sampling day, electrodes from storage solution was removed, rinsed with distilled water, blot dried with a soft tissue paper and placed in buffer solutions (pH 4 and 9.2) and set the pH meter with the pH of buffer (APHA, 1995).

3.5.3. Transparency:

The transparency was measured in the field by lowering a secchi disc of 20 cm diameter in the river with the help of a string tied to it, until it just disappeared. The depth was noted by marking on the string. Then the secchi disc was uplifted and noted the depth at which it reappeared again. For better results, measurements should be made during the middle of the sunny days. The secchi disc transparency was calculated by the following equation (Trivedi and Goel, 1986).

Secchi disc light penetration = A+B/2

Where,

A = depth at which secchi disc appears

B = depth at which secchi disc disappears

3.5.4. Electric conductivity:

For the measurement of conductivity of water, the calibrated (with standard potassium chloride solution of 0.01 N) conductivity meter of Model 4150 *(with Accuracy of* ± 0.5 % ± 2 digits) was first brought into the conductivity mode. Then the electrode was

washed and rinsed a few time with distilled water and then dipped in the beaker containing the sample water. The conductivity reading was noted down after the reading stabilized at the certain point.

3.5.5. Total dissolved solids (TDS):

Total dissolved solids are the residue left after evaporation of the filtered water sample. TDS in a water sample can be estimated by multiplying conductivity (in μS/cm) by an empirical factor. This factor may vary from 0.55 to 0.9, depending on the soluble components of the water and on the temperature of measurement. Relatively, high factors may be required for saline or boiler waters, whereas lower factors may apply where considerable hydroxide or free acid is present (APHA, 1995). For the measurement of TDS, the instrument (conductivity meter of Model 4150) was first brought into the TDS mode. The electrode was rinsed with distilled water. The electrode was dipped into the sample water contained in a clean beaker that gave TDS directly.

3.5.6. Total Suspended Solids (TSS):

Total Suspended Solids are the solids retained on the filter paper. A well-mixed water sample (of 100 ml) was filtered through a weighed standard filter paper (Whatmann no. 44) and the residue retained on the filter paper was dried to a constant weight at 105 . The increase in weight of the filter paper represents the TSS. If suspended material clogs the filter and prolongs filtration, the difference between the total solids and TDS may provide an estimate of the TSS. It is calculated by the following equation (APHA, 1995).

TSS (mg/L) = (A-B) $\times$1000/Volume of sample taken (ml)

Where,

A = Weight of filter paper + dried residue (mg)

B = Weight of filter paper (mg)

3.5.7. Alkalinity:

For the determination of alkalinity, 100 ml of water sample was taken and added 2 drops of phenolphthalein indicator. When the solution remained colorless, Phenolphthalein Alkalinity (PA) is zero. When the color changed into pink after addition of phenolphthalein, it was titrated with 0.1 N HCl until the color disappeared at end point.

This is PA. Then 2-3 drops of methyl orange was added to the same sample and continued the titration further until the yellow color changed into pink at end point. This is total alkalinity (TA) (APHA, 1995; Trivedi and Goel, 1986). They are calculated by the following equations:

PA as $CaCO_3$ (mg/l) = (A×normality of HCl×50/vol. of sample taken) ×1000

TA as $CaCO_3$ (mg/l) = (B×normality of HCl×50/vol. of sample taken) ×1000

Where,

P= Phenolphthalein alkalinity

T= Total alkalinity

A= Volume of HCl used in titration with Phenolphthalein.

B= Volume of HCl used in titration with Methyl orange.

Concentration of carbonates, bicarbonates and hydroxyl ions can be determined from the table 4 using data of PA and TA.

Table 3.2: Values of hydroxyl ions, carbonates and bicarbonates from the values of phenolphthalein and total alkalinities

Result of Titration	OH alkalinity as $CaCO_3$	CO_2 alkalinity as $CaCO_3$	HCO_3 alkalinity as $CaCO_3$
P = 0	0	0	T
P = ½ T	0	2P	T – 2P
P = ½ T	0	2P	0
P > ½ T	2P – T	2(T – P)	0
P = T	T	0	0

Source: APHA, 1995

Where,

P= Phenolphthalein alkalinity

T=Total alkalinity

3.5.8. Total Hardness

For the determination of hardness, 50 ml of water sample was taken in a clean beaker. If the water sample is having higher calcium, a smaller volume should be taken and diluted to 50 ml. Then 1 ml of buffer solution was added. If the water sample is having higher amounts of heavy metals, 1 ml of Na_2S should be added. Then, 100-200 mg of Erichrome Black T indicator was added, the solution turned wine red. The content was

titrated against the EDTA solution and the color changed from wine red to blue at the end. The hardness is calculated by the following equation. (APHA, 1995; Trivedi and Goel, 1986).

Hardness as $CaCO_3$ (mg/l) = (Vol. of 0.01N EDTA used/Vol. of sample in ml) ×1000

When hardness numerically is greater than the sum of carbonate and bicarbonate alkalinity, that amount of hardness equivalent to the total alkalinity is called "Carbonate hardness"; the amount of hardness in excess of this is called "non-carbonate hardness". When the hardness numerically is equal to or less than the sum of carbonate and bicarbonate alkalinity, all hardness is carbonate hardness and non- carbonate hardness is absent (APHA, 1995).

3.5.9. Free Carbon dioxide (CO_2):

For the determination of free carbon dioxide content of water sample, 100 ml of water sample was taken in a conical flask and added few drops of phenolphthalein indicator. If the color turns pink, free CO_2 is absent. When the water sample remained colorless, it was titrated against 0.05 N sodium hydroxide till pink color appeared at the end point. It is calculated by the following equation (APHA, 1995).

Free (CO_2) mg/l = (A×normality of NaOH×44/Vol. of sample taken) ×1000

Where,

A= Volume in ml of NaOH used

3.5.10. Chloride

To determine chloride, 50 ml of water sample was taken and added 2 ml of potassium chromate (K_2CrO_4) solution. It was titrated against 0.02 N silver nitrate until a persistent red tinge appeared. It is calculated by the following equation (Trivedi and Goel, 1986)

Chloride (mg/l) = (V×N×35.5/Vol. of sample taken) ×1000

Where,

V= volume of titrate (silver Nitrate)

N= Normality of $AgNO_3$

3.5.11. Dissolved Oxygen

Dissolved Oxygen (DO) was determined by the Wrinkler or Iodometric method. The water sample was filled in a glass stoppered bottle (BOD bottle) avoiding any kind of bubbling and trapping of the air bubbles in the bottle after placing the stopper. 2 ml of each $MnSO_4$ and alkaline KI solution was poured well below the surface from the walls. A precipitate appeared. The contents were shaken well in an "8" shape repeatedly. The bottle was kept for some time to settle down the precipitate. If the titration is to be prolonged for few days, the water sample at this stage with precipitate should be kept Then 2 ml of concentrated H_2SO_4 was added and shaken well to dissolve the precipitate. 50 ml of the contents was taken preventing any bubbling to avoid further mixing of oxygen. 2-3 drops of starch as indicator was added to it and titrated against sodium thiosulphate where color changed from blue to colorless at the end. The dissolved oxygen is calculated by the following equation (APHA, 1995; Trivedi and Goel, 1986).

$$\text{Dissolve oxygen (mg/l)} = \frac{(\text{Vol.} \times \text{normality of thiosulphate} \times 8 \times 1000}{V_2 \times [(V_1 - V)/V_1]}$$

Where,

V_1= Volume of sample bottle

V_2 = Volume of part of content titrated

V = Volume of $MnSO_4$ and KI added

3.5.12. Orthophosphates:

Orthophosphate can be calorimetrically determined by stannous chloride method which is more suited for the range of 0.01 to 6 mg P/L (APHA, 1995). The standard calibration curve containing concentration and absorbance was prepared as follows. For this, 4.388 gm of dried anhydrous potassium hydrogen phosphate (K_2HPO_4) was dissolved in distilled water and made the volume of 1 liter. This solution was diluted to 100 times to make the standard solution containing 10 mg P/L i.e. 1 ml = 0.01 mg P. From the standard phosphate solution, various dilutions at the interval of 0.1 mg P/L were made. Absorbance of these diluted standard solutions was determined employing the same procedure as for the sample. A standard calibration curve of absorbance versus concentration was prepared from this (Trivedi and Goel, 1986).

Sample measurement:

50 ml of filtered water sample was taken in a volumetric flask. If the water sample contains color and colloidal impurities, they can be removed by adding a spoonful of activated charcoal and then filtering the water sample. 2 ml of ammonium molybdate was added to the water sample which was followed by 5 drops of stannous chloride solution. A blue color appeared. Reading was taken at 690 nm in spectrophotometer of Model 7225 using a distilled water blank with the same amount of chemicals. The readings were taken after 10 minutes but before 12 minutes of the addition of the latest reagent. Using the same specific interval for all determinations, the concentration was found out with the help of the standard calibration curve (APHA, 1995 and Trivedi and Goel, 1986).

3.5.13. Nitrate-Nitrogen:

Nitrate was determined by phenol disulfonic acid method. The standard calibration curve containing concentration and absorbance was prepared as follows. For this, 0.722 gm of potassium nitrate (KNO_3) was dissolved in distilled water and made up the volume of 1 liter. This solution contains 100mg N/L. It was diluted to 100 times to prepare a solution having 1 mg N/L. From this standard nitrate solution, different dilutions from 0.1mg N/L to 1.0 mg N/L at the interval of 0.1 were prepared. Absorbance of these diluted standard solutions was determined following the same procedure as for the sample. Using concentrations and their respective absorbance, a standard calibration curve was prepared (APHA, 1995 and Trivedi and Goel, 1986).

Sample measurement:

50 ml of water sample containing not more than 1 mg/L of NO_3-N was taken in a conical flask. Then an equivalent amount of silver sulphate solution was added to remove chlorides. It was then heated slightly and the precipitate of silver chloride (AgCl) was filtered. Then the filtrate in the porcelain basin was evaporated to dryness. It was then cooled and the residue was dissolved in 2 ml phenol disulphonic acid and diluted to 50 ml. Then 6 ml of liquid ammonia was added which developed yellow color. Similar process was done for blank distilled water. Then the absorbance was noted in spectrophotometer of Model 7225 at 410 nm (Trivedi and Goel, 1986).

3.5.14. Iron

The iron present in the water sample was determined by Spectro-photometry. The iron content in water reacts with Phenonthroline as indicator to form a colored complex. The amount of light absorbed by this complex was measured. Beer‘s law can be used to determine the concentration relative to absorption. For construction of the calibration curve various dilutions from the standard iron solution were prepared up to volume 100 ml and discard 50 ml then add 2 ml of conc. HCL, 1 ml of Hydroxylamine Hydrochloride solution, 10 ml of ammonium acetate buffer and 2 ml of Phenonthroline solution and make the volume 100 ml and finally after the 10 minute take the reading at 510 nm on a spectrophotometer.

Sample Measurement:

Fifty ml of water was taken in a 150 ml conical flask and added 2 ml of concentration HCl and 1 ml of Hydroxylamine hydrochloride. Then keep the some glass beads in a conical flask and boil till the content is reduced to half and then cooled. After cool the boiled sample added 10 ml of Ammonium acetate buffer solution and then 2 ml of Phenonthroline solution and appears orange- red color. After orange-red color appeared added the distilled water and make the volume 100 ml and finally after 10 minute reading was taken at 510 nm on a Spectrophotometer.

3.6 Methods of analysis of Socio-economic parameters:

The overall population, literacy rate, no. of households, agricultural and irrigable land of the project affected VDCs were obtained from the secondary data published by Central Bureau of Statistics, District Development Committees of Dailekh and Achham and Village Development Committees of Bhairabsthan and Sattala. District Profiles published by the DDC of Achham and Dailekh, related map and other published documents were also consulted.

For primary data collection, a combination of structural and informal research techniques were used. Field observation, household level survey questionnaires, key informant interviews, group discussion with the severely project affected families (SPAFs) were also conducted. Individual household survey was conducted in 70 households of the Project Affected Families (PAFs) which were randomly selected in Ward no. 1, 3 and 4

of Bhairabsthan VDC (Achham district) and ward no. 1 and 4 of Sattala VDC (Dailekh district) for primary data collection of socio-economic condition. Among them, 58 were male and 12 were female respondents.

Previously, NESS had identified 236 households as SPAFs of which 184 households will lose their agricultural land and 52 households will completely lose their houses and other physical infrastructures (Summarized version of EIA report of UKHEP, NESS, 2012). The individual household survey was carried out in Daba village of Sattala VDC which lies 1.5 km upstream of proposed dam site, Thalpata village of Bhairabsthan VDC and Asaraghat Bazaar of Sattala VDC which lies 5.5 km upstream of the proposed dam site and Tallo Balde village of Bhairabsthan VDC which lies 1.25 km downstream of proposed powerhouse site. All the 70 households are regarded as PAFs and among them, 53 households are regarded as SPAFs. That means the sampling for primary data collection covered 22.46% of SPAFs as identified by NESS.

Out of 70 respondents, 20 were fishermen and separate questionnaires regarding fisheries were also asked to them. During the field survey, the study team had number of consultative meeting with the local people, local political leaders, teachers and Pariyojana Sarokar Samiti. There were also informal meetings with the civil engineer and other officials of GMR Company offices established in Surkhet and Daba, Dailekh.

The collected data were compiled, presented in a tabular or graphical form and analyzed using MS-Excel 2007. The socio-economic impacts were assessed based on:

Impact Identification

A set of questions were prepared and asked to the project affected people. The questions were linked to each other to the extent possible and used tick mark (√) on respondents' answers (Uprety, 2003).

Impact prediction

Expert judgment was used to predict impact of the proposed action on the environment (Uprety, 2003).

Impact evaluation

In this process, consultation was done with stakeholders and experts in order to evaluate the significance of impact of the project on the environment. In addition, the prevailing laws and existing cultural norms were also used to evaluate the significance of some impacts (Uprety, 2003).

National EIA Guidelines 1993 developed the scoring and ranking system for evaluating the socio-economic and bio-physical impacts of the proposed project which was followed in order to evaluate the level of socio-economic impacts and their significance. The scoring method used for determining the level of impact to be created is as follow.

Table 3.3: Impact categories used in level of impact (National EIA Guidelines, 1993)

Nature	Categories	Score given	Basis of classification
Magnitude (M)	High (H)	60	Observation on magnitude and reversibility of impact
	Medium (M)	20	
	Low (L)	10	
Extent (E)	Regional (R)	60	Beyond the watershed
	Local (Lo)	20	Close to project area/ within watershed
	Site Specific (Ss)	10	Confined to project area
Duration (D)	Long term (Lt)	20	>20 years
	Medium term (Mt)	10	3 to 20 years
	Short term (St)	5	< 3 years

The scores allocated for each impact parameter were then summed up to get the total score of each impact parameter. Impacts having total score of over 70 were considered very significant; impacts having 40 to 70 score were considered significant; and impacts having total score of less than 40 were considered insignificant for this project. However, some of the impacts whose total score exceeded 40 were not taken as significant in view of the nature of the predicted impacts. All identified impacts were considered highly significant. Some impacts having less than 40 score were also considered as significant and logical base for such ranking had been given in the remarks, and it is more or less related with the extent and duration of the impacts. For example, impacts likely to occur outside the project's core area and of indirect nature may not be significant although the total score exceeds 40 (Shrestha, 2012).

CHAPTER: IV

RESULT

4.1 Water Resource Potential:

The value of 40% design discharge was found to be 439.11 m^3/s as shown in figure 4.1. Considering net head of the proposed project of 150.11 m and overall efficiency of 85%, the theoretical hydropower potential of the proposed UKHEP was calculated as 549.63MW.

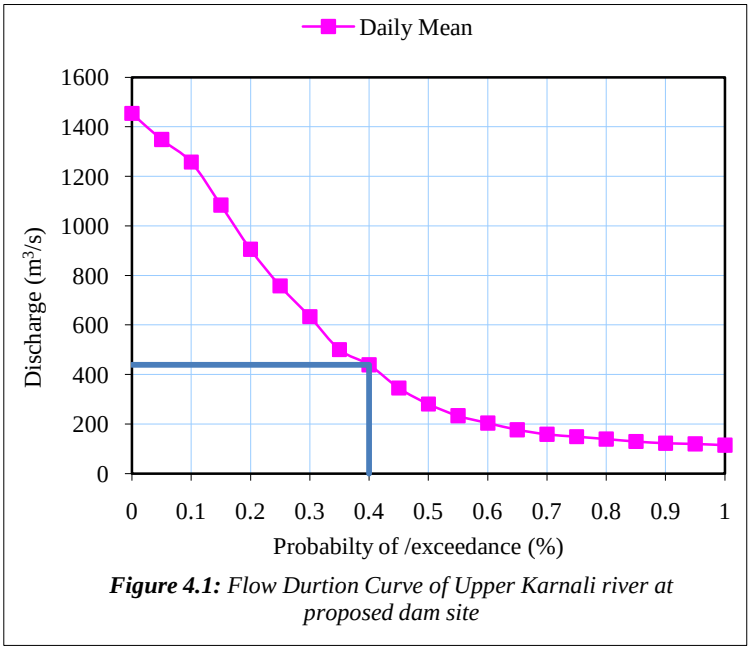

Figure 4.1: *Flow Durtion Curve of Upper Karnali river at proposed dam site*

Thus obtained value is the theoretical hydropower potential. If the developer constructs the hydroelectric project considering 549.63MW as the firm power, the project will be operated 24 hours in full capacity for only four months i.e. from June to September as shown in figure 4.2, at which time heavy discharges occur in the Karnali river due to monsoon rainfall. The capacity will reduce in other months. About 518.51MW and 494.02MW power will be produced in the months October and May respectively while in rest of the year, less than half or only one third power will be produced from the project because of heavy reduction in river discharge.

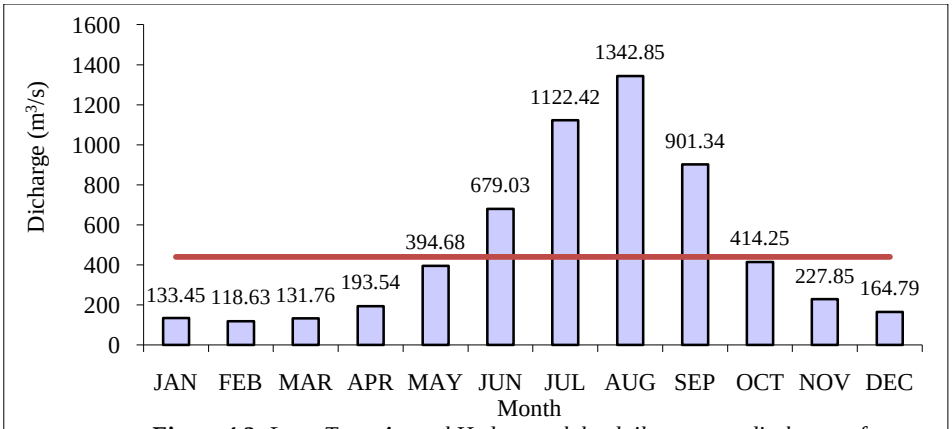

Figure 4.2: *Long Term Annual Hydrograph by daily average discharge of Upper Karnali*

4.2 Physico-chemical parameters:

4.2.1 Ambient air temperature ( )

The ambient air temperature of the sampling sites varied from 29 to 31 during pre-monsoon (June, 2012) while it ranged from 18 to 20 during post-monsoon which is shown in figure 4.3. Minimum temperature was recorded in powerhouse site both in pre and post-monsoon period.

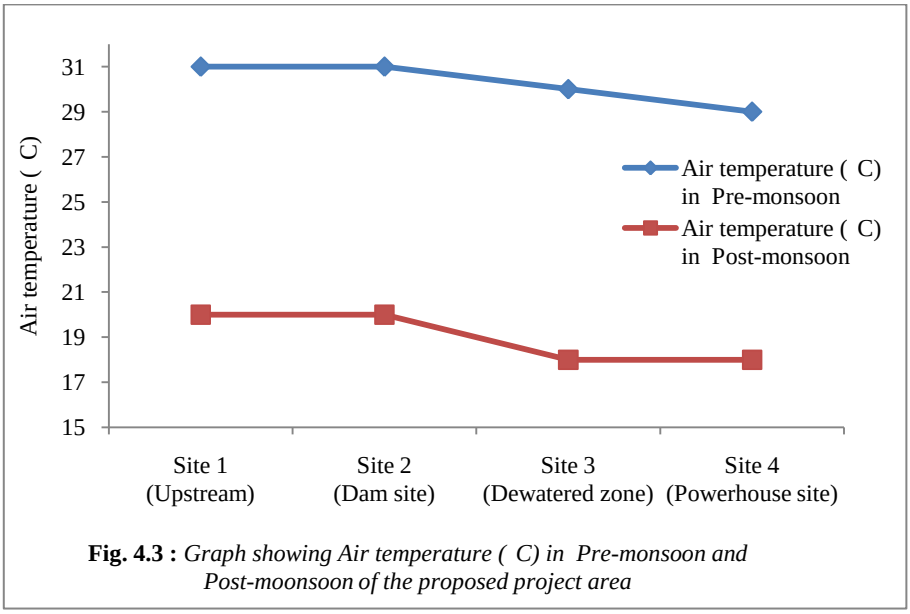

Fig. 4.3 : *Graph showing Air temperature (C) in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.2 Water temperature ( ):

Water temperature of the sampling sites varied from 15 to 17.5 in pre-monsoon and 10.4 to 14.4 in post-monsoon.

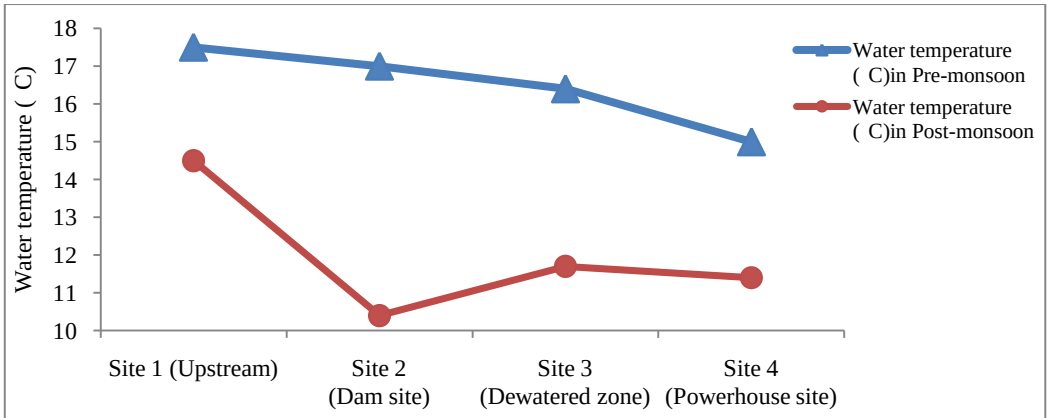

Fig. 4.4 : *Graph showing Water temperature (℃) in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.3 pH:

pH values recorded in all the sampling sites were found to be quite alkaline in post-monsoon. pH values of upstream, dam site, dewatered zone and powerhouse site were recorded 8.4, 8.7, 8.4 and 9.7 in post-monsoon whereas those in pre-monsoon were recorded 7.3, 7.3, 7.2 and 7.4 respectively.

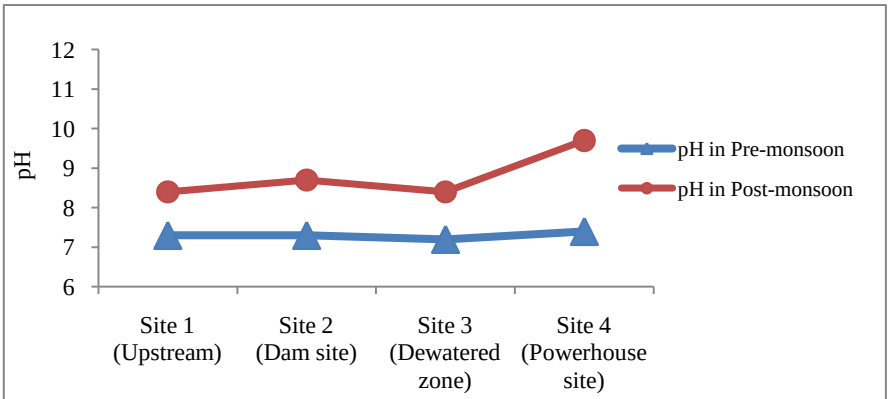

Fig. 4.5: *Graph showing pH in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.4 Secchi disc transparency:

The secchi disc transparency of the sampling sites ranged from 93 cm to 102 cm during pre-monsoon while it varied from 203cm to 227cm during post-monsoon. In pre-monsoon, transparency value was found to be the highest (102cm) in upstream and lowest in dewatering zone (93cm).The case is different in post-monsoon. It was found to be the highest in dam site (227cm) and the lowest in powerhouse site (203cm).

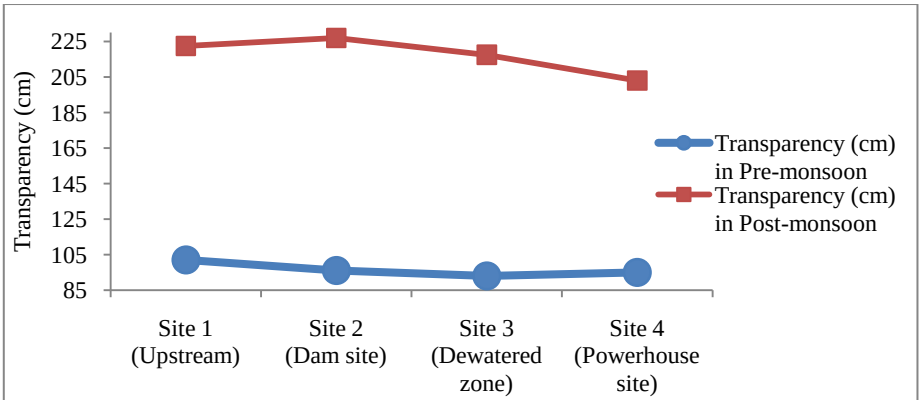

Fig. 4.6: *Graph showing Transparency in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.5 Electric conductivity:

The electric conductivity values were recorded as 113 µs/cm, 134 µs/cm, 158 µs/cm and 147 µs/cm in upstream, dam site, dewatered zone and powerhouse site respectively in pre-monsoon and those in post monsoon were 255 µs/cm, 325 µs/cm, 340 µs/cm and 298 µs/cm respectively.

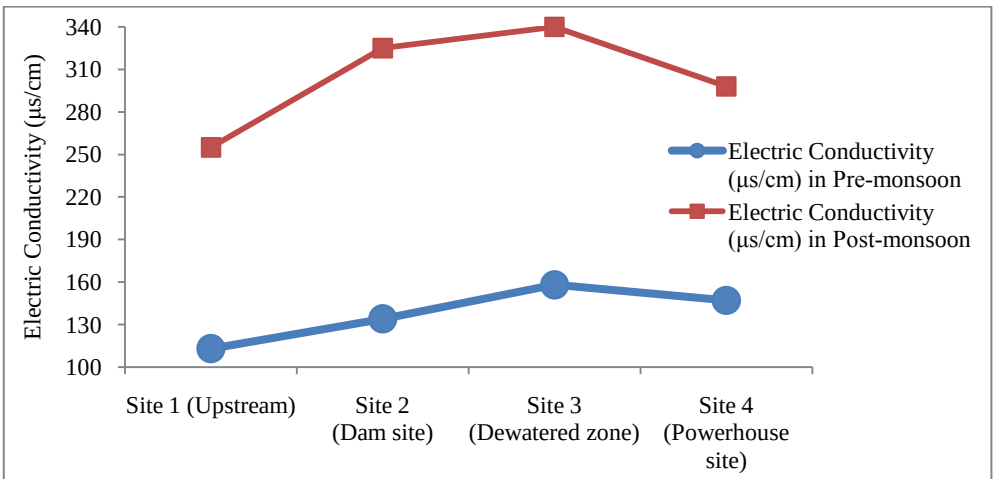

Fig. 4.7 : *Graph showing Electric Conductivity in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.6 Turbidity:

Turbidity values of upstream, dam site, dewatering zone and powerhouse site were found to be 0.4 NTU, 0.6 NTU, 0.6 NTU and 0.3 NTU respectively in post-monsoon. It was lowest in powerhouse site. Similarly, the values were 1.2 NTU, 8.9 NTU, 2.8 NTU and 1.3 NTU respectively in pre-monsoon. The highest value of turbidity was found in dam site in pre-monsoon.

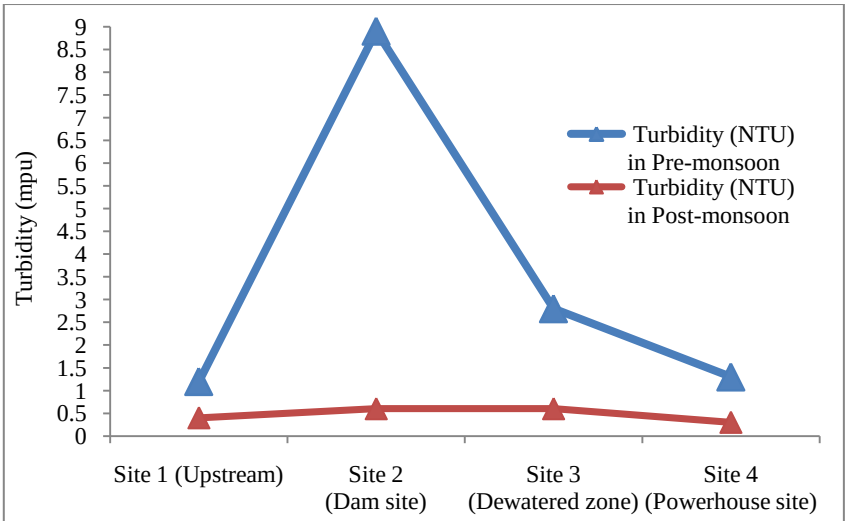

Fig. 4.8 : *Graph showing Turbidity in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.7 Chloride:

The chloride content of the Karnali river varied from 7.1 mg/l to 11.36 mg/l during pre-monsoon while it ranged from 19.88 mg/l to 24.14 mg/l during post-monsoon.

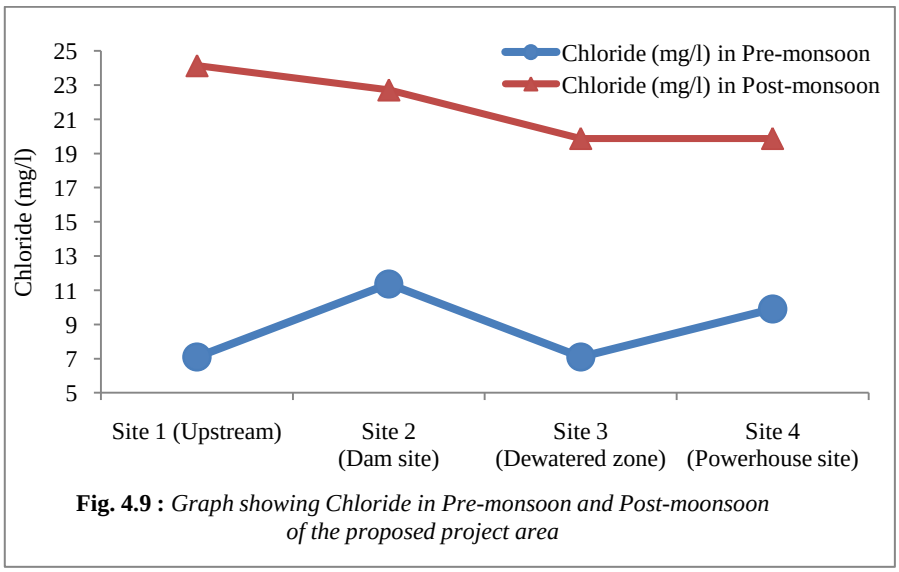

Fig. 4.9 : *Graph showing Chloride in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.8 Free CO_2:

Free CO_2 concentration of the sampling sites ranged from 13.2 mg/l to 15.4 mg/l during pre-monsoon and from 17.6 mg/l to 19.8 mg/l in post-monsoon.

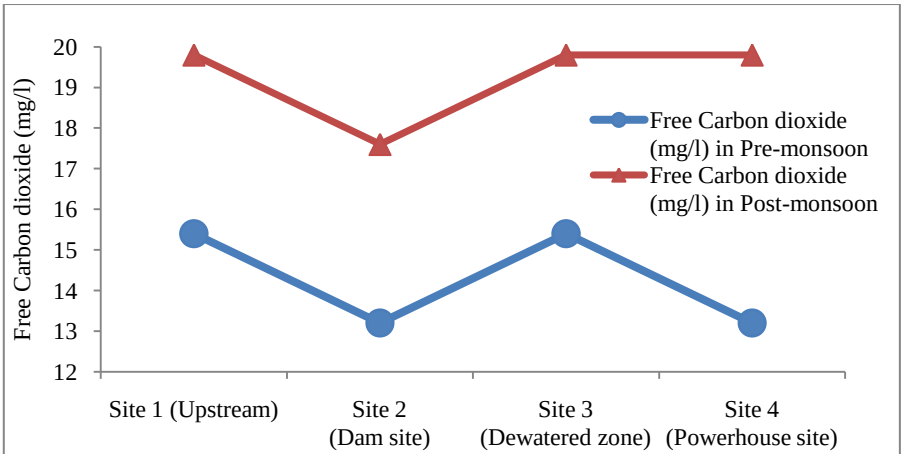

Fig. 4.10 : *Graph showing Free Carbon dioxide in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.9 Total hardness:

The values of total hardness were recorded 90 mg/l, 88 mg/l, 90 mg/l and 86 mg/l in upstream, dam site, dewatered zone and powerhouse site respectively in post-monsoon. In the same way, the values were 142 mg/l, 136 mg/l, 150 mg/l and 150 mg/l respectively in pre-monsoon.

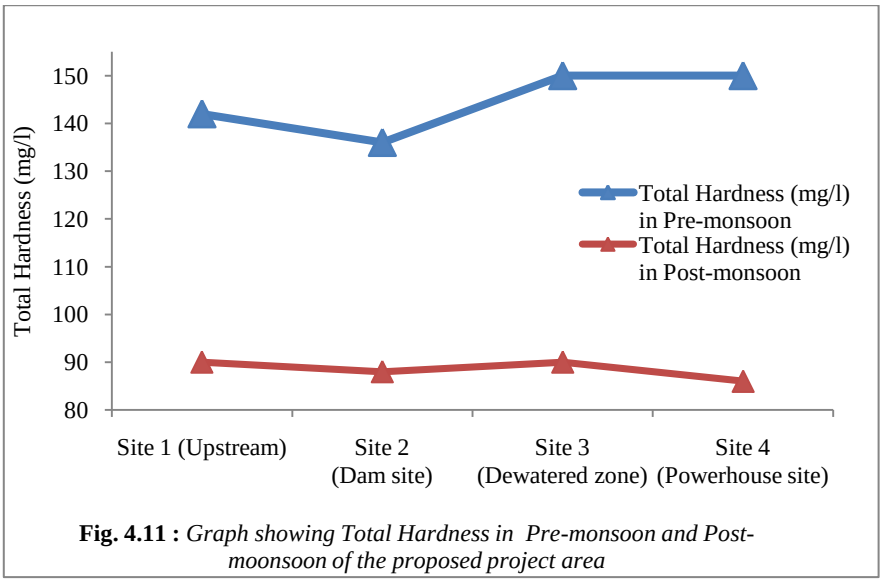

Fig. 4.11 : *Graph showing Total Hardness in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.10 Total alkalinity:

Total alkalinity of the sampling sites varied from 5 mg/l to 10 mg/l in pre-monsoon and from 10 mg/l to 15 mg/l in post-monsoon which is shown in figure 4.12.

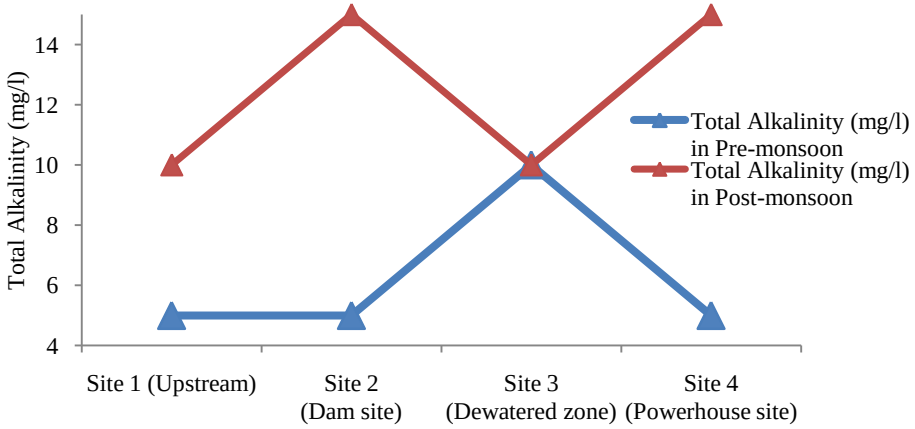

Fig. 4.12: ***Graph showing Total Alkalinity in Pre-monsoon and Post-moonsoon of the proposed project area***

4.2.11 Dissolved oxygen (DO):

Dissolved oxygen concentration was lowest (8.86 mg/l) in upstream in pre-monsoon while it was lowest in powerhouse site (11.27 mg/l) in post-monsoon. The values upstream, dam site, dewatered zone and powerhouse site were found to be 8.86 mg/l, 10.07 mg/l, 9.26 mg/l and 10.07 mg/l respectively in pre-monsoon while they were 12.73 mg/l, 12.89 mg/l, 12.73 mg/l and 11.27 mg/l respectively in post-monsoon.

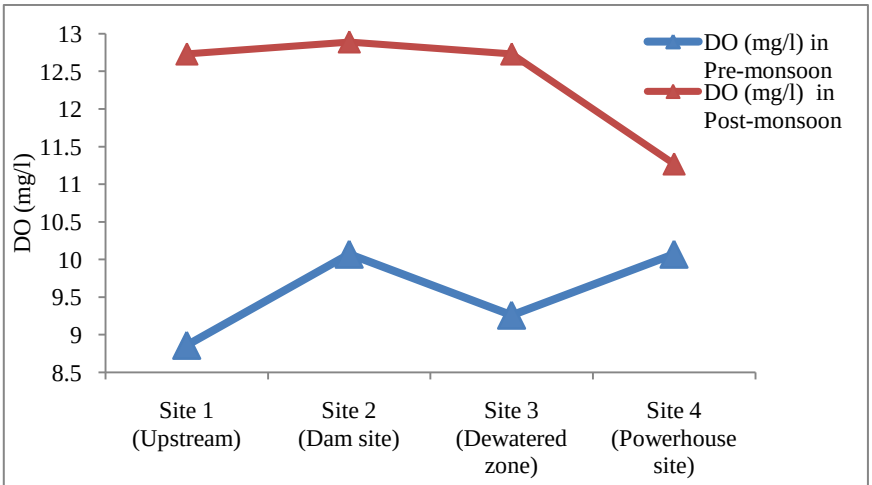

Fig. 4.13 : *Graph showing DO in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.12 Iron and nitrate:

In the water sample collected from the various sites, iron and nitrate-N content were found to be 0.13 mg/l, 0.02 mg/l, 0.05 mg/l and 0.05 mg/l; and 0.25 mg/l, 0.25 mg/l, 0.27 mg/l and 0.27 mg/l respectively in upstream, dam site, dewatered zone and powerhouse site.

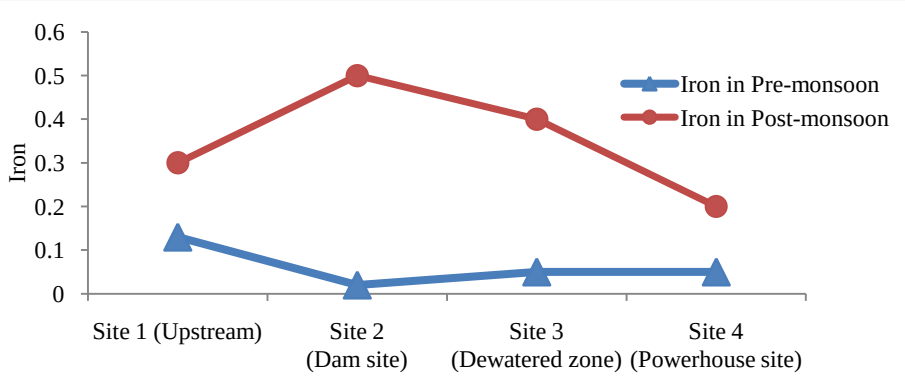

Fig. 4.14 : *Graph showing Iron in Pre-monsoon and Post-moonsoon of the proposed project area*

In the same manner during post monsoon, iron and nitrate concentration were found to be 0.3 mg/l, 0.5 mg/l, 0.4 mg/l and 0.2 mg/l; and 0.28 mg/l, 0.5 mg/l, 0.25 mg/l and 0.75 mg/l respectively. The trend is shown in figure 4.14 for iron and figure 4.15 for nitrate.

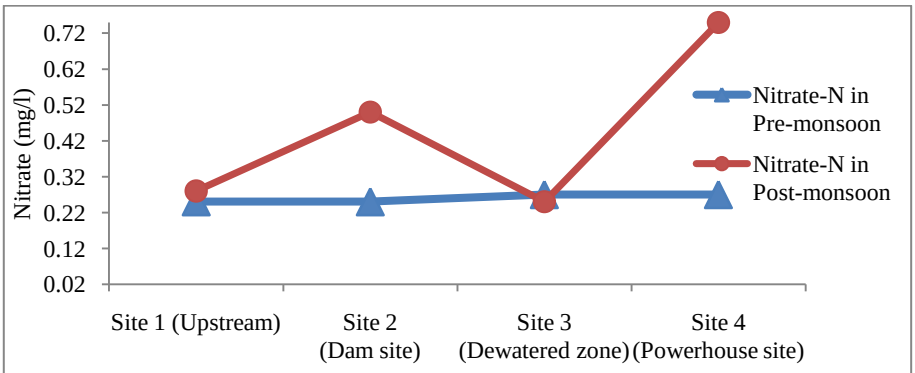

Fig. 4.15 : *Graph showing Nitrate in Pre-monsoon and Post-moonsoon of the proposed project area*

4.2.13 Phosphate:

Phosphate concentration varied from 0.01 mg/l to 0.2 mg/l in pre-monsoon and from 0.22 mg/l to 0.8 mg/l in post-monsoon.

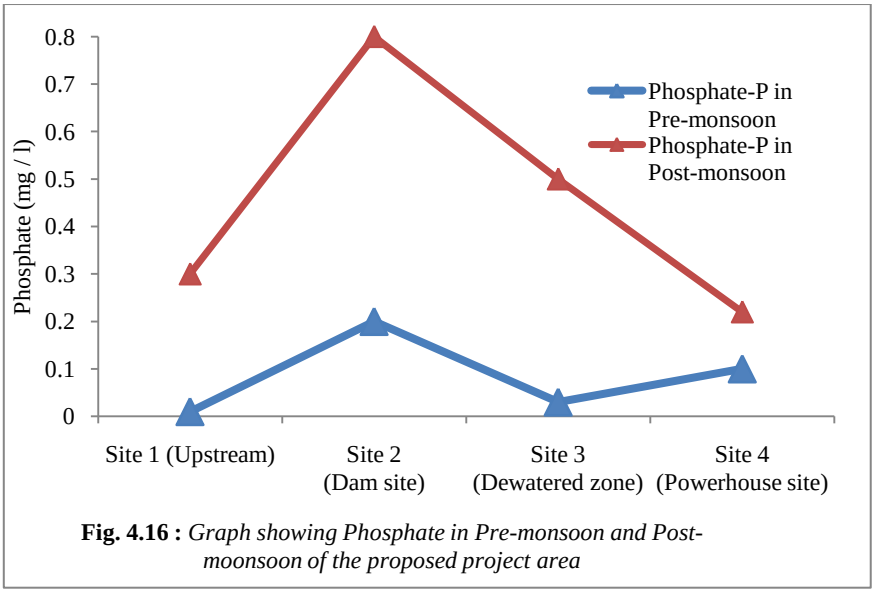

Fig. 4.16 : *Graph showing Phosphate in Pre-monsoon and Post-moonsoon of the proposed project area*

4.3 Microbiological parameter:

4.3.1 *E. coli* and normal coliform:

Some microbiological parameters like *E. coli* and normal coliform were counted from the water samples taken from the sampling sites only in post-monsoon. Normal coliform was counted 192 in number in powerhouse site and in all other sites, it exceeded 300 in number. On the other hand, density of *E. coli* was counted 18/100ml, 12/100ml, 15/100ml and 0/100ml in upstream, dam site dewatered zone and powerhouse site respectively. The data is presented in table 4.1.

Table 4.1: Obs. table for micro organisms found in the water samples

S. N.	Parameters	pre-monsoon				Post-monsoon			
		Site 1 (upstream)	Site 2 (Dam site)	Site 3 (Dewatered zone)	Site 4 (Power house site)	Site 1 (Upstream)	Site 2 (Dam site)	Site 3 (Dewatered zone)	Site 4 (Power house site)
1	Normal coliform					>300	>300	>300	192
2	*E. coli*					28	12	15	0

Source: Field survey, 2012

4.4 Socio economic environment:

4.4.1 Demography of Project Affected VDCs:

4.4.1.1 Sattala VDC, Dailekh

Sattala VDC lies on the western part of Dailekh district located on the eastern bank of the dam site of proposed Upper Karnali Hydroelectric Project. The 2011 Census shows

that the total population of the VDC is 4,865 with male population of 2,405 and female 2,460 with literacy rate of 65%. The VDC contains 895 households. About 40% of the total area is cultivated with crops out of which 35% have irrigation facility.

4.4.1.2 Bhairabsthan VDC, Achham

Bhairabsthan VDC lies on the south eastern part of Achham district located on the western bank of the proposed Upper Karnali Hydroelectric Project. According to the 2011 Nepal Census, the VDC has total population of 4,382 with male population 2,111 and female 2,271 and average literacy rate 63%. The total no. of households is recorded 820. About 35% of the total area is cultivated of which only 22% have irrigation facility. The demography data of both Sattala and Bhairabsthan VDC is shown in table 4.2.

Table 4.2: Demographic data of Sattala (Dailekh) and Bhairabsthan VDC (Achham)

Parameters	Total population	Male population	Female population	Total no. of HHs	Total literacy rate %	Available cultivated land %	Available irrigated land %
Sattala	4865	2405	2460	895	65	40	35
Bhairabsthan	4382	2111	2271	820	63	35	22

Source: CBS, 2011 and VDC offices of Sattala and Bhairabsthan, 2011

4.4.2 Socio-economic condition of Project Affected Family (PAF):

4.4.2.1 Population distribution:

The total population of surveyed 70 households was found to be 544 of which 339 were male and 205 were female. The average family size of the surveyed PAFs was found to be quite large. Averagely 8.2 members were stayed together in each family. It is shown in table 4.3.

Table 4.3: Demography of PAFs

Description	No. of HH	Total Population	Male population	Female population	Average family size
Project Affected Families (PAFs)	70	544	339	205	8.2

Source: Field survey, 2012

Out of them, 74.3% families are inhabited there for more than two generation. 7.1% families are inhabited there for less than 10 years and the rest are inhabited for more than one generation. Similarly, 13.6% of the population of the constituent VDCs is below 5 years and 12.32% is above 45 years. There is 27.02% population in school going age i.e. at the age interval of (5-15). 47.06% of the total population is economically very active group. The population distribution of the survey is shown in figure 4.17.

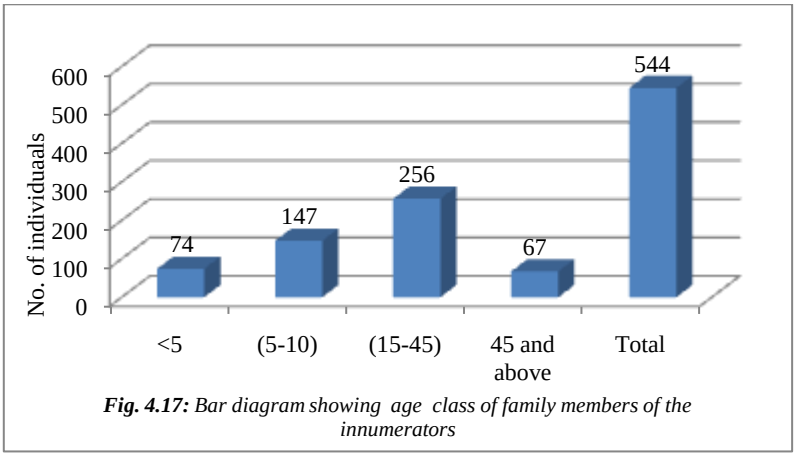

Fig. 4.17: *Bar diagram showing age class of family members of the innumerators*

4.4.2.2 Caste/Ethnicity:

Most of the population in the constituent VDCs was found to be Chhetri. It possessed 51% followed by Thakuri, Brahmin, Janajati and Dalit with 20%, 11%, 7% and 11% respectively.

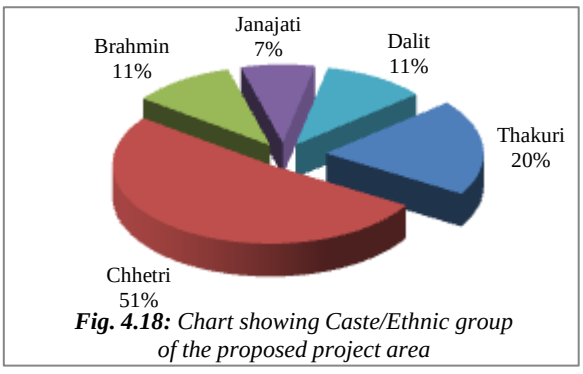

Fig. 4.18: *Chart showing Caste/Ethnic group of the proposed project area*

4.4.2.3 Education status:

Majority of the population of PAFs (35.85%) have attained secondary level succeeded by 21.51%, 20.59% and 10.29% attaining lower secondary level, primary level and higher secondary level. There is only 1.1% attaining bachelor level and 0.37% attaining master

level. Still 8.09% of the total population in the PAFs is illiterate while 2.21% is the share of the people who can just read and write their name.

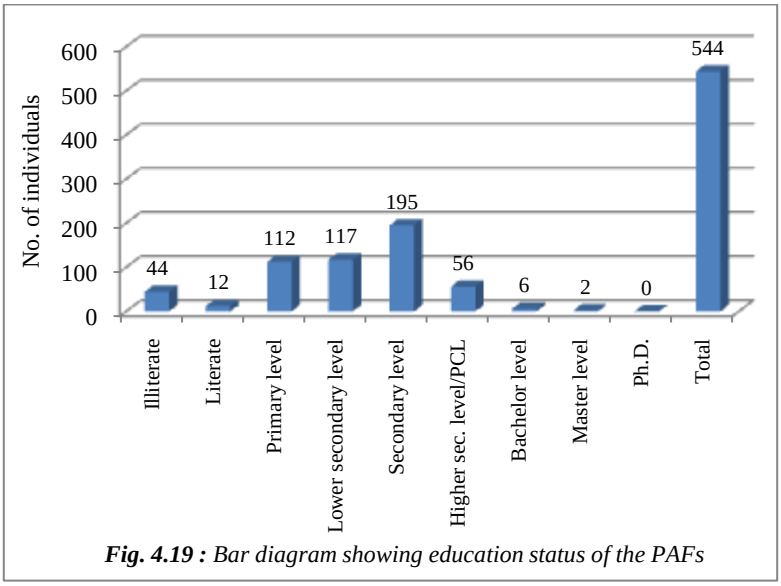

Fig. 4.19 : *Bar diagram showing education status of the PAFs*

4.4.2.4 Occupation:

Majority of PAFs were found to be engaged in agricultural works. However, only 31.80% of them were reported fulltime in agricultural and livestock farming. 8.82% were reported seasonally out-migrated especially to India, and also to the nearby cities on Nepal such as Nepalgunj, Dhangadi, and Surkhet etc. for employment. Similarly, teaching, business/shop, labor and student profession shared 3.13%, 3.3%, 6.80% and 21.14% respectively while 25% of the total population was found to be incapable.

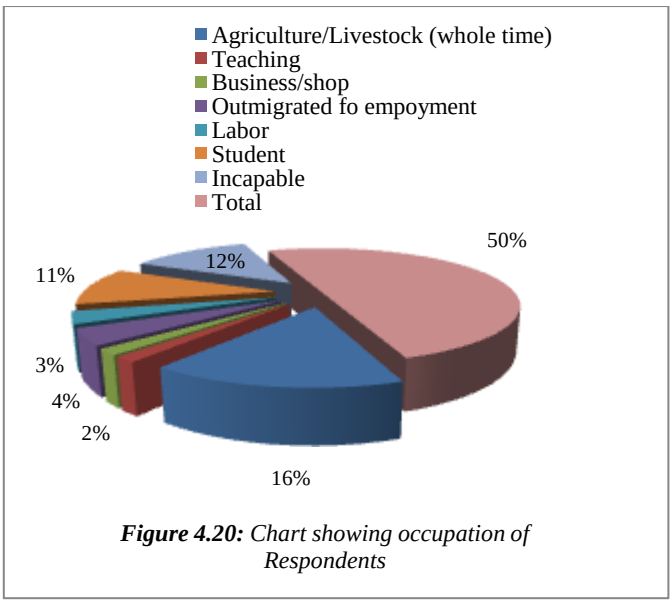

Figure 4.20: *Chart showing occupation of Respondents*

4.4.2.5 Drinking water facility:

There is no any problem in the project affected VDCs because most of the population have access of tap water in or nearby their house. During field survey, it was found that 34% have had facility of tap in house and 33% had tap nearby house. Only 14% villagers were found to go far away to get drinking water and 19% used water from Karnali river for drinking purpose.

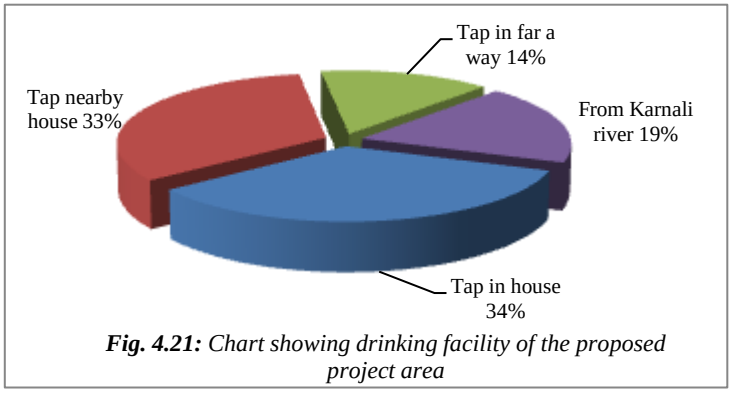

Fig. 4.21: *Chart showing drinking facility of the proposed project area*

4.4.3 Agriculture

4.4.3.1 Land ownership:

Each household possessed averagely 23.3 ropanis agricultural land including paddy field and terraced land.

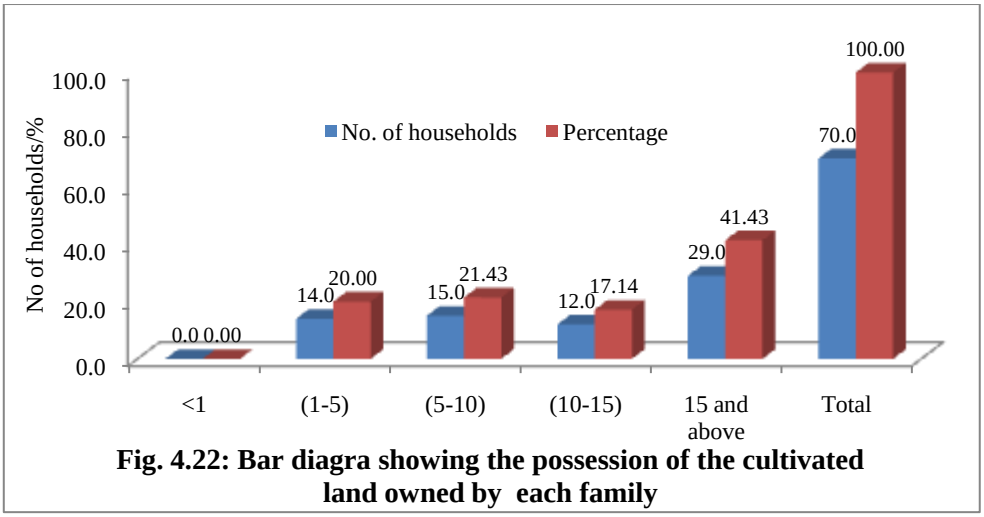

Fig. 4.22: Bar diagra showing the possession of the cultivated land owned by each family

4.4.3.2 Irrigation facility:

The PAFs mostly use water from Karnali river for irrigation in their paddy field. 37.14% was found to be relied on Karnali river whereas 21.43% irrigated from the associate

rivulets and 10% used tap water to irrigate their land. On the contrast, still 31.43% did not have irrigation facility. They were totally dependent on precipitation and hence their productivity was greatly reduced.

Table 4.4: Irrigation facility

S.N.	Source of Irrigation	No. of PAFs	Percentage
1	Karnali river	26	37.14
2	Associate rivulets	15	21.43
3	Tap water	7	10.00
4	No. irrigation facility	22	31.43
	Total	**70**	**100.00**

Source: Field survey, 2012

4.4.3.3 Crop productivity:

Paddy, maize and wheat are the major cereal crops grown by PAFs. Potato, vegetables (mustard) and pulses other crops grown by them just to satisfy their own needs, usually not for commercial purposes. The average production per household of paddy, maize, wheat, pulses, mustard and potato was found to be 510.71kg, 612.14kg, 452.14kg, 79.29kg, 454.29kg and 440.71kg respectively.

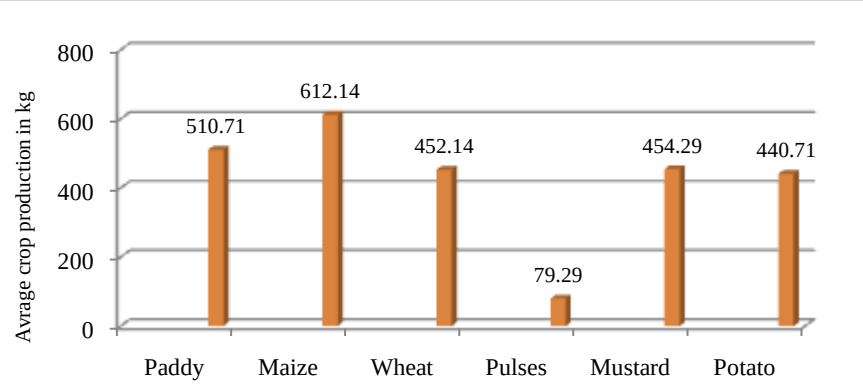

***Fig. 4.23** : Chart showing the annual average crop production in each household in kg*

4.4.3.4 Food sufficiency:

Only 11.43% of the total PAFs were found to have enough food for all around the year and most people either purchased or burrowed crops during deficient period. 55.71% did have enough food for 9 months whereas 22.86% and 10% people had enough food for 6 and 3 months respectively.

Table 4.5: Food sufficiency of PAFs

S.N.	Food sufficiency	No. of HH	% of PAFs
1	Enough for 3 months	7	10.00
2	Enough for 6 months	16	22.86
3	Enough for 9 months	39	55.71
4	Enough for 12 months	8	11.43
	Total no. of HH	**70**	**100.00**

Source: Field survey, 2012

4.4.3.5 Livestock:

There were altogether 68 buffaloes domesticated by the PAFs. In the same way, they possessed 154 cow/oxen, 717 goat/sheep and 300 chickens. Cows and buffaloes are generally kept for milk, ghee and manure and oxen for plauging their agricultural fields. Goats and sheep are for meat and for sale. Chicken are kept for eggs, meat and for sale. From the survey, it was clear that PAFs kept a large no. of goat/sheep and they sold them in the local market and in return bought crops, cereal and other daily needs. Averagely, each household possessed about 10 goat/sheep whereas there were approx. 4 chickens, 2 cow/oxen and 1 buffalo in each household.

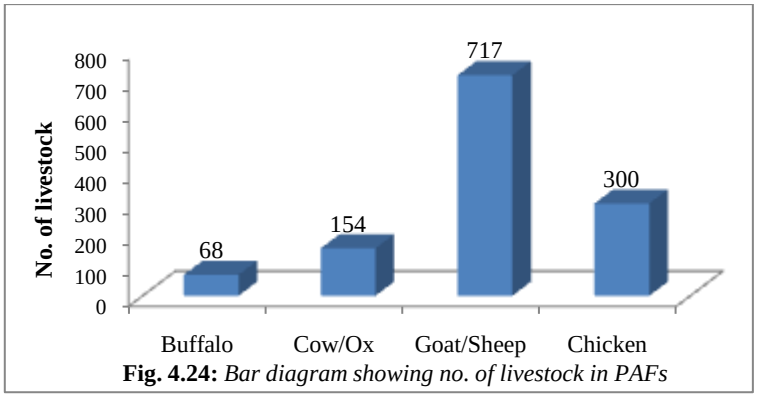

Fig. 4.24: *Bar diagram showing no. of livestock in PAFs*

4.4.4 Income status:

4.4.4.1 Income source:

Even though a large portion of the proposed project area were dependent on agriculture, selling of raring animals like goat, chicken etc. was found to occupy 26% of their total income. Secondly, seasonal working in India served 21% of total income. In the same manner, fishery and daily wages served each of 16% whereas shop/business, fruits/vegetables and food grains selling and salary served 8%, 5%, 4% and 3% respectively. Only 1% income source was from house and land rent.

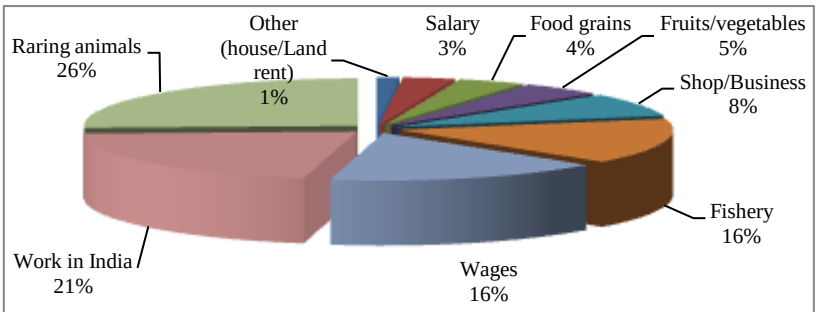

Fig. 4.25 : *Chart showing income source of the proposed project area*

4.4.4.2 Income and expenditure:

The average income of each HH in the project area was found to be NRs. 1,25,714.28 while the average expenditure was NRs. 1,68,857.15 hence the average deficit of each HH was found to be NRs. 42,857.15.

Table 4.6: Income/Expenditure of PAFs

Amount in NRs.	No. of families with			
	Total income	Total expenditure	Surplus	Deficit
<50,000	7	4	12	5
50,000-1,00,000	19	9	3	13
1,00,000-1,50,000	23	11	5	19
1,50,000-2,00,000	8	14	3	10
>2,00,000	13	32	0	0
Total	**70**	**70**	**23**	**47**

Source: Field survey, 2012

4.4.5 Settlement pattern:

PAFs live in separate clusters based on their ethnicity and economic status. Housing pattern was found to be more or less same throughout the project area, irrespective of ethnicity and economic status of the people.

Most of the PAFs owned a single 2 storied house. 47% of the total surveyed households have straw roof whereas 29%, 17% and 7% were found to have stone roof, steel roof and permanent roof respectively.

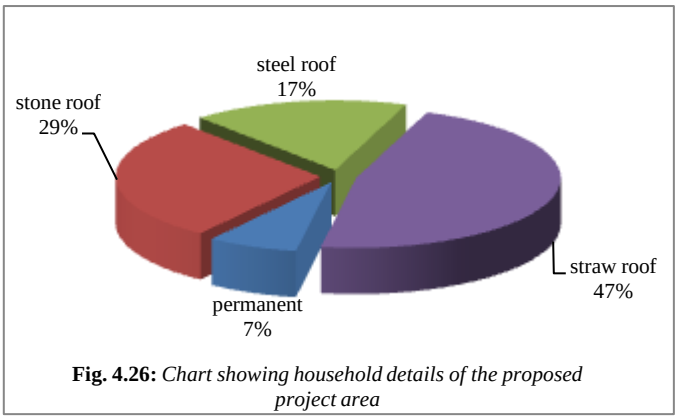

Fig. 4.26: *Chart showing household details of the proposed project area*

4.4.6 Energy use:

The only source of energy for cooking in the project area was found to be firewood collected from the community forests. Kerosene was only used in lightening but its use was negligible. Solar panel was observed in the roof of most of the houses. The Government of Nepal (GoN) provide up to 75% subsidy in solar electrification. Hydro electricity was not produced so far.

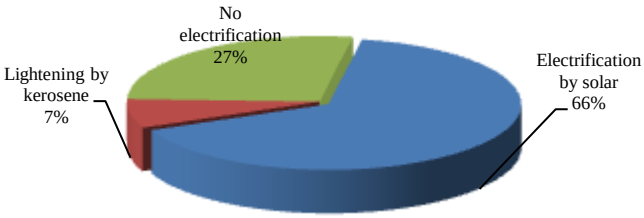

Fig. 4.27 : *Chart showing condition of eletrfication in the proposed project area*

4.4.7 About fisherman:

The Karnali river is a huge resource for fishery. Villagers residing along the river bank generally catch fishes daily during spring, autumn and winter season. The survey found that the average one day collection of fish was about 4 kg. The fishes partially sold in the local market in excess of consumption by the fisherman. The average annual income per HH from fisheries was calculated NRs. 28,000; however it varied from NRs. 3,000 to 60,000.

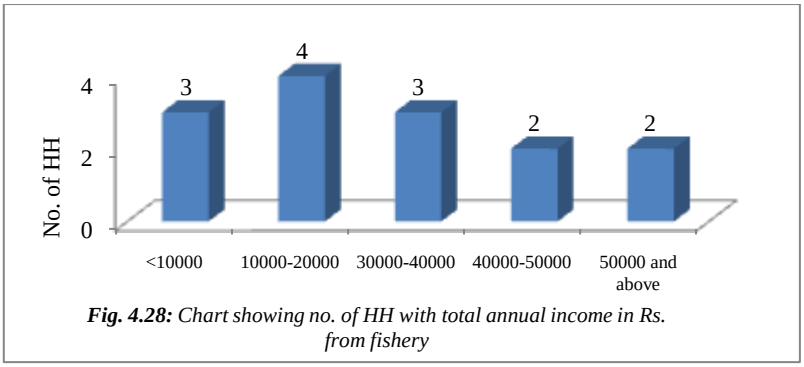

Fig. 4.28: *Chart showing no. of HH with total annual income in Rs. from fishery*

4.4.8 Attitude towards the proposed UKHEP:

Out of 70 respondents, 52% poured positive attitude towards the proposed UKHEP whereas 31% had negative attitude and 17% did not make any idea of the project. It shows that more than half of the PAFs were found to be in favor of the project but they strongly condemned some correction should be made on MoU agreed by both GoN and GMR-ITD Company. Most of the villagers were found to support the project innocently only because they would get chances of labor work.

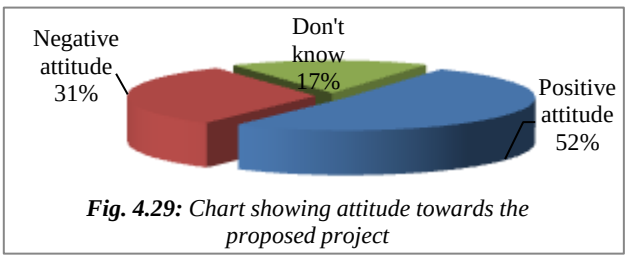

Fig. 4.29: *Chart showing attitude towards the proposed project*

4.4.9 Expectation for compensation:

The field survey showed that out 70 respondents, 53 would lose their land of which 17 would lose their house too. Among them, 41.5% would lose (1-5) ropanis cultivated land and 34% would lose more than 10 ropanis lands.

Table 4.7: Probable inundation of land and house

Probable inundation (Ropani)	No. of HH with Land inundation	% of HH with land inundation	No. of HH with house inundation	No inundation
<1	0	0.0	17	17
1-5	22	41.5		
5-10	13	24.5		
>10	18	34.0		
Total	**53**	**100.0**		

Source: Field survey, 2012

Most of the PAFs expressed for fair and satisfactory compensation for all lost assets from the developer of the project. Among them, 20% expressed their expectation of land for land and 13% expected cash for land/house. Similarly, 30% expected job (either monthly salary based or daily wage based) in the proposed project, 26% demanded vocational training, 10% expected alternative house and rest 1% poured other demands such as recreation facility, employment in India etc.

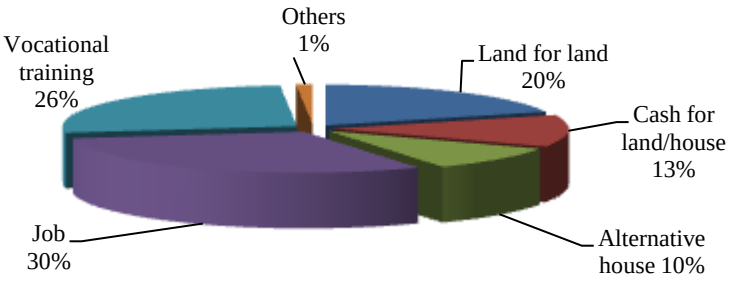

Fig. 4.30: *Chart showing expectation for compensation from the project developer*

4.4.10 Impact on fish population after construction of dam:

50% of the total respondents predicted that the fish population would be decreased after construction of dam. It would be because of water pollution, drastic decrease in the water level in the downstream, human encroachment and so on. Next 50% did not have any idea of impact on fish population.

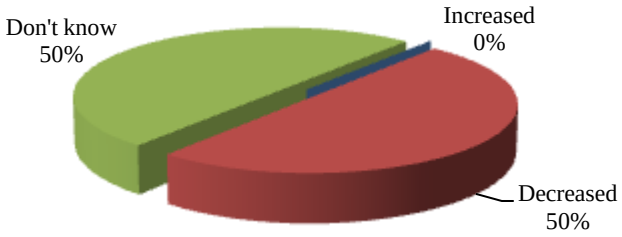

Fig. 4.31 : *Chart showing probable impact on fish after implementation of the project*

4.4.11 Villagers' demand from the project:

It is obvious to put demands to the developer and other concerned bodies by the PAFs at the cost of construction and operation of the project on their land. The villagers were seemed to be very innocent. They put forward their simple and basic demands. Most of them demanded for construction of higher secondary school in each project affected

VDCs and a hospital with 100 beds in an appropriate location for the people of Karnali region. Secondly, they wanted to have right of consumption of certain portion of electricity produced from the same HEP in order to lightening and operating small scale industries and business. Thirdly, they demanded to have black topped and wide road facilities in the project affected VDCs.

4.5 River water quality and socio-economy of PAFs:

4.5.1 Drinking water quality and disease occurrence:

About 19% of the PAFs were found to use Karnali river as a source of drinking water all around the year. The water samples had found *E. coli* in the range of (88-150)/100ml and more than 300/100ml normal coliform. Similarly, turbidity and total hardness of the water samples were found to be in the range of (1.2-8.9) NTU and (88-150) mg/l respectively in pre-monsoon. In the same period, there were 16 patients of enteric fever (Typhoid) and 21 patients of dysentery and cholera reported in GMR primary health post. The data is shown in table 4.39.

Table 4.8: Drinking water quality and disease occurrence

Water quality		**% of PAFs using Karnali river as source of drinking water**	**Type of disease occurrence**	**No. of patients recorded in GMR primary health post**		
Parameter	**Amount**			Male patients	Female patients	Total no. of patients
E. coli	(0-28)/100ml	**19%**	Enteric fever	9	7	16
Normal coliform	(192->300)/100ml		Dysentery/ Cholera	6	15	21
Turbidity	(1.2-8.9) TU					
Total hardness	(88-150) mg/l					

Source: Field survey, 2012 and GMR primary health post, Sattala, 2012, August

4.5.2 Waste disposal/ sanitation and water quality:

Out of total respondents, 8.57% was found to dispose solid waste directly to the Karnali river and 37.14% mix the liquid waste to the river. Likewise, about 65% of the total respondents were not found to have even simple toilet and most of them usually go to the Karnali river bank for toileting. As a result of that, disease causing microbial organisms like *E. coli* and normal coliform were noticed in the water samples. Waste disposal and defecation may serve to increase the concentration of chloride, free CO_2, nitrate and

phosphate in the river water but these human activities are not the sole factors that affect the concentration of such chemical parameters. Many natural processes like erosion, flood etc. play major roles for increasing the concentration. However, the concentrations of such chemical parameters do not exceed the WHO standard for drinking.

Table 4.9: Waste disposal/ sanitation and water quality

Types of waste / Sanitation	% of PAFs disposing waste to Karnali river	Water quality	
		Parameter	**Concentration range (mg/l)**
Solid waste	8.57	Chloride	(7.1-11.32) in pre-monsoon 19.88-24.14 in post-monsoon
Liquid waste	37.14	Free CO_2	13.2-15.4 in pre-monsoon 17.6-19.8 in post-monsoon
HH having simple toilet	35	Nitrate	0.02-0.05 in pre-monsoon 0.25-0.75 in post-monsoon
HH not having toilet	65	Phosphate	0.01-0.2 in pre-monsoon 0.22-0.8 in post-monsoon
		E. coli	(0-28)/100ml in post-monsoon
		Normal coliform	(192->300)/100ml in post-monsoon

Source: Field survey, 2012

4.5.3 Water quality and irrigation:

37.14% of the total PAFs were found to use water from Karnali for irrigation and 21.43% use water from the associate rivulets which ultimately join with the Karnali river. Except pH in post monsoon, all other physico-chemical parameters were found to be suitable for irrigation.

4.5.4 Water quality and fishery:

All the physico-chemical parameters studied in the project area were found to be suitable for fishes. During household survey, respondents stated that they found 46 species of fishes in the river. Among them, some species such as Sahar, Asala, Rajbam, Jalkapoor, Goz, and Katle were reported in a large number. NESS has collected 17 species of fish during EIA study period (Summarized version of EIA of UKHEP, NESS, 2012).

4.6 Socio-economic Impact Assessment

The proposed Upper Karnali Hydroelectric Project will create both positive and negative impacts on its socio-economic environment. Such impacts will be visible in due course

of time in the project area. Therefore, impact analysis is essential to identify their type and intensity so that measures could be proposed to minimize adverse impacts and to promote beneficial ones.

The study prevailed that, most of the PAFs have had very little knowledge about project planning and implementation including construction schedules, proposed interventions, impacts and their mitigations. Majority of them were not satisfied with the way that the project has been operating. Information dissemination mechanism of the developer (GMR) was regarded unsatisfactory. Some respondents even do not know the exact power generation capacity of the project. However, they strongly advocated about their rights on equity share in the project and benefit sharing from power generation. Some of them (especially, teachers and the local political leaders) were of the view that there should be tripartite agreement between GMR (the developer), Government of Nepal and the local governments/communities and assure in advance that they will be provided fair share on the investment and also the benefits from power generation.

The anticipated impacts due to implementation of the project identified, predicted and evaluated with due consideration of the National EIA Guidelines 1993. They are discussed in the sections below:

4.6.1 Demographic Characteristics

The most identifiable impact in terms of demography will be observed at a period of time during the peak construction. Major construction projects, especially in rural areas, tend to attract large numbers of work seekers and small entrepreneurs. The numbers fluctuate over the course of project construction. Generally, people arrive rapidly when there are jobs and business opportunities and disappear when the project's work cease. So, the magnitude of impact is medium, extent is local and duration is medium term and therefore impact is significant as shown in table 4.10.

4.6.2 Loss of land and properties as a part of Site Clearance

The EIA study report indicates that there will be 46.85 ha privately owned land acquired for site clearance at different locations which will directly affect 236 households. Among them, 55 households will completely lose house and other physical infrastructures and

184 households will lose their agricultural land (Summarized version of EIA report of UKHEP, NESS, 2012). In addition, some land and houses are to be leased during construction purpose. The level of impacts on them may vary with the proportion of loss of land and its effects on the overall household income. Loss of land and production is direct loss of income to the PAFs. Agricultural land is scarce in the hills. Hence magnitude of the impact is high, duration is long term and extent is site specific. Therefore, this impact is very significant as shown in table 4.10.

4.6.3 Great reduction in crop production:

Loss of agricultural production will increase food shortage in the area. In the reservoir area, the productive land will be inundated all around the year which causes direct loss of crop production. As a result, there will be hardship in food availability to the landowners even if they are compensated for their lands. The productive lands likely to be affected by the project are Lode, Asaraghat, Nisana, Chhatabagar, Ghodaghanti, Naugade, Ramgad, Daba, Kumalu, Sisne etc. It is for sure that the people will have difficulty to find similar lands in the area and may have to depend fully on the market for purchasing food grains. In the downstream area people presume that the productivity of lands would decline gradually and they would depend on purchasing imported food grains all over their life. Hence, the magnitude is high (H), extent is site specific (SS) and duration is long term (LT). Therefore, this impact is also very significant as shown in table 4.10.

4.6.4 Socio-Cultural Values and Norms

At present, the ethnically diverse groups of people have set relatively stable relationships. These are based on a combination of kinship, residential proximity and economic cooperation and mutuality. The dislocation of these communities as of land acquisition and of other project activities especially at the dam site may be disruptive to the network of relationships that they are practicing. Also, the influx of large number of in-migrated population into these communities is certain to cause major changes in social relationships and cultural and traditional norms. These changes will be greatest in the vicinity of the main project area and along the project roads.

The project construction workforce will create social disharmony in the project area although the work force are recruited from local area. Girl trafficking, drug addiction and

prostitution may increase during the project implementation. So, the magnitude of impact is medium, extent is local and duration is short term and therefore impact is significant as shown in table 4.10.

4.6.5 Gender Issues

The women are still considered as a second group citizen. They will be given less priority in recruiting job in the project. If men are employed in the project, women will remain at home to bear additional domestic chores. Though women are employed in work, their daily wages will be less than their male counterparts and in some cases; their wages will be taken over by their husbands. Once men will have cash income, they might start to consume more alcohol and initiate conflicts in their own families. When the construction of the project ceases, the temporary workforce will more likely migrate to other areas for seasonal work. If property holdings are acquired by the project and cash is paid for land and houses, women will have to take most of the burden and they will feel insecure till their family in well resettle somewhere. So, the magnitude of impact is low, extent is local and duration is short term and therefore impact is insignificant as shown in table 4.10.

4.6.6 Employment

Preliminarily, it is estimated that during peak construction phase of the UKHEP, about three thousand and five hundred skilled, semi-skilled and unskilled workers will be getting jobs in the project. The employment opportunity could also be further enhanced by providing skill training in different areas that are required during construction works. Similarly, the increase in numbers of shops and groceries make the local people indirect employment and benefit from new market and better prices. A large no. of skilled and unskilled manpower might also be engaged from neighboring districts. Thus, the magnitude of impact is high, extent is local and duration is short term and therefore impact is very significant as shown in table 4.10.

4.6.7 Industry, Trade and Commerce, and Markets

New entrepreneurs will appear in the project area to expedite and explore new opportunities. The provision of electricity will enhance new cottage industries and other

entrepreneurs creating direct and indirect job opportunities. The impact would also be in a regional scale. The Karnali region is economically backward in Nepal. The area is food deficit and has less agricultural land. In this context, implementation of the UKHEP will assist to boost its employment and economic activities. This will reduce seasonal out-migration from the project affected VDCs. It will also attract local and foreign entrepreneurs to invest in other development activities. So, the magnitude of impact is high, extent is local and duration is short term and therefore, impact is very significant as shown in table 4.10.

4.6.8 Risk factor:

The downstream people appeared worried about potential risk on their lives and livelihood in case of floods in the river. The major risk for them is the loss of many people in case the dam is burst due to unprecedented floods. The downstream people, especially in Ramgad Bazaar which is about 500 meter below the dam site pointed out to look for options to protect them from such disaster. Other potential risk factors might be the damage of house/structures due to blasting and use of heavy machineries which need to be carefully monitored and addressed. So, its magnitude of impact is high, extent is local and duration is short term. Therefore, impact is very significant as shown in table 4.10.

4.6.9 Loss of water sources/springs:

The construction works would dry up the existing water sources such as springs, kuwa, mool etc. in the nearby area. Consequently existing water sources would discharge less water affecting adversely the water supply used for drinking purpose and agricultural activities. Decreased water sources would cause further hardship in the area where many areas are already facing water shortage. Thus, the magnitude of the impact is high, extent is local and duration is long term and therefore, the impact is very significant.

4.6.10 Livelihood of fisher community:

The downstream people, particularly the Badi communities living in Ramgad Bazaar are landless and highly marginalized groups who depend quite significantly on the income from fishery in the Karnali river. Many other poor people also earn their livelihood from

fish selling. The reduced water flow in the river after the project would deprive them from their fishery occupation leading them to further impoverishment. Thus, the magnitude of impact on fishery is medium, extent is local and duration is long term and therefore, impact is significant as shown in table 4.10.

4.6.11 Tourism

The proposed dam site is located on the way to Jumla and the Karnali (Surkhet-Jumla) highway passes through the bank of the river. It is also the only motor way to Rara National Park in Mugu district. After implementation of the project the whole region might be electrified and the highway might also be widening and black topped. At that time, the project area would be the attractive residential point for the internal as well as external tourists. On the contrast, water rafting in the river at a long distance from dam site to powerhouse site would be adversely affected by the implementation of the project. Therefore, the magnitude of impact is medium, extent is local and duration is medium term and consequently impact is significant as shown in table 4.10.

4.6.12 Corporate social responsibility:

The project has been supported to local people and communities in different areas that include construction of suspension bridge in Asaraghat, erection of telecommunication tower at the top of Bhairabsthan VDC, physical support to local schools, establishing primary health post and childcare centre in Ramgad Bazaar etc. These are the positive impacts. So, the magnitude of impact is medium, extent is local and duration is medium term and therefore, impact is significant as shown in table 4.10.

4.6.13 Important Sites

There are a no. of important religious sites such as cremation sites (Ramaghat, Asaraghat, Sisneghat etc.), river confluence where priests bathe on special occasions and also a small temple in Sisne. People of Hindu religion from nearby villages usually go there in local jatras. All these cremation sites and religious sites would be dislocated after implementation of the project. Thus, the magnitude of impact is medium, extent is local and duration is short term and therefore, impact is significant as shown in table 4.10.

Table 4.10: Evaluation of socioeconomic impacts

SN	Likely impacts	Environmental impacts							Total Score	Significance of impact
		Type	Nature	Identified	Predicted	Magnitude	Extent	Duration		
1	Demographic Characteristics	-ve	D	√		M (20)	L (20)	MT (10)	50	Significant
2	Loss of land and properties as a part of site clearance	-ve	D	√		H (60)	SS (10)	LT (20)	90	Very significant
3	Reduction in crop production	-ve	D	√		H (60)	SS (10)	LT (20)	90	Very significant
4	Socio-Cultural Values and Norms	-ve	D		√	M (20)	L (20)	ST (05)	45	Significant
5	Gender issues	-ve	ID		√	L (10)	L (20)	ST (05)	35	Insignificant
6	Employment	+ve	D	√		H (60)	L (20)	ST (05)	85	Very Significant
7	Industry, trade and commerce and markets	+ve	ID		√	H (60)	L (20)	ST (05)	85	Very significant
8	Risk factor	-ve	ID		√	H (60)	L (20)	ST (05)	85	Very significant
9	Loss of water resources/springs	-ve	D	√		H (60)	L (20)	LT (20)	100	Very Significant
10	Livelihood of fisher community	-ve	ID	√		M (20)	L(20)	LT(20)	60	Significant
11	Tourism	+ve	ID		√	M (20)	L (20)	MT (10)	50	Significant
12	Corporate social responsibility	+ve	D	√		M (20)	L (20)	MT (20)	60	Significant
13	Important sites	-ve	D	√		M (20)	L (20)	ST (05)	45	Significant

(Source: Field Survey, 2012)

Note:

Type: -ve = negative impact; +ve = positive impact

Nature of Impact: Direct = D; Indirect = ID

Magnitude: High (60) = H; Medium (20) = M; Low (10) = L

Extent: Regional (60) = R; Local (20) = L; Site Specific (10) = SS

Duration: Long Term (20) = LT; Medium Term (10) = MT; Short Term (05) = ST

The points in the parenthesis are taken from the National EIA Guideline, 1993

CHAPTER: V

DISCUSSION

5.1 Water Resource Potential:

During the feasibility study of UKHEP carried out by NEA from Oct. 1996 to June, 1998, normal trend of design discharge was Q_{50}% to Q_{60}%. For 300MW of firm capacity, NEA applied Q_{54}% with river discharge of 239.68 m^3/s and overall efficiency of 85% with optimization.

Presently, NEA as well as DoED approves PPA upto Q_{40}% design. Considering this, theoretical hydroelectric potential of the project was calculated as 549.63MW by taking design discharge of Q_{40}% with river discharge of 439.11 m^3/s, overall efficiency of 85% and net rated head of 150.11 m. This figure may certainly change if GIS software and other engineering approaches are applied in estimation of the hydropower potential.

If the developer constructs a project considering the firm capacity of 549.63MW, it will produce such amount only in 4 months in a year i.e. from June to September. In the month May and October, the project will produce about 494.02MW and 518.51MW respectively and in rest 6 months, electricity production will be gradually reduced. Only 148.49MW will be produced in February.

But the developer of the UKHEP (GMR) applied optimization with peaking provision for 3.26 hours daily and hence, it has calculated firm capacity to reach 900MW.

It is also possible to attain the potential capacity of 900MW, if design discharge is maintained at Q_{29}% with discharge of 664.32 m^3/s and overall efficiency of 92%. In that case, firm capacity of 900MW will be produced only for 2 months from the same project and in rest 10 months, there will be gradually decreasing in electricity production.

5.2 Physico-chemical parameters:

The temperature of water may not be considered as an important factor in pure water because of presence of wide range of temperature tolerant aquatic life. The fluctuation in

river water temperature usually depends on season, geographic location, diurnal variation of temperature which more or less fluctuate with the air temperature and temperature of effluent entering the stream (Ahipathi, 2006). Both the air and water temperature were recorded the highest in both season (air temperature was 31 and 20 in pre-monsoon and post-monsoon while water temperature was 17.5 and 14.5) at the upstream site and lowest in powerhouse site in both season. Although the altitude of the powerhouse site is lower than that in upstream, air temperature and water temperature falls down in the powerhouse site. It is because the powerhouse site gets sunlight for only few hours during the day time and both the river banks are steep cliff covered with dense forest. On the contrast, the upstream site usually gets direct sunlight for more than 6 hours daily and the left bank of the sampling site (Dailekh) is plain area of agricultural land.

pH of the river was found in the normal range (7.2-7.4) in pre-monsoon. But it drastically increased to (8.4-9.7) in post-monsoon. It shows the water is alkaline in post-monsoon. Generally, pH of most natural water falls within the range 6.o-8.5 (Chapman, 1992 cited by www.projectsearch.org) which is suitable for the drinking and domestic purposes. Below 6.5, the water tends to be corrosive and above 8.5, it is soapy. The apparent reason of increasing pH value in post-monsoon might be because sampling sites selected are the cremation sites. Death bodies are burnt frequently at those sites.

Turbidity of natural water is an important determinant factor for water physico-chemical property and river productivity. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter and plankton and other microbial organisms. The turbidity of the river was recorded up to 8.9 NTU in pre-monsoon while it was recorded as less as 0.3 NTU in post-monsoon. National drinking water quality standard (NDWQS) as well as WHO standard for turbidity is below 5 NTU (National Drinking Water Quality Standards, MPPW, 2005). High level of turbidity can stimulate bacterial growth and protect micro-organisms from the effects of disinfection.

The water transparency was measured in all sites and found low in pre-monsoon than the post-monsoon season. According to the recorded precipitation data of Asaraghat hydrological station, the average annual precipitation is measured 1,202 mm of which monsoon precipitation (from June to October) shares 73%. The average monsoon precipitation of the station is 872 mm. This high precipitation carries large amount of

sediment load from the steep and unstable hill slope preferably during the monsoon season. However, during the post-monsoon season (from the last October) precipitation stops and only base flow from its tributaries carries insignificant amount of sediment due to which the transparency is high.

Conductivity measures the ability of an aqueous solution to carry an electric current. This ability depends on the pressure of ions; on their total concentration, mobility, and violence; and temperature measurement. The increasing level of conductivity and cations are the product of decomposition and mineralization of organic materials (Abida, 2008). Conductivity of the river and streams might get affected by the geology throughout its drainage area. Higher the values of dissolved solids, greater the amount of ions in water (Bhatt *et al.*1999). The conductivity of Karnali river was found to be lower in the pre-monsoon season than in the post-monsoon season. In pre-monsoon, the conductivity was recorded in a range of (113-158) μs/cm and (225-340) μs/cm during post-monsoon.

Chloride occurs in appreciable amount naturally in all types of water. High concentration of chloride is considered to be the indicator of pollution due to organic wastes of animal or industrial origin. The chloride content of the Karnali river was found in a range of (7.1-11.32)mg/l in pre-monsoon and (19.88-24.14)mg/l in post-monsoon. The NDWQS value for chloride is below 250mg/l (National Drinking Water Quality Standards, MPPW, 2005). However, Nepal's guideline value for the irrigated water is below 100 mg/l whereas for aquaculture below 600 mg/l but in this level the production is not optimum (CBS, 2008).

In the same way, CO_2 concentration of the river varied from 13.2mg/l to 15.4mg/l in pre-monsoon and from 17.6mg/l to 19.8mg/l in post-monsoon. These values show the river water was natural and less polluted from the anthropogenic sources. The less concentration of free carbon dioxide might be due to presence of low organic matter and high gradient flow through out drainage area which increase the dissolve oxygen in river.

Dissolved Oxygen (DO) is an important limnological parameter indicating the level of water quality and organic pollution in the water bodies (Wetzel and Likens, 2006). It plays a vital role in supporting aquatic life. The consequence of community respiration poses to the oxygen depletion in the water which also delineates with the water quality

and evaluates degree of freshness of the river (Fakeyode, 2005). In pre-monsoon lowest concentration (8.86mg/l) of DO was found at upstream while it was lowest at powerhouse site (11.27mg/l) in post-monsoon. It might be due to high turbulent river water flow with high gradient which is good for aquatic animals like fishes and benthic organisms. The time at which water sampling was taken, might also differ the concentration of DO. During pre-monsoon, water sampling was taken from the powerhouse site at 2.45 PM and that from upstream at 11.30 AM during post-monsoon at which time, the water temperature at the site was 14.5 , higher in comparison to the temperature of other sites. This shows that with increasing water temperature, the level of dissolved oxygen decreases which might be due to the molecular reaction in the water surface. During the day time low photosynthetic activity posed by high turbidity decreases DO level in the river water. In other hand DO in post-monsoon at day time was found higher than the pre-monsoon which might be due to less turbid water, proper photosynthesis and low water temperature. The obtained DO value is almost equal and in most cases higher than the Nepal standard which is 8.9 mg/l for the cold water fishes (CBS, 2008).

Total alkalinity of water is due to presence of mineral salt present on it. It is primarily caused by the carbonate and bicarbonate ions. In fresh water, the value of alkalinity is typically between 20 to 200 mg/l (www.projectsearch.org). The total alkalinity in the river was found higher in post-monsoon than in the pre-monsoon. In post-monsoon, the values were 10mg/l, 15mg/l, 10mg/l and 15mg/l in upstream site, dam site, dewatered zone and powerhouse site respectively while the values were less in pre-monsoon. The presence of alkalinity in the river water means it has capacity to neutralize the acidity. The present value might be due to the presence of lime stone in the forms of $CaCO_3$ along the Karnali drainage which increase the alkalinity.

Total hardness indicates the presence of dissolved minerals (Ca and Mg), determining suitability of water for domestic, industrial and drinking purposes and attributed to presence of bicarbonates, sulphates, chloride and nitrate of calcium and magnesium (Taylor, 1949).The total hardness of the river was found higher in pre-monsoon (136 mg/l-150 mg/l) than in post-monsoon season (86 mg/l-90 mg/l). NDWQS for total hardness is 500 mg/l (National Drinking Water Quality Standards, MPPW, 2005).

Similarly, the Nepal's guideline of hardness for aquaculture range from 20-100 mg/l where as higher than 175 mg/l, causes the osmo-regulation of river fish (Singh, 2012).
The Iron content in the river was found lesser. It might be due to the Snow-fed/Himalayan origination having less iron in the form of ferrous and ferric ion and no underground water source contribution. The NDWQS for iron is 0.3 mg/l (National Drinking Water Quality Standards, MPPW, 2005). Above this value, it affects on domestic uses, water supply structures etc. The less value obtained also indicates that there is low chance of increase the water pH by formation of ferrous bicarbonate, ferric hydroxide and carbon dioxide.

The orthophosphate and nitrate are important parameters in assessing the potential biological productivity of surface water. High concentrations of phosphorus and nitrogen compounds in lake/pool or reservoir lead towards eutrophication. Phosphorus is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species. In natural water and waste water, phosphorus occurs mostly as dissolved orthophosphates and polyphosphates, and organically bound phosphates (UNESCO, 1996; APHA, 1995). In pre-monsoon season phosphate was ranged from 0.01 mg/l to 0.2 mg/l and in post-monsoon it ranged from 0.2 mg/l to 0.8 mg/l. The agricultural runoff and phosphate rock of the drainage might have significant contribution to the larger amount of total phosphate in the river water.

Similarly, Nitrogen is essential for living organisms as an important constituent of proteins, including genetic materials. Nitrogen is present in organic and inorganic form in water. Inorganic nitrogen, in the order of decreasing oxidation states are nitrate (NO_3), nitrite (NO_2), ammonium ion (NH_4^+) and molecular/elemental nitrogen (N_2) (UNESCO, 1996; APHA, 1995). The obtained total nitrogen content in pre-monsoon season was in the range (0.25-0.27) mg/l and in post-monsoon it was in the range (0.25-0.5) mg/l which is less than NDWQS for nitrate i.e. 50 mg/l (National Drinking Water Quality Standards, MPPW, 2005). The possible natural source of nitrate in water of Karnali river includes agricultural runoff and plant debris.

5.3 Micro biological parameters:

Thermo-tolerant fecal coliform was taken into consideration as micro biological parameters. The density of *E. coli* was found 28 cfu/100ml, 12 cfu/100ml, 15 cfu/100ml

and 0 cfu/100ml in upstream dam site, dewatered zone and powerhouse site respectively. Similarly, the density of normal coliform was found more than 300 cfu/100ml in all sites except in powerhouse site where it was 192 cfu/100ml. The NDWQS and WHO standard value for both normal coliform and *E. coli* is 0 cfu/100ml (National Drinking Water Quality Standards, MPPW, 2005). The WHO classified that water containing 0/100ml of *E. coli* is of no risk and it is very hygienic. In case, the water contains 1-10/100ml of *E. coli*, it is considered to have low risk and if it contains 11-100/100ml of *E. coli*, then it is considered to have high risk and such type of water should be chlorinated before consumption. If the water contains 101-1000/100ml of *E. coli*, it is considered to have very high risk and it should not be used for drinking purpose. The local people directly use water from Karnali river for drinking and other household purpose. They do not have an idea of chlorination. That is the region; the local people are often suffering from diarrhoea, dysentry, cholera and other water borne diseases as endemism.

5.4 Socio-economic parameters:

5.4.1 Population distribution:

The demographic data of the project affected VDCs shows that there is a large portion of the population falls under the age interval of 16-45 years having high capacity for reproduction. The survey also revealed that 47.06% of the total PAFs are at the interval of 16-45 years and next 27.02% are the school going age i.e. at the age interval of 5-15 years. They will mature in near future. This data shows that population of the project affected VDCs is increasing in a fast rate. Moreover, the average household size of the PAFs is 8.2, indicating a large family that needs large quantity of foodstuff, more expenses for education and treatment and so on. The implementation of the project will certainly increases in-migration as labor force, entrepreneurs and businessman.

5.4.2 Health and sanitation:

19% of the total PAFs directly use the water from Karnali river without using any purification method. On the other hand, 8.57% dispose solid waste to the river and 37.14% directly mix their liquid waste into the river. Another data which reveals that only 35% of the PAFs have simple toilet and rest 65% usually go to river bank and jungle for defecation. Although these anthropogenic activities do not largely contribute for water pollution, *E. coli* and normal coliform were reported in the water samples. So,

the local people are usually suffering from diarrhoea, dysentry, cholera as endemism. There were 16 patients of enteric fever (Typhoid) and 21 patients of dysentry and cholera registered in GMR primary health post in the month of Bhadra, 2069 BS.

The implementation of the project will further decrease the water quality of Karnali river. As a result, various normal as well as fatal diseases might be introduced causing lost of human lives and properties. But it is also true that after development of road in the project affected villages, people will have access of transportation and hence they will get treatment easily.

5.4.3 Occupation:

The project affected VDCs are remote and less developed areas. So, the people have no variety of choices for occupation as in the cities. However, the survey showed that only 31.8% were fully engaged in agricultural and livestock farming whereas 8.82% were seasonally out-migrated to India and other cities of Nepal for employment and 6.8% were engaged in daily wage labor. The implementation of the project will help the local people creating new opportunities of job. It will make their life easy. The direct and indirect employment opportunities will certainly raise the livelihood of the PAFs.

5.4.4 Land holding and agricultural productivity:

The household survey revealed that each household of the PAFs possessed about 23.3 ropanis agricultural land including paddy field and the terraced land. The project will acquire 46.85ha privately owned land for dam construction which adversely affects the agricultural productivity. Similarly, due to construction of tunnels, deforestation and other physical and mechanical activities, the sources of water such as mool, kuwa, springs etc. might be shrunk. The people of upstream using water from Karnali river for irrigation might not be allowed to irrigate their fields after construction of dam. This will make hardship in the livelihood of the PAFs.

5.4.5 Employment and income:

The Badi communities and some marginalized groups living in the dewatered zone i.e. in Ramgad Bazaar, who are poor and totally dependent on fishery will be severely affected by the project. The project would deprive them from their only one occupation leading to

further impoverishment. That's why the project needs to identify such groups and individuals all along the dewatered zone and provide them with suitable alternatives like employment in the project or provide them skill training and other income generating activities.

5.4.6 Energy use:

The survey revealed that the only source of energy for cooking in the project affected VDC was firewood. Solar panels are used for lightening in 66% of the PAFs. The initial cost of solar system is very expensive. The Government of Nepal provides subsidy up to 75% for each solar system to the villagers.

After implementation of the project, the local people are hoping for using the hydro electricity generated by the project for domestic use. But it is uncertain because the 12% free energy that will provide from the project as per the MoU will connect to the national grid and there is no provision to distribute the hydro electricity to the PAFs in that document. That is the main region; the local people are raising their voice to make some correction in the document during PDA by consulting their opinion.

Another cause of people's dissatisfaction is that the project is not for fulfilling the needs of Nepalese people. It is clearly stated in the MoU that the project is export oriented and the Nepalese people get only 12% as free energy from the project. The whole ownership of the project is handed over to the foreigner private company for at least 30 years. During that period, the controlling key for construction and operation will be in the hand of GMR Company and even the local people will not have right to utilize the water resources in upstream and downstream zone because that may harm the project in power generation.

5.4.7 Fish population:

50% of the total respondents predicted that the fish population would be decreased after construction of dam. It would be because of water pollution, drastic decrease in the water level in the downstream, human encroachment and so on.

CHAPTER: VI

CONCLUSION AND RECOMMENDATION

6.1 Conclusion:

It is surprising that the theoretical hydropower potential of the proposed UKHEP with 40% design discharge, 85% overall efficiency and 150.11 m net rated head was calculated as 549.63MW. This value would be certainly changed if GIS software and other engineering approaches are utilized in estimation of the hydropower potential, but it is hard to reach 900MW. However, the developer (GMR) proposed to harness firm capacity of 900MW electricity from the project. It is only possible when the developer design the project with Q_{29}% design discharge and 92% overall efficiency. In that case, firm capacity of 900MW will be produced only for 2 months from the same project and in rest 10 months, there will be gradually decreasing in electricity production. Furthermore, the developer applied optimization with peaking provision for 3.26 hours daily.

The present status of physico-chemical parameters of Karnali river is in the normal range for aquatic lives. The river is snow-fed and there is no presence of any industries and ore extraction site in the upstream site. Moreover, the river is highly turbulent due to high gradient. So, anthropogenic activities do not significantly affect the water quality in the river. However, the pH value recorded in post-monsoon was abruptly increased to 9.7 which is alkaline in nature. On the other hand, concentration of DO in the Karnali river was found greater than that in other normal rivers reaching up to 12.89 mg/l during post-monsoon. The density of microbiological organisms such as *E. coli* was found as high as 28 cfu/100ml. Similarly, the density of normal coliform was found more than 300 cfu/100ml in all sites except in powerhouse site where it was 192 cfu/100ml. The NDWQS and WHO standard value for both normal coliform and *E. coli* is 0 cfu/100ml. The local people directly use water from Karnali river for drinking and other household purpose. That is the region; the local people are often suffering from diarrhea, dysentery, cholera and other water borne diseases as endemism.

By implementation of the project, there would be changed the land use pattern of about 254.8ha land including both government owned jungle and the privately owned cultivated land. 46.85ha of privately owned agriculturally land would be acquired directly affecting 236 households out of which 55 HHs would lose their houses and other physical infrastructures; and 184 HHs would completely lose their agricultural land. Similarly, since the river flow pattern from the dam site to the powerhouse site (the distance in between these two points is 54km) alters after the construction of dam, the fisheries communities such as Majhi, Badi and other marginalized groups would face hardship in their livelihood. Besides, social norms that have been practiced from generations would be altered and social disharmony might occur due to influx of in-migrated population to the project area. Different types of environmental problems such as pollution, landslide, unprecedented flooding to downstream, deforestation, loss of wildlife etc; and social crime and introduction of HIV/AIDS would also be the adverse impact after implementation of the project.

However, there are many positive impact of the project. More than 3500 skilled, semi-skilled and unskilled work force would be generated and the local people from the PAFs might be taken the top priority. Furthermore, the villagers who have been practicing the traditional agricultural system for long time would have new options of jobs such as business and small enterprises, tourism, monthly wage basis permanent job and so on. Along with transportation facility to the villages, academic institutions like school, colleges, training centers etc would be established which help the local youth making academically sound personality and sustaining their lives on their own feet. Development of hospitals, clinics and medical shops are other positive impacts to the local people. Tourism sector might be another new approach that would flourish after implementation of the project because the only motorable way to Jumla and Rara National Park in Mugu district passes through the project.

6.2 Recommendation:

The major recommendations to be integrated during the implementation of the proposed project are listed below.

i. There are very few scientific studies carried out on water quality; bio-physical conditions of environment, socio-economic and cultural aspects of the Karnali river and its surrounding areas. So, scientific study on the Karnali river should be highly encouraged so that the exact identification, prediction and evaluation of the impacts by implementation of UKHEP and any other project could be done; mitigation measures proposed by such types of study would be more effective.

ii. The land or other property acquired by the project should be fairly compensated according to the Land Acquisition Guidelines, 1993.

iii. Use of local labors should be maximized. Potentially all the unskilled and some semi-skilled labors required the project can be recruited from the local area and if needed, a short skill development and enhancement training should be given to potential local labors. This will improve project-public relationship.

iv. Proper information dissemination mechanism should be established so that the stakeholders including PAFs and local political leaders would be convinced to the project.

v. Some points regarding to the MoU that has been agreed to both the party (i.e. GMR and GoN) should be changed respecting the voice raised in national as well as local level during PDA.

REFERENCES

Abida, B., Harikrishna, (2008). *Study on the quality of water in some streams of Cauvery River*. E- Journal of chemistry, 5 (2), pp 337- 384.

Acharya, B., (2009). Environmental assessment of hydropower: A case study of the Hewa-A Hydropower Project, Panchthar, Nepal. A dissertation submitted to Central Department of Environmental Science, Kirtipur, Kathmandu, Nepal.

Adhikari, S.P., (2009). Energy mapping using GIS and hydropower model in Karnali, Mahakali and West Rapti basins. M.Sc. thesis submitted to Department of Civil Engineering (M.Sc. Program in Water Resources Engineering), Pulchowk Engineering Campus. Lalitpur, Nepal.

APHA, (1995). "Standard Methods for the Examination of Water and Waste water", 19th edition, American Public Health Association. 1015 Fifteenth Street, NW, Washington DC.20005.

Ahipathi, M.V., Puttaiah, E.T., (2006). "Ecological characteristics of Urishabhavanthi river in Banglore (India)". Environmental Geology, 49, pp 1217-1222.

Barnwal, S.K., (2004). Kulekhani First Hydropower Project and socio-economic impact on the adjoining area. A dissertation submitted to Central Department of Economics, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Bhatt, L.R., Lacoul, H., Lekhak, H.D., Jha, P.K., (1999). "Physico-chemical characteristics and phytoplankton of Taudaha Lake, Kathmandu". Poll. Res. 18(14), pp 353-358.

CBS, (2008), "Environmental Statistics of Nepal". Central Bureau of Statistics, Kathmandu, Nepal.

CBS, (2011). "National Population and Housing Census 2011 (Village Development Committee/Municipality), Vol.2, NPHC 2011". Central Bureau of Statistics, Kathmandu, Nepal.

Chapman, D., (1992). "Water Quality Assessment; A guide to the use of biota, sediments and water in environment". University Press, Cambridge, pp 585.

Dixit, A. (2002), "Basic Water Science". Nepal Water Conservation Foundation (NWCF), Kathmandu, Nepal, pp 287; 352-357.

DoED, (2004). Environmental impact assessment of Mewa khola at Taplejung District, Nepal.

EPC, (1993). Nepal Environmental Policy and Action Plan. Environmental Protection Council, His Majesty's Government of Nepal, Kathmandu, Nepal.

Fakeyode, S.O., (2005). "Impact assessment of industrial effluent on water quality of the receiving Alaro river in Ibadan Nigeria". Ajean-rangee, 10, pp 1-13.

Ghimire, B.N., (2004). Effect of sedimentation on the Upper Modi Hydroelectric Project. A dissertation submitted to School of Environmental Management and Sustainable Development, Pokhara University, Kathmandu, Nepal.

GITEC, (2000). Environmental impact assessment of Upper Modi Hydro Electricity Project. A scoping, TOR and public hearing documents submitted to the Ministry of Population and Environment through Department of Electricity Development and Ministry of Water Resources, Kathmandu, Nepal.

GMR Upper Karnali Hydropower Ltd., (2010). Upper Karnali Hydroelectric Project, Nepal, detailed project report, volume III.

GMR Upper Karnali Hydropower Ltd., (2011). Brousher of Upper Karnali Hydroelectric Project, Nepal.

GoN, (1992). Industrial Policy 1992. Government of Nepal, Kathmandu, Nepal

GoN, (1993). Water Resource EIA Guidelines 2050 BS. Government of Nepal, Kathmandu, Nepal

GoN, (1995). EIA Guidelines for Forestry Sector 2050 BS. Government of Nepal, Kathmandu, Nepal

GoN, (1995). EIA Guidelines for Industry Sector 2050 BS. Government of Nepal, Kathmandu, Nepal

GoN, (1997). Forest Act, Rules and Regulation 2052 BS. Government of Nepal, Kathmandu, Nepal

GoN, (1997). Irrigation Policy 1993 (Revision in 1997). Government of Nepal, Kathmandu, Nepal

GoN, (1998). Environmental Protection Act 2054 BS. Government of Nepal, Kathmandu, Nepal

GoN, (1999). Environmental Protection Regulations, First Amendment 2055 BS. Government of Nepal, Kathmandu, Nepal.

GoN, (2002). Water Resource Strategy 2002. Government of Nepal, Kathmandu, Nepal

GoN, (2003). National Wetland Policy 2003. Government of Nepal, Kathmandu, Nepal

GoN, (2007). Interim Constitution of Nepal 2063 BS. Government of Nepal, Kathmandu, Nepal

HMG, (1993). National Environmental Impact Guidelines. His Majesty's Government of Nepal, Nepal Gazette, Volume 43, Number 5, Kathmandu, Nepal.

HMG/IUCN, (1988). Building on Success: National Conservation Strategy. His Majesty's Government of Nepal and the World Conservation Union, Kathmandu, Nepal.

Jha, R.N. (2010). Total run-of-river type hydropower potential in Nepal. Department of Civil Engineering (M.Sc. Program in Water Resources Engineering), Pulchowk Engineering College, Lalitpur, Nepal.

Khadka, M.S., (1983). *Study of major ions in Bagmati river near Pashupatinath temple on the day of Mahashivaratri, 2040 B.S.* Journal of Nep. Chem. Soc., Vol. 3, pp 53 – 56.

Khadka, R.B., (2004). Environmental auditing of Modi khola Hydroelectric Project. A dissertation submitted to School of Environmental Management and Sustainable Development, Pokhara University, Kathmandu, Nepal.

KHC, (2001). Environmental impact assessment of Langtang khola Hydroelectric Project, Volume 1: Main report submitted to Ministry of Population and Environment through Department of Electricity Development and Ministry of Water Resources, Chabahil, Kathmandu, Nepal.

LEDCO, (1991). Environmental impact assessment of Nyadi Hydropower Project: Final report submitted to His Majesty's Government of Nepal/Ministry of Population and Environment, Kathmandu, Nepal.

LEDCO, (2001). Environmental impact assessment of Khudikhola Hydropower Project located in Annapurna Conservation Area, Khudi VDC, Lamjung.

Magar, D.P., (2005). A study of socio-economic impact of Piluwa khola Small Hydropower Project, Sankhuwasabha, Nepal. A dissertation submitted to Central Department of Economics, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

MoWR, (1993). Nepalese legal provisions on hydropower development: Hydropower Development Policy 1992, Water Resource Act 1992 and Electricity Act 1992. His Majesty's Government of Nepal, Ministry of Water Resources, Kathmandu, Nepal.

Napit, N.P., (1988), *Pollution problems of the Pashupati area*. Proceedings of seminar on environmental issues of Pashupati area: Identification and control measures, Nov. 7-9, 1987. Royal Nepal Academy of Science and Technology (RONAST), Kathmandu. pp 91-98.

NDWQSC, (2005). "Drinking Water Quality Standards in Nepal". Task Force for Nepal Drinking Water Quality Steering Committee (NDWQSC), Kathmandu, Nepal. pp 26-30.

NEA, (1998). Feasibility study of Kabeli Hydropower Project located in the area close to Hewa A Hydropower Project.

NEA, (2000). Environmental monitoring of Modi khola Hydroelectric Project: Fourth monitoring report, Integrated Consultants Nepal, Baneswor, Kathmandu, Nepal.

NEA, (2003). Post construction environmental impact audit of Kali Gandaki 'A' Hydroelectric Project (final report). Nepal Electricity Authority, Environmental and Social Studies Department, Engineering Services, Kathmandu, Nepal.

NEA, (2005). Environmental impact assessment of Chameliya Hydroelectric Power Project.

NEA, (2012). "Vidyut" a half yearly magazine, Yr. 23, Issue No. 1 (2069 Bhadra), Nepal Electricity Authority, Kathmandu, Nepal.

NESS, (2012). Environmental impact assessment study of Upper Karnali Hydroelectric Project. Summarized version published for public hearing in September, 2012.

NPC, (1975). The Fifth Plan (1975-1980). His Majesty's Government of Nepal/National Planning Commission, Kathmandu, Nepal.

NPC, (2000). "Public Infrastructure (Build, Own, Operate and Transfer) policy 2000". His Majesty's Government of Nepal/National Planning Commission, Kathmandu, Nepal.

Pandey, B., Gupta, V.N.P., Devkota, S., (2002). *Environmental impacts of hydropower development on vegetation and wildlife resources of Kali Gandaki 'A' Hydroelectric Project, West Nepal.* Nepal Journal of Science and Technology 4:19-26. Royal Nepal Academy of Science and Technology (RONAST), Kathmandu, Nepal.

Pandey, U., (2005). Environmental impact assessment of Middle Marsyangdi Hydroelectric Project during construction phase. A dissertation submitted to Central Department of Environmental Science, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Pradhananga, T.M.; Singh, B., Khanal, S.N., (1988). *Water quality of the Bagmati river in the Pashupati river*. Proceeding of seminar on environmental issues of Pashupati area: Identification and control measures, Nov. 7 – 9, 1987. Royal Nepal Academy of Science and Technology (RONAST). Kathmandu, pp. 99 – 124.

Prajapati, R.N. (2011). Theoretical assessment of hydropower potential using GIS and hydrological modeling Technique: A case study of Karnali basin. M.Sc. thesis submitted to Department of Civil Engineering (M.Sc. Program in Water Resources Engineering), Pulchowk Engineering Campus. Lalitpur, Nepal.

Pun, S.B., (2008). *Whither Indo-Nepal water resource? - Part IV, issues and episodes to reflect on Karnali river: from Karnali Chisapani to Mahakali Pancheswar-barking up the wrong tree? "*Vidyut" half yearly magazine, yr.18, Issue No. 2, (2064 BS), Nepal Electricity Authority, Kathmandu, Nepal.

Reddy, J.R. (2002). "A Textbook of Hydrology". Lumbini Publications (P) Ltd., 22 Golden House, Daryaganj New Delhi, India, Reprint in 2002, pp 339-342.

Roy, R., (2002). EIA implementation of different projects with special emphasis on forest resources: Case study of EIA in three projects. A dissertation submitted to School of Environmental Management and Sustainable Development, Pokhara University, Kathmandu, Nepal.

Sagarmatha Power Company (P) Ltd., (2005). Environmental impact assessment of Upper Marsyangdi "A" (UM-O) Hydropower Project, final report.

Shah, R.K., (2009). Energy mapping using GIS and hydropower model in Koshi, Narayani, Bagmati and Karnali basins. M.Sc. thesis submitted to Department of Civil Engineering (M.Sc. Program in Water Resources Engineering), Pulchowk Engineering Campus. Lalitpur, Nepal.

Sharma, C.K., (1977). "River Systems of Nepal". Mrs. Sangeeta Sharma, Kathmandu, Nepal. pp. 1 – 23.

Sharma, R.K., (2004). Post project evaluation of environmental mitigation measures of Kali Gandaki 'A' Hydroelectric Project and 132 KV transmission line. A dissertation submitted to School of Environmental Management and Sustainable Development, Pokhara University, Kathmandu, Nepal.

Sharma, S., Banjade, S., Bhandari, R., (2007). *Impact assessment of Khimti-I Hydropower Project in Nepal on the ecological status of river and fisherman's livelihood*. International conference on small hydropower, Sri-Lanka, October 22-24, 2007.

Shrestha J., Singh D. M., and Saund, T. B., (2009). *Fish diversity of Tamor river and its major tributaries of eastern Himalayan region of Nepal*. Nepal journal of science and technology 10, pp 219-223.

Shrestha, R.R., (1990). Biological and physico-chemical investigation of the Bagmati river (with special reference to water pollution). M. Sc. thesis, Central Department of Botany, Tribhuvan University, Kathmandu.

Shrestha, G.K.C., (2012). Social impact assessment of the proposed Arun III Hydropower Project, Sankhuwasabha, Nepal. A dissertation submitted to Department of Sociology/Anthropology, Tri-Chandra Multiple Campus, Tribhuvan University, Ghantaghar, Kathmandu, Nepal.

Singh M. R., Gupta A., Beeteswari K.H. (2010). *Physico-chemical properties of water samples from Manipur river system, India*. International journal of ecology and environmental management vol.14 (4) pp 85-89.

Singh, K., (2012). Impact assessment on fishes and macro-invertebrates due to proposed high dam on Arun River, Sankhuwasabha, Eastern Nepal. A dissertation submitted to Central Department of Environmental Science, Kirtipur, Kathmandu, Nepal.

Singh, V.B., (2003). Environmental auditing of Ilam Puwa khola Hydropower Project. A dissertation submitted to School of Environmental Management and Sustainable Development, Pokhara University, Kathmandu, Nepal.

Timsina, R.R., (2006). Study of implementation of the environmental mitigation measures in Khudi Hydropower Project. A dissertation submitted to Central Department of Environmental Science, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Trivedi, R.K., Goel, P.K., (1986). "Chemical and biological methods for water pollution studies". Department of Environmental Pollution, Karad, India. pp 1-75.

UNESCO, (1996). "Water Quality Assessment-A Guide to Use of Biota, Sediments and Water in Environmental Monitoring". Second Edition.

Uprety, B. K. 2003. Environmental Impact Assessment: Process and Practice. Mrs. Uttara Uprety, Koteshowr, Kathmandu, Nepal.

Vaidya, K.; Gorkhali, A.P.; Khanal, S., Pradhananga, T.M., (1988). *Water pollution in the Bagmati river of the Pashupati Development Area*. Proceedings of seminar on environmental issues of Pashupati area: Identification and control measures, Nov. 7-9, 1987. Royal Nepal Academy of Science and Technology (RONAST). Kathmandu, pp.158-180.

Water Resource Consult (P) Ltd., (2008). Environmental impact assessment of the Pancheswar Multipurpose Project. Lalitpur, Nepal.

WECS, (2002), "Water Resources Strategy in Nepal", WECS/HMGN, P.O. Box 1340, Kathmandu, Nepal. pp 1-10.

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

West Seti Hydroelectric Project, (2007). "Seti river aquatic ecology extension study". Maharajgunj, Kathmandu, Nepal.

Wetzel R.G., Likens G. E., (2006). "Limnological Analysis". 3rd edition. Springer-Verlag, New York 391.

www.projectsearch.org (accessed on December 15, 2012)

ANNEXES

Annex: 1

MEMORANDUM OF UNDERSTANDING between The Government of Nepal, represented by Ministry of Water Resources and GMR-ITD Consortium, concerning the Execution of Upper Karnali Hydropower Project in Nepal

This Memorandum of Understanding (hereinafter referred to as "MOU") is made and entered into as of this 24th day of January 2008 by and between The Government of Nepal represented by Ministry of Water Resources (hereinafter referred to as "MOWR") and the GMR-ITD Consortium comprising of GMR Energy Limited (GEL), a company incorporated under the Companies Act, 1956 of the Republic of India, GMR Infrastructure Limited (GIL), a company incorporated under the Companies Act, 1956 of the Republic of India, both having their registered offices at Skip House, 25/1,Museum Road, Bangalore 560 025, India and Italian-Thai Development Public Company Limited (ITD), a company incorporated under the appropriate laws of Thailand and having its Registered office at 2034/132-161 New Petchburi Road, Bang Kapi, Huay Kwang, Bangkok 10320, Thailand(hereinafter referred to as "GMR-ITD"), which expression shall unless repugnant to the context or meaning thereof, include its Members of the Consortium, successor(s), administrator(s) and permitted assignee(s) including a public limited company which shall be incorporated in Nepal for the purpose of executing the Upper Karnali Hydropower Project as defined in the subsequent provisions contained herein.

WHEREAS, the Government of Nepal has promulgated its Hydropower Development Policy, 2001 to enhance the development process of hydropower by creating investment friendly settings;

WHEREAS, MOWR on behalf of the Government of Nepal has been working for the promotion of hydropower development in the country in order to implement hydropower projects based on the concept of Build, Operate, Own and Transfer (BOOT);

WHEREAS, the Government of Nepal solicited the Expression of Interest (EOI) to select the Proponent/Developer in order to implement the Upper Karnali Hydropower Project with a minimum installed capacity of 300 MW and associated transmission system for evacuation of power and energy and access road (hereinafter referred to as "Project");

WHEREAS, GMR-ITD had submitted its proposal and wishes to implement the Project and the Government of Nepal, after the careful evaluation of the proposals submitted by various other potential developers evaluated and established GMR-ITD as the most substantially responsive developer to implement the Project of such magnitude thereby invited GMR-ITD to enter into this MOU;

WHEREAS, GMR-ITD is to involve Nepal Electricity Authority (hereinafter referred to as "NEA"), an entity constituted under the Nepal Electricity Authority Act, 2041, having its office at Durbar Marg, Kathmandu, as an equity partner in the execution of the Project;

WHEREAS, the Government of Nepal appreciates that GMR-ITD shall choose appropriate financial options, suppliers, credit options and technologies in the best interests of the Project, and

WHEREAS, MOWR and GMR-ITD have held discussions and wished to formalize endeavor to expedite the execution of the Project; and

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NOW, THEREFORE, MOWR and GMR-ITD hereto hereby agree as follows:

1. Both the Parties acknowledge that the Project is export oriented. GMR-ITD agrees to execute the Project, a peaking Run-of- the river Project located in Karnali River in Achham, Surkhet and Dailekh Districts of Far Western Development Region of Nepal. The Project is more fully described in the report as studied by NEA. The brief description of the Project is attached herewith as Annex I for ready reference. GMR-ITD shall receive, within a period of two weeks, all available information, document, and the Report etc., from NEA, with an one-time complete payment of NRs 80,000,000/- (Nepali Rupees Eight Crores only), for the same. List of documents to be provided, is enclosed as Annexure II.

2. For the purpose of developing the Project, GMR-ITD shall enter into an agreement with Nepal Electricity Authority to establish a Joint Venture Company in accordance with the Company Act, 2056 of Nepal. The Joint Venture Company, (hereinafter referred to as the "JVC"), shall be incorporated within ninety (90) days from the date of signing of this MOU. It is agreed that NEA shall be subscribed 27.00 (Twenty Seven point zero zero) percent of equity, free of costs, by GMR-ITD in the JVC. Provided, however, no financial obligation shall be imposed to NEA for being equity partner. The GMR-ITD consortium, through the JVC, will be responsible for the management and implementation of the Project.

3. GMR-ITD agrees to provide 12 (twelve) percent of monthly generated power and energy from the Project, net of auxiliary

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consumption and transformation losses, measured at the Bus-bar, free of costs from the date of the commencement of generation in addition to the royalty and export tax applicable pursuant to the Hydropower Development Policy 2001 and Electricity Act, 2049 respectively. The export tax shall not be exceeding 0.005% (Point Zero Zero Five Per cent) of export sales revenue.,

4. GMR-ITD assures MOWR that the JVC shall study the possibility of supply of power and energy generated from the Project to the markets of India in order to allow the sales of the generated power and energy in an attractive rate wherever available in the Indian markets. JVC shall ensure suitable arrangements for transmission and evacuation of Power from the Project in the most optimal manner, including through another affiliate Company / Third Party Company.

5. The JVC shall undertake studies, based on the required inputs from NEA, to examine and assess the technical requirements for evacuation of power meant for GoN, at the Project bus-bar/switch yard.

6. The Parties may mutually agree upon the schedule of supply of power and energy to be provided to the Government of Nepal, but the quantum of supply shall not be, in any case, less than 12 percent of the monthly generation, as referred in Clause 3 above. The switchyard infrastructure required for such supply of power and energy to the Government of Nepal shall be constructed, operated and maintained by GMR-ITD, free of cost.

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7. GMR-ITD agrees that JVC shall carry further studies and investigations as may be required bringing the level of studies of the Project to Detailed Engineering Report ("DER") level so as to make the studies at par with internationally accepted pre-construction engineering level. The DER shall also include the access road and the transmission line study for evacuation of power and energy to India and switchyard infrastructure necessary for supply of Power and energy to Nepal, as an integral part of the study.

8. GMR-ITD further assures that JVC shall carry out the Environmental Impact Assessment of the Project in accordance with the Environment Protection Act, 2053, Environment Protection Rules, 2054 and other relevant internationally accepted practices as an integral part of the DER.

9. GMR-ITD shall ensure that the JVC shall apply for Survey License as required to undertake required studies and investigations as mentioned hereinabove with all particulars required therein in accordance with the Electricity Act, 2049 and the Electricity Regulation, 2050 within thirty (30) days from the date of establishment of JVC.

10. A non-refundable fee of NRs. 1,00,000/- (Nepali Rupees One Lac only) per MW of the proposed installed capacity shall be submitted in favour of Department of Electricity Development (DOED), Ministry of Water Resources before the application for survey licence is submitted.

11. The Government of Nepal agrees to grant the Survey License to JVC within 15 (Fifteen) days of submission of complete

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application to DoED in accordance with the prevailing laws of Nepal. The validity of the Survey License to carry out the necessary study/survey/investigation and completion of DER as well as concluding necessary agreement(s) and arranging finance for the development of the Project shall be for the period of thirty (30) months from the date of issuance of such license.

12. GMR-ITD shall ensure that JVC shall start the works within three (3) months from the date of issuance of the Survey License and duly inform the same to MOWR. The JVC shall submit progress of its works to MOWR every six (6) months. The JVC shall submit five copies of DER along with all relevant documents including data/maps at the end of the study/investigation.

13. In the event JVC does not apply for the Generation License or fails to meet the requirements stipulated hereinabove for the purpose of grant of Generation License, all documents, reports including DER, Data /maps, etc. submitted to MOWR shall remain as the property of the Government of Nepal without any obligation, whatsoever.

14. The JVC shall conduct an Environmental Impact Assessment Study (EIA) and prepare a detailed EIA Report and an Environmental Management Plan for the Project. The Government of Nepal agrees to provide any assistance requested by the JVC during the time the EIA is conducted and prepared. The Government of Nepal also agrees to use its best efforts to procure the grant of all environmental approvals and forest clearances from the concerned departments within the minimum possible time for the Project.

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15. GON shall make available all necessary land, structures, buildings and utilities owned by third parties to JVC for the construction of the project in accordance with section 33 of the electricity act 2049. If the land is already owned by GON, the land shall be made available on lease, with either a reasonable annual rent or such other rent as may be required by applicable law, for the period of project license for land needed for permanent use or for such shorter period as may be necessary for temporary use. For rehabilitation of displaced families, rehabilitation and resettlement arrangement would be facilitated by Govt. of Nepal and implemented by the JVC as per prevailing guidelines and practices.

16. The Government of Nepal shall grant to the JVC such incentives and concessions as are provided in the relevant Policy and enactments in force. The Government of Nepal shall take necessary action to provide overall security as per applicable law. Any additional security arrangements as may be required by the JVC for the Project , the same shall be provided by the Govt. of Nepal and the cost of the same shall be borne by the JVC

17. JVC shall ensure that JVC shall apply for Generation License and Transmission License along with relevant Power Purchase Agreement(s), Financial Closure, approved EIA, etc. within the validity period of the Survey License in accordance with the Electricity Act, 2049 and Electricity Regulations, 2050.

18. JVC shall be held responsible for the completion of the construction works within fifty four (54) months from the date of Financial Closure to Commissioning of the Project.

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Provided that, in case JVC complètes the work envisaged as in Clause 11 above, before 30 months, then the time so saved (30 months minus actual time taken in months) will be credited to the period from Financial Closure to Commissioning of the Project i.e., 54 months plus time saved in completing the works envisaged in clause 11 above.

19. The JVC while implementing the Project undertakes to comply with all statutory requirements in respect of laws, regulations and procedures governing establishment and operation of hydropower.

20. The Government of Nepal agrees to grant the licenses for generation and transmission of Electricity to JVC for the development and operation of the Project for a period of thirty (30) years from the date of issuance of such licenses on Build, Own, Operate and Transfer (BOOT) basis. During the validity period of the licenses, JVC shall maintain and operate the Project according to generally acceptable prudent hydropower and electricity utility practices and handover the ownership of the Project to the Government of Nepal, free of cost, at the end of such period. At the time of handing over to the Government of Nepal, the Project shall be in a good running condition. Government of Nepal shall have an entitlement to inspect Project periodically. The Cost of such inspection shall be borne by the Government of Nepal.

21. The Government of Nepal, in the course of issuing a Generation License, shall demand a Performance Security at the rate of NRs 5,00,000/- (Nepali Rupees Five Lacs only) per MW which shall be in the form of an unconditional Bank Guarantee issued by an international bank acceptable to

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MOWR and counter guaranteed by a Nepalese Bank. The Government of Nepal shall have the unconditional entitlement to forfeit such Performance Security, if JVC fails to comply with any material terms and conditions prescribed in the Generation License.

22. The performance security shall be valid until the commissioning of the Project. No claim shall be made against such security after the commissioning of the Project.

23. GMR-ITD shall ensure that JVC shall develop the Project in accordance with the terms and conditions as agreed upon as well as within the purview of the relevant laws of Nepal and shall be responsible for all taxes, duties, fees, levies etc., to be paid to the Government of Nepal as provided in the applicable Nepalese laws in force on the date of this MoU. However, in case of any reduction in the taxes, duties, fees, levies etc., the benefit of such change shall be extended to the JVC.

24. The Government of Nepal shall facilitate all clearances and approvals. It also agrees to extend all privileges and facilities to JVC according to the Electricity Act, 2049, the Electricity Regulations, 2050 and other prevailing laws of Nepal in relation to licenses, permissions, authorizations and assurances, etc for the preparation of DER and development and operation of the Project.

25. JVC shall save harmless and indemnify the Government of Nepal in respect of all claims, proceedings, costs, damages, charges and expenses whatsoever arising out of, or in relation to, any such matter in so far as JVC is responsible for the Project.

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26. Each Party hereto agrees that it shall not divulge throughout the validity of the Survey License, any trade, commercial or technical secrets or confidential matters, reports, documents, data, information, including DER, of one another to any third Party save and except for the purpose of implementing the understanding reached in this MOU. However, any sharing of information between the Parties shall be subject to their respective policies on the disclosure of information.

27. Neither Party shall be liable for any default in performing activities hereunder beyond its control including but not limited to, acts of God, war, riots, civil disturbances/disobediences and acts of terrorism or suppression or any other cause beyond the reasonable control of the Party whose performance is affected.

28. GMR-ITD agrees to ensure that JVC shall utilize as much as possible and to the extent qualified, available local skills and labour crafts and shall maximize the use of local institutions, consulting firms, professionals, individuals and contractors for the preparation of DER and the development and operation of the Projects pursuant to the Labour Act, 2049 and the Labour Regulations, 2050.

29. JVC shall ensure that their employees, contractors, advisers or any authorized person/body involved in the preparation of DER and the development and operation of the Project shall abide by the prevailing laws of Nepal.

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30. Time is the essence for each and every provision of this MoU and the target dates mentioned herein shall form an integral part. Failure to accomplish the assignments as prescribed in this MoU within the stipulated time limit for reasons other than Force Majeure or beyond the control of any Party, shall lead this MoU null and void except for Article 9 above. However, in the event any Force Majeure conditions or conditions beyond the control of any Party, time shall be extended for such duration.

31. Provided that in the event of failure by GMR-ITD to accomplish the assignments as prescribed in this MoU, within the stipulated time limit or breach of any conditions in this MoU, due opportunity shall be provided to GMR-ITD to remedy any delay or fulfill any obligations within a period of not less than Ninety (90) days, after receipt of the notice.

32. Each Party to this MOU and each individual signing on behalf of each Party, hereby represents and warrants to the other that it has full power and authority to enter into this MOU and that both the Parties shall facilitate each other for the execution, delivery and performance of the terms of this MOU.

33. In addition to the actions specifically mentioned in this MOU, the Parties will each do whatever may reasonably be necessary to accomplish the transactions contemplated in this MOU including, without limitation, executing any additional documents reasonably necessary to effectuate provisions and purposes of this MOU. Both Parties shall enter into a detailed Project Agreement for the development and operation of Project, within the validity period of this MOU, where the

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content or contents of this MOU may be incorporated in the Project Agreement.

34. GMR-ITD shall not assign responsibilities under this agreement without the prior approval of the Government of Nepal. The transfer of License shall not be allowed during the period of Survey License.

35. The terms and conditions prescribed at the time of solicitation of EOI and the offer made by GMR-ITD shall be an integral part of this MOU. If any provision of EOI together with the GMR-ITD's offer and MOU contradict each other the provision of MOU shall prevail.

36. GON acknowledges that due consideration may be accorded to GMR-ITD Consortium for the allotment of upstream / downstream project, if any.

37. GoN shall ensure that the development, implementation and operation of upstream / downstream Projects by other developers shall not be detrimental in any way to the Project.

38. If any provision or any part or parts of the provision of this MOU is held invalid or contrary to the prevailing laws of Nepal, the remaining provisions of this MOU shall remain valid and unaffected.

39. This MOU shall commence from the date of its signature. It shall remain valid up to the validity of the Survey License or the Project Agreement, whichever is earlier, unless otherwise agreed between the parties in writing.

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40. This MOU constitutes the entire MOU and understanding of the Parties. This MOU may not be modified except in writing signed by both the Parties.

41. Any difference or dispute arising out of this MOU at any time between the Parties shall be resolved by mutual consultation and in good faith.

IN WITNESS WHEREOF, the Parties hereto, acting through their duly authorized representatives, have caused this Memorandum of Understanding signed on the date first above written at Kathmandu, Nepal.

On behalf of
The Government of Nepal,
Ministry of Water Resources

Mr. Anup Kumar Upadhyay
Joint Secretary

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Witnesses

1. Mr. Rajendra K. Kshatri
   Joint Secretary
   Water and Energy Commission
   Secretariat

2. Mr. Sunil B. Malla
   Deputy Director General
   Department of Electricity Development

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On behalf of
GMR-ITD Consortium

Mr. Avinash Shah
Sr. Vice President

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Witnesses

1. Mr. Harvinder Manocha
   Associate Vice President
   GMR Energy Limited

2. Mr. Rajib Misra
   General Manager
   GMR Energy Limited

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Annex: 2

Daily discharge (m^3/s) in Karnali river at the proposed dam site and flow duration curve

	Asaraghat	Head works
Area	21438	21458
Precipitation	920	920.0

factor = 1.000933

Upper Karnali Hydropower Project

Long Term Daily Average Discharge (m^3/s) in Karnali at Asaraghat (Stn No:240)

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	145.24	123.61	122.25	156.45	270.00	461.64	890.61	1358.85	1190.27	565.97	276.94	187.69	479.13
2	144.52	121.85	122.15	154.31	283.64	487.61	892.88	1350.03	1169.00	543.36	272.00	184.69	477.17
3	143.39	121.45	120.45	154.18	297.58	501.27	901.30	1365.33	1144.24	525.33	267.42	182.69	477.05
4	141.52	120.82	119.58	154.33	302.18	529.36	904.58	1369.18	1134.18	508.76	268.88	180.78	477.84
5	140.85	120.52	121.24	152.66	301.94	524.97	925.70	1324.76	1121.67	517.52	260.06	179.47	474.28
6	139.79	118.85	123.50	154.66	306.18	509.58	932.24	1336.15	1150.67	535.97	254.97	177.63	478.35
7	139.03	118.40	123.31	157.11	313.82	535.45	946.36	1326.45	1139.64	536.12	251.79	176.16	480.30
8	145.00	118.65	122.42	161.88	327.42	567.73	975.85	1324.21	1080.64	507.33	247.82	174.28	479.44
9	139.39	120.17	122.33	164.55	341.27	645.30	1003.00	1331.30	1031.48	489.39	243.97	173.09	483.77
10	137.03	117.93	121.10	169.39	347.48	621.21	1018.61	1350.76	1034.82	461.06	241.24	176.81	483.12
11	135.52	118.96	121.58	170.61	349.76	612.97	1006.64	1366.67	1036.79	453.85	239.21	171.75	482.02
12	134.85	121.32	124.24	173.52	345.85	637.09	1013.61	1426.45	1010.58	499.33	235.76	169.41	491.00
13	134.27	120.25	126.33	176.45	357.97	694.06	1027.94	1452.79	956.30	457.58	233.67	169.06	492.22
14	133.24	120.64	126.31	179.64	404.52	673.06	1082.00	1366.76	939.61	430.09	230.42	167.94	487.85
15	132.67	119.58	127.97	185.85	425.52	667.39	1085.52	1358.33	904.27	413.85	225.70	165.25	484.32
16	133.64	117.97	127.55	194.52	468.39	675.91	1109.27	1384.97	879.55	404.97	221.39	162.91	490.09
17	133.06	116.36	128.82	197.52	449.61	685.45	1152.48	1356.79	844.42	393.48	219.59	161.55	486.60
18	131.76	115.95	133.95	200.82	451.52	672.55	1169.21	1393.55	800.33	384.79	217.06	160.30	485.98

19	132.39	116.50	133.19	204.45	439.85	703.91	1205.79	1431.30	776.82	371.30	213.84	158.73	490.67
20	132.36	117.43	132.32	205.91	438.70	731.58	1218.15	1393.00	812.97	357.94	212.16	157.09	492.47
21	130.39	116.94	134.98	209.82	437.39	742.76	1249.12	1381.97	761.27	347.15	209.78	155.82	489.78
22	129.12	115.74	135.80	214.70	430.30	775.15	1266.91	1350.94	729.91	338.33	206.94	154.09	487.33
23	127.85	115.72	140.19	218.15	429.88	799.06	1254.88	1351.76	718.55	332.36	206.47	153.79	487.39
24	127.61	114.62	142.38	220.76	429.85	816.03	1238.39	1304.18	719.33	326.70	203.78	152.61	483.02
25	126.45	116.86	141.77	226.79	448.85	817.64	1283.27	1286.55	702.24	320.12	201.44	152.15	485.34
26	125.91	117.72	146.05	232.42	459.27	823.36	1313.12	1288.76	675.06	314.27	198.47	152.64	487.25
27	125.33	119.20	141.84	241.03	473.03	845.94	1325.76	1284.15	662.79	308.67	196.13	152.48	489.70
28	125.36	118.43	141.95	247.52	483.45	856.76	1362.52	1283.79	628.36	303.15	192.97	149.33	491.13
29	122.45	114.50	145.70	257.09	489.73	868.58	1335.55	1257.91	644.12	305.33	190.66	148.45	490.01
30	121.91		152.69	263.67	461.30	868.67	1330.94	1231.00	615.12	290.67	188.56	148.30	515.71
31	121.09		156.84		457.39		1340.27	1200.88		284.88		146.82	529.74
Mean	**133.32**	**118.52**	**131.64**	**193.36**	**394.31**	**678.40**	**1121.37**	**1341.60**	**900.50**	**413.86**	**227.64**	**164.64**	**484.93**

Generated Long Term Daily Average Discharge (m3/s) at Upper Karnali Head works

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	145.38	123.72	122.36	156.60	270.25	462.07	891.44	1360.12	1191.38	566.50	277.20	187.86	479.57
2	144.65	121.97	122.27	154.46	283.90	488.06	893.71	1351.29	1170.09	543.87	272.25	184.86	477.61
3	143.53	121.57	120.57	154.32	297.85	501.74	902.14	1366.61	1145.31	525.82	267.67	182.86	477.50
4	141.65	120.93	119.69	154.47	302.46	529.86	905.42	1370.46	1135.24	509.23	269.13	180.95	478.29
5	140.98	120.63	121.35	152.81	302.22	525.46	926.56	1325.99	1122.71	518.00	260.30	179.64	474.72
6	139.92	118.96	123.62	154.80	306.47	510.05	933.11	1337.40	1151.74	536.47	255.21	177.79	478.79
7	139.16	118.51	123.42	157.25	314.11	535.95	947.25	1327.69	1140.70	536.62	252.02	176.32	480.75
8	145.14	118.76	122.54	162.03	327.73	568.26	976.76	1325.45	1081.64	507.81	248.05	174.44	479.88
9	139.52	120.28	122.45	164.70	341.59	645.91	1003.94	1332.55	1032.45	489.85	244.20	173.26	484.22

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
10	137.16	118.04	121.21	169.55	347.81	621.79	1019.56	1352.02	1035.78	461.49	241.47	176.98	483.57
11	135.64	119.07	121.69	170.77	350.08	613.54	1007.58	1367.94	1037.76	454.27	239.44	171.91	482.47
12	134.97	121.44	124.36	173.68	346.17	637.69	1014.55	1427.79	1011.52	499.80	235.98	169.56	491.46
13	134.40	120.36	126.45	176.62	358.30	694.71	1028.90	1454.14	957.20	458.00	233.88	169.22	492.68
14	133.37	120.75	126.43	179.80	404.89	673.69	1083.01	1368.03	940.48	430.49	230.64	168.09	488.31
15	132.79	119.69	128.09	186.02	425.91	668.02	1086.53	1359.60	905.12	414.23	225.91	165.40	484.78
16	133.76	118.08	127.67	194.70	468.83	676.54	1110.31	1386.26	880.37	405.35	221.60	163.06	490.54
17	133.18	116.47	128.94	197.70	450.03	686.09	1153.56	1358.05	845.21	393.85	219.80	161.70	487.05
18	131.88	116.05	134.07	201.01	451.94	673.17	1170.30	1394.85	801.08	385.15	217.27	160.45	486.43
19	132.52	116.61	133.32	204.65	440.26	704.57	1206.91	1432.64	777.54	371.65	214.04	158.88	491.13
20	132.49	117.54	132.45	206.10	439.11	732.26	1219.29	1394.30	813.73	358.27	212.35	157.24	492.93
21	130.52	117.05	135.11	210.01	437.80	743.45	1250.29	1383.26	761.98	347.48	209.98	155.96	490.24
22	129.24	115.85	135.93	214.90	430.70	775.87	1268.09	1352.20	730.59	338.65	207.13	154.23	487.78
23	127.97	115.83	140.32	218.36	430.28	799.81	1256.05	1353.02	719.22	332.67	206.66	153.93	487.84
24	127.73	114.73	142.51	220.96	430.25	816.79	1239.55	1305.40	720.00	327.00	203.97	152.75	483.47
25	126.57	116.97	141.90	227.00	449.27	818.40	1284.47	1287.75	702.90	320.42	201.63	152.29	485.80
26	126.03	117.82	146.19	232.64	459.70	824.13	1314.35	1289.96	675.69	314.57	198.65	152.78	487.71
27	125.45	119.31	141.97	241.26	473.47	846.73	1326.99	1285.35	663.41	308.95	196.31	152.63	490.15
28	125.48	118.54	142.08	247.75	483.91	857.56	1363.79	1284.99	628.95	303.43	193.15	149.47	491.59
29	122.57	114.61	145.83	257.33	490.18	869.39	1336.79	1259.08	644.72	305.62	190.83	148.59	490.46
30	122.02		152.83	263.91	461.73	869.48	1332.18	1232.15	615.70	290.94	188.74	148.44	516.19
31	121.21		156.99		457.82		1341.52	1202.00		285.14		146.96	530.23
Mean	**133.45**	**118.63**	**131.76**	**193.54**	**394.68**	**679.03**	**1122.42**	**1342.85**	**901.34**	**414.25**	**227.85**	**164.79**	**487.88**

By Daily Average

Flow Duration Curve		
S.N.	Probability of excedence	River Discharge (m^3/s)
1	0%	1454.14
2	5%	1348.85
3	10%	1257.57
4	15%	1083.89
5	20%	905.12
6	25%	757.35
7	30%	633.32
8	35%	500.28
9	40%	439.11
10	45%	345.03
11	50%	280.55
12	55%	232.95
13	60%	203.97
14	65%	176.89
15	70%	158.06
16	75%	148.81
17	80%	139.16
18	85%	129.17
19	90%	122.40
20	95%	119.41
21	100%	114.61
	40%	439.11

S.N.	Month	River Flow	D/S Release	Available flow for Diversion
1	Jan	133.45	11.46	121.99
2	Feb	118.63	11.46	107.17
3	Mar	131.76	11.46	120.30
4	Apr	193.54	11.46	182.08
5	May	394.68	11.46	383.22
6	Jun	679.03	11.46	667.57
7	Jul	1122.42	11.46	1110.95
8	Aug	1342.85	11.46	1331.39
9	Sep	901.34	11.46	889.88
10	Oct	414.25	11.46	402.78
11	Nov	227.85	11.46	216.39
12	Dec	164.79	11.46	153.33
13	Annual	487.88	11.46	476.42

Annex: 3

Detailed salient features of proposed Upper Karnali Hydropower Project

LOCATION	
Country	**Nepal**
District	Surkhet, Dailekh and Achham
River	Karnali
Geographical location	Boundary of Mid-Western and Far-Western development regions of Nepal
Survey license boundary	Latitude 28^{o}42'00"N to 28^{o}58'00" N and Longitudes 81^{o}25'00" E to 81^{o}35'30" E
Dam location	Eastern arm of Karnali bend 1.5 km upstream of Ramgad khola confluence Latitude 28^{o}55'23" N and longitude 81^{o}28'20" E
Powerhouse location	Western arm of Karnali bend on right bank 1.25 km upstream of Tallo Balde khola latitude 28^{o}54'02" N and longitude 81^{o}26'40" E
HYDROLOGY	
Catchment area	21,458 km^2
Annual Average rainfall	920 mm
Max. average monthly flow	1384 cumec
Min. average monthly flow	117 cumec
1 in 1000 year flood	6700 cumec
1 in 10,000 year flood	8050 cumec
RESERVOIR	
Full reservoir level (FRL)	EL. 637.00 m
Min. draw down level (MDDL)	EL. 633.00 m
Gross storage	17.86 MCM
Live storage	6.66 MCM
Surface area at FRL	196 ha
Length of reservoir at FRL	8.9 km
RIVER DIVERSION WORKS	
Diversion discharge	600 cumec
Diversion tunnel/Sediment diversion tunnel	
Length	1050 m
Size and shape	9 m diameter and horse-shoe shape
Upstream coffer dam	
Location	1050 m upstream of dam site
Height	21 m

Top elevation	EL. 632.00 m
Downstream Coffer dam	
Location	200 m downstream of dam site
Height	9 m
Top elevation	EL. 618.50 m
DAM	
Type	Concrete gravity type
Dam top	EL. 640.00 m
Length at dam top	207 m
Max. height	64 m from deepest foundation level and 30 from river bed level
SPILLWAY	
Main spillway	
Type	Orifice type
Crest elevation	EL. 613.00 m
No. and size of bays	5 bays; 11m×14 m
Auxiliary spillway	
Type	Overflow type
Crest elevation	EL. 631.00 m
No. and size of bays	1 bay; 3 m×6 m
Energy dissipation	
Type	Stilling Basin
Cistern level	EL. 607.00 m
POWER INTAKE	
No. and size of openings	4 nos.; 15m×11.25m
Design discharge	744 cumec
Invert level	EL. 617.50 m
Length	146 m
Sediment protection wall top	EL. 625.00 m
Trash rack	Inclined at 10 with vertical
Gate size	7.5m×7.5m
INTAKE TUNNELS	
No.	4 nos.
Size and shape	7.5 m diameter and horse-shoe shape
Length	235 m each
HEAD RACE TUNNEL (HRT)	

No.	2 nos.
Size and shape	10 m diameter and horse-shoe shape
Length	2332 m and 2220 m
Design discharge	744 cumec
BRANCH TUNNELS	
No.	4 nos.
Size and shape	7.5 m diameter and horse-shoe shape
DESILTING CHAMBERS	
No.	4 nos.
Size and shape	20m×22.8m×210m and Defour shape
Particle size to be excluded	90% coarser than 0.30 mm
SILT FLUSHING TUNNELS (SFT)	
Branch SFTs	
No.	4 nos.
Size and shape	7.4 m diameter and horse-shoe shape
Main Feeder tunnels	
No.	2 nos.
Size and shape	10 m diameter and horse-shoe shape
Length	350 m and 340 m
SURGE SHAFTS	
Type	Restricted orifice
No.	2 nos.
Size and shape	28 m diameter circular×40m high
Top level	EL. 660.00 m
Surge gallery	
No.	2 nos.
Elevation	EL. 623.00 m
Size and shape	10 m diameter and horse-shoe shape
Length	300 m each
PRESSURE SHAFTS	
No.	4 nos.
Length	250 m to 275 m (including horizontal limbs)
Size and shape	6 m diameter and circular
Penstocks	
No.	8 nos.

Length	50 m each
Size and shape	4.25 m diameter and circular
Power house	
Type	Surface
Installed capacity	900MW
No. and capacity of units	8 nos.×112.5MW
Type of turbine	Francis
Design discharge	664.32 cumec
Normal tail water level (8 machines)	EL. 476.41 m
Min. tail water level (1 machine)	EL. 473.30 m
Max. tail water level (HFL)	EL. 486.20 m
Gross head	159.26 m
Rated net head	150.11 m
PLOT HEAD YARD	
Size	40m×100m
Elevation	EL. 499.00 m
POWER GENERATION	
Design annual energy generation	3466 MU
PLF (Design)	43.96%
Min. peaking hours	3.26 hours

Source: NESS, 2012

Annex: 4

Observation table for physico- chemical parameters of the proposed Upper Karnali Hydroelectric Project

parameters	pre-monsoon				Post-monsoon			
	Site 1 (upstream) 5-Jun-12 2.45 PM	Site 2 (Dam site) June 4,2012 10.0 AM	Site 3 (Dewatered zone) 6-Jun-12 9.30 AM	Site 4 (Powerhouse site) 8-Jun-12 11.0 AM	Site 1 (Upstream) Nov. 21, 2012 11.30 AM	Site 2(Dam site) Nov. 20, 2012 12.07 PM	Site 3 (Dewatered zone) Nov. 20, 2012 4.30 PM	Site 4 (Powerhouse site) Nov. 24, 2012 3.45 PM
Air temperature (°C)	31	31	30	29	20	20	18	18
Relative Humidity	98%	94%	98%	96%	58%	59%	58%	51%
Water temperature (°C)	17.5	17	16.4	15	14.5	10.4	11.7	11.4
pH	7.3	7.3	7.2	7.4	8.4	8.7	8.4	9.7
Transparency (cm)	102	96	93	95	222.5	227	217.5	203
Turbidity (NTU)	1.2	8.9	2.8	1.3	0.4	0.6	0.6	0.3
Electric Conductivity (µs/cm)	113	134	158	147	255	325	340	298
Chloride (mg/l)	7.1	11.36	7.1	9.9	24.14	22.72	19.88	19.88
Free Carbon dioxide (mg/l)	15.4	13.2	15.4	13.2	19.8	17.6	19.8	19.8
Total Hardness (mg/l)	142	136	150	150	90	88	90	86
Total Alkalinity (mg/l)	5	5	10	5	10	15	10	15
Iron	0.13	0.02	0.05	0.05	0.3	0.5	0.4	0.2
Phosphate-P	0.01	0.2	0.03	0.1	0.3	0.8	0.5	0.22
Nitrate-N	0.25	0.25	0.27	0.27	0.28	0.5	0.25	0.75
DO (mg/l)	8.86	10.07	9.26	10.07	12.73	12.89	12.73	11.27

Annex: 5

PROPOSED 900MW UPPER KARNALI HYDROPOWER PROJECT
Socio-economic Questionnaire Survey

Name of Data Collector: Date:

HOUSEHOLD SURVEY

A. Enumerator Information

Development Region: District: VDC/Municipality:
Ward No.: Tole: Respondent Name:
Caste/Ethnic group: Sex: Age:
Education: Occupation: Religion:
Family Structure: Nuclear/ Joint Experience /Training:
Resident Period:
(a) Recently (before 30 Years); (b) Only One Generation; (c) More than 2 Generation

B. Family Information

S. N.	Full Name of Individual	Sex 1	Marital Status 2	Age (Yrs)	Relation to Respondent	Education 3	Occupation 4	Experience/ Training (5)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Note: Fill the following code numbers appropriate column

Sex 1: (1) Male (M) (2) Female (F)

Marital Status 2: (1) Single(S) (2) Married (M) (3) Widow/Widower(W)
(4) Separated (S) (5) Divorce (D)

Education 3: (6yrs above)

Occupation 4:

Experience/Training 5: (Above 15yrs)

(1) Uneducated	(1) Farmer	(1) Carpenter
(2) Read and write only	(2) Business	(2) Tailor
(3) Primary level (1-5 class)	(3) Office……..	(3) Tanner
(4) Lower secondary (6-8 class)	(4) Wage labor	(4) Shoe maker
(5) Secondary (9-10 class)	(5) Student	(5) Driver
(6) SLC	(6) Unable to work	(6) Construction worker

(7) Intermediate …… (7) Other …… (7) Basket maker

(8) Bachelors ……... (8) Employer

(9) Masters……

(10) PhD……

(11) Technical …….

Is your family member work in abroad? (a) Yes; (b) No

If yes,

S.N.	Relation to Respondent	Country	Average monthly income (NRs)
1			
2			
3			
4			

House Hold Details

S.N.	House hold type	Number of Rooms	Electrification	Cattle shed	storage
1	Permanent				
2	Stone roof				
3	Steel roof				
4	Straw roof				

C. Sanitation facilities

(a) Open/indiscriminate; (b) Simple latrine; (c) Pour flush latrine; (d) Septic tank

D. Solid waste disposal

(a) Open/indiscriminate; (b) Open dump; (c) Bury in yard (d) Public container;

(d) Dispose into the river; (e) Burn (f) Other (specify) …….

E. liquid waste disposal

(a) Open/indiscriminate; (b) dispose to farmland (c) mix into river

F. How much time takes for portable water? ……

G. Farm Size/Production

1. Do you have cultivated land? (a) Yes; (b) No

If Yes

S. N.	Land type	Own land				Shared Tenant				Rented land (in/out)				Land type (Guthi/Ailani)			
		R	A	P	D	R	A	P	D	R	A	P	D	R	A	P	D
1	Khet																
2	Bari																
3	Kharbari																
4	Forest																
5	Garden																
6	Total																

Note: R = *Ropani*(रोपनि); A = *Ana*(आना):P = *Paisa*(पैसा); D = *Dam*(दाम)

2. What types of Crop do you grow?

S. N.	Food crop	Cultivated land			Production			Consumption (Kg)	Surplus (Kg)	Deficit (Kg)	Deficit Period	Buy/Sell Amount (Kg)	Buy/Sell Cost (NRs)
		R	A	P	D	Muri	Kg						
1	**Khet**												
	Rice												
	Wheat												
	Millet												
	Corn												
	Potato												
	Pulses												
	Mustard												
	Vegetables												
	Other												
2	**Bari**												
	Ghaia (rice'												
	Corn												
	Wheat												
	Millet												
	Pulses												
	Mustard												
	Potato												
	Other												

Note: R = *Ropani*(रोपनि); A = *Ana*(आना); P = *Paisa*(पैसा); D = *Dam*(दाम)

3. How will you manage for the deficit months?

(a) Buy (b) burrow (c) Barter (d) Wage Labor (e) Other (specify)……

4. If surplus what do you do with the surplus crops?

(a) Store (b) Sale (c) Other (specify)…….

H. Livestock Type and Holding

S. N.	Types of Animal	Numbers		Stall Feeding	Grazing	Both
		Local	Breeding			
1	Buffalo					
2	Cow/Ox					
3	Goat/sheep					
4	Birds (chicken, duck, pigeon)					

1. Where do you sell your animal products?

Product	Market	Total sell/ month	Rate/Unit (Rs.)	Income/Month (Rs.)
egg				
Milk				
Butter				
Cheese				
Wool				
Woolen product				
Others				

I. Do you have community forest?

(a) Yes (b) No

If yes, how much resource do you get from your forest?

Fodder/ Fuel Wood/ Timber

Season/ Month	Fodder			Fuel Wood			Timber		
	Species	Quantity	Bhari/Kg	Species	Quantity	Bhari/Kg	Species	Quantity	Bhari/Kg
Dry season									
Rainy season									
Winter season									

J. Alternative Energy

Fill in the information on use of fuel and how it is obtained (Record use for **each month**, liter of kerosene and Bhari for fire Wood) (1 Bhari = ….)

S.N.	Type of Energy used	Amount	Expenditure	Source
1	Kerosene			
2	Electricity			
3	Solar			
4	Battery			
5	LPG Gas			
6	Others (Specify)			

1. Do you have Biogas Plant in your House?

(a) Yes; (b) No

If Yes,

Installed Date	Biogas	
	Capacity (cub. M)	Expenditure

K. Income and Expenses

Annual income and expenses

Income			Expenses		
S.N.	Description	Income (NRs)	S.N.	Description	Income(NRs)
1	Food grain		1	Food grain	
2	Pulses		2	Vegetables and fruits	
3	Milk product		3	Meat	
4	Raring animals		4	Oil and spices	
5	Vegetables		5	Milk, sugar and tea	
6	Fruits		6	Cigarette	
7	Wages		7	Drinks	
5	Salary		5	Cloth and sandals	
8	International income		8	Fuel	
9	Cottage industry		9	Fertilizer and grain	
10	Fishing		10	Wages	
11	Industry/Shop		11	Education	
12	Rent		12	Treatment	
13	Other		13	Transportation	
			14	Jewelry	
			15	Buy land	
			16	Religious purposes	
			17	Other	

PROJECT SITE DESCRIPTION

1. **Do you know about the Upper Karnali Hydropower project?** Yes/ No
2. **Would you help the project?** Yes/ No
3. **How would the project help you?**
4. **Where is your land?**

   (a) At Project Site; (b) Near PS; (c) Far from PS
5. **how many Ropanis?** *(Not needed for option (c)*

   Own land

S.N.	Land type	Land Area				Crops Grown	Current Value
		R	A	P	D		
1	Khet						
2	Bari						
3	Kharbari						
4	Forest						
5	Total						

Cultivated but not own land

S.N.	Land type	Land Area				Crops Grown	Current Value
		R	A	P	D		
1	Khet						
2	Bari						
3	Kharbari						
4	Forest						
5	Total						

6. **If land is Khet, Do you use the River water for irrigation?** Yes/ No
7. **If Yes, What will be the problems faced after constructing hydro power project?**
8. **Food sufficiency/ deficiency**

a. **Do you have sufficient food?** Yes/ No

   If sufficient (yes)

b. **Where do you sell your surplus?**

   (a) Local market; (b) Village; (c) Export to other district; (d) Others (specify)

   If Deficient (No)

c. **For how many months _____**

d. **How do you manage food during deficient period?**

   (a) By trade; (b) By service; (c) Wage Labor; (d) Debt (specify source)

9. **What type of compensation do you desire if land is confiscated?**

   (a) Land for land (Desired location); (b) Cash for land; (c) Don't know

10. **What do you expect as compensation for the properties lost by you due to the project?**

    - Land for land
    - Cash for land/House
    - Alternative house
    - Job
    - Vocational training
    - Others:

11. **What will you do with the money you get as compensation?**

    (a) Buy land nearby and settle; (b) Start business; (c) Migrate to nearest town;

    (d) Migrate to big cities like Kathmandu/ Surkhet/ Nepalgunj; (d) Others

12. **Do you want to say any more about the project, your problem or any suggestion to commence the development activities?**

13. **Villagers demand & expectation from the project :**

    1.
    2.
    3.
    4.

PROPOSED 900MW UPPER KARNALI HYDROPOWER PROJECT

QUESTIONNAIRE

Name of Data Collector: Date:

QUESTIONNAIRE FOR FISHERMEN

Enumerator Information

Development Region:	District:	VDC/Municipality:
Ward No.:	Tole:	Respondent Name:
Caste/Ethnic group:	Sex:	Age:
Education:	Occupation:	Religion:
Family Structure: Nuclear/ Joint		Experience /Training:

Resident Period:

(a) Recently (before 30 Years); (b) Only One Generation; (c) More than 2 Generation

1. **Do you think Karnali River as resource?**

   (a) Yes ; (b) No

2. **If yes, what type of resource materials are you taking from it?**

   (a) Water; (b) Fisheries; (c) Flooded fuel wood; (d) Construction material;

   (e) Other (Specify)

3. **How long being are you involving in this profession?**

   ……

4. **How much do you have income from this profession?**

Income type	Income/day/season	Total income/year
Fisheries		
Flooded fuel wood		
Others (specify)		
All		

5. **In which season you caught fish in good amount?**

   (a) Spring; (b) Rainy; (c) Autumn; (d) Winter

6. **How much fish you caught in one day?**

Fish Caught	Amount (Weight) Kg	Price NRs.
General one day accumulation		
General monthly accumulation		
Highest in season		
Single fish Record weightiest		

7. What do you do with caught fisheries?

(a) Consume yourself; (b) Sell; (c) Partial sell

8. What methods do you use to catch fish?

(a) Mesh; (b) Hook; (c) Poison (d) River divert (e) Electric shock

9. What species of fish are available in this river?

a)	e)	i)
b)	f)	j)
c)	g)	k)
d)	h)	l)

10. Which fish species are most common in this river?

a)	c)	e)
b)	d)	f)

11. Do you know which species of fish migrate?

……

12. When they migrate (month) upstream?

……

13. When they migrate downstream?

……

14. What do you think fish population will be increased or decreased after construction of this project?

(a) Increased; (b) Decreased; (c) Don't know

15. What problem will you face after construction of this project?

(a)	(b)
(c)	(d)

Annex: 6

Types of patients registered in the GMR primary health post in the month Bhadra, 2069 BS

S.N.	Disease	Male patients	Female patients	Total patients
1	Typhoid (Enteric fever)	9	7	16
2	Amoebic Dysentry/Amoebiasis	6	15	21
3	Intestinal worms	8	2	10
4	Lower respiratory tract infection	54	51	105
5	Pneumonia	1	4	5
6	Bronchitis	2	5	7
7	Asthma		6	6
8	Urinary tract infection	3	2	5
9	Avitaminoses and other nutrient deficiency	7	3	10
10	Skin diseases (Impetigo/boils	2	4	6
11	Skin diseases (Abscess)	3	3	6
12	Skin diseases (Echzema/Dermatitis)	14	17	31
13	Skin diseases (Fungal infection)	2	8	10
14	Skin diseases (Scabies)	7	10	17
15	Skin diseases (Lymphadenitis)	1		1
16	ENT (Acute/chronic suprative otitis media		4	4
17	ENT (Pharyngities/sore throat		1	1
18	Dental carries/toothache		1	1
19	Trachoma	1	2	3
20	Gyne problem (Menstrual disorder)	4		4
21	Gyne problem (Breast lumps/breast abscess)	1		1
22	Gyne problem (Mastitis or engorged breast)	5		5
23	Acute rheumatic fever		1	1
24	Headache		1	1
25	Pyrexia of unknown origin (PUO)	16	19	35
26	Falls/injuries/fractures	33	32	65
27	Gastritis (APD)	19	30	49
28	Insect/wasp bites	16	15	31
29	Arthritis	19	11	30
30	Cirrhosis of liver	21	17	38
31	Dog bite	4		4
32	Other rabies susceptible animal bite		1	1
33	Surgical problem	1	1	2
	Total Patients	**259**	**273**	**532**

Annex: 7

Snaps of Field Survey:

1. Water quality testing in site 1

2. Water quality testing in site 2

3. Water quality testing in site 3

4. Water quality testing in site 4

5. Interviewing with severely project affected family in Asaraghat Bazaar

6. Interviewing with severely project affected families in Thalpata village

7. Group discussion with the teachers of Basundhara Higher Secondary School, Bhairabsthan VDC

8. GMR office at powerhouse site in Tallo Balde

9. Agricultural land of Thalpata that would be inunded after construction of dam

10. Suspension bridge over Karnali river constructed by GMR in Asaraghat

11. GMR primary health post in Ramgad Bazaar

12. Educational materials provided by GMR to Basundhara Higher Secondary School