Department of Energy
Royal Government of Bhutan

Dagachhu Hydropower Project

Environmental Assessment (EA) Report

July 2006

Section I - Main Report

Bhutan Consultants & Research (BHUCORE)
Consultants in Engineering, Natural Resources and Environmental Management
Changlam Plaza, Room No 56,
Chang Lam, P.O. Box 955
Thimphu, Bhutan
Telephone: +975 1760 - 1111, Fax: +975 2 326594
E-Mail: kjimba@druknet.bt, bhucore@druknet.bt

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ACRONYMS

ACO	Austrian Coordination Office
BHU	Basic Health Unit
BHUCORE	Bhutan Consultants and Research
BPC	Bhutan Power Corporation Ltd.
CDM	Clean Development Mechanism
CGI	Corrugated Iron
CMP	Catchment Management Plan
DGM	Department of Geology and Mines
DHPP	Dagachhu Hydro Power Project
**DHPPA*	*Dagachhu Hydropower Project Authority*
DMO	Dzongkhag Medical Officer
DOF	Department of Forestry
DOE	Department of Energy (former Department of Power)
DOR	Department of Roads
DYT	Dzongkhag Yargye Tshogdu (District Development Committee)
DzFO	Dzongkhag Forest Officer
EA	Environmental Assessment
EC	Environmental Clearance
ECP	Environmental Codes of Practice
ECU	Environment Community Unit
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FDCL	Forestry Development Corporation Limited
FNCA	Forest & Nature Conservation Act, 1995
GDP	Gross Domestic Product
GPS	Global Positioning Systems
GYT	Geog Yargye Tshogchung (Block Development Committee)
HH	Household
MoA	Ministry of Agricultural
NEC	National Environmental Commission
NHS	National Health Survey
NOC	No Objection Certificate
OECD	Organisation for Economic Co-operation & Development
OHS	Occupational Health & Safety
PSMP	Power System Master Plan
RAP	Replacement Action Plan
RGOB	Royal Government of Bhutan
ROW	Right of Way
TOR	Terms of Reference

*(*The Dagachhu Hydropower Project Authority (DHPPA) does not yet exist but is used for reporting purposes only.)*

BHUTANESE TERMS

Chimi	Elected Member of Parliament
Chuzhing	Wet land agriculture
Dow Khelpai Genthey	Rock Steps of Eon
DoW Namgi Kaw	Pillar of Rocks
Dzongkhag Yargye Tshogdu	District Development Committee
Dzong	Fortress
Dzongda	District Administrator
Dzongkhag	District
Geog	Lowest Administrative Block
Gup	Elected Head of Geog/Block
Geog Yargye Tshogchung	Block Development Committee
Kamzhing	Dry land agriculture
Lhengye Zhungtshog	Cabinet
Nyes	Religious Site
Sa Tshogpa	Land Committee
Tshechu	Religious Festival
Tshogpas	Geog Committee Member
Zomdu	Community Meeting

EXECUTIVE SUMMARY

Project Background

The Royal Government of Bhutan (RGoB) approached the Government of Austria in 2004, through the Austrian Coordination Office (ACO), requesting assistance to develop a hydropower project under the Clean Development Mechanism (CDM), an initiative agreed under the Kyoto Protocol.

As a result, Dagachhu Hydropower Project (DHPP), which is located in Dagana Dzongkhag, has been selected for detail feasibility studies. The objectives of the project are as follows:

- The Dagachhu Hydropower Project, which will have an installed capacity of 114 MW, will be registered under the CDM as defined by the Kyoto Protocol;
- The power produced by the project will be exported to India, thereby displacing fossil fuel based electricity generation in the Indian power grid; and
- As a result, Green House Gas emission reduction certificates will be generated, which can be sold to industrialized countries to provide additional revenues for the Project, thus promoting sustainable development energy in Bhutan;

The Department of Energy (DoE) under Ministry of Trade & Industry has contracted M/s Bernard & Partner-ZT GmbH (hereinafter Bernard Engineers) to conduct a feasibility study for the DHPP. Bernard Engineers subcontracted environmental assessment (EA) of the project to Bhutanese consulting firm, Bhutan Consultants & Research (BHUCORE).

The EA report was prepared in close co-operation with the DoE, Bernard Engineers, and in consultation with the National Environmental Commission (NEC) Secretariat, the environmental authority in Bhutan.

The EA method and approach is based on the guidelines for hydropower (NEC, August 2004), as well as guidelines from the Organization for Economic Co-operation & Development (OECD). The EA was carried out parallel to technical feasibility study.

Project location

The proposed Dagachhu Hydropower Project is located in central part of Dagana Dzongkhag (district) on Dagachhu about 10 km upstream of Dagachhu bridge in Trashiding. This proposed hydropower project site lies southeast of Dagana Dzong mainly falling under Kana, Khebisa, Goshi, Tsendagang, Drujegang and Trashiding geogs while transmission line goes all the way from Churmuthang in Khebisa geog of Dagana to Dhajey in Rangthangling geog of Tsirang Dzongkhag. (Map 1 shows the location of project.)

Physical and Technical Features

The Dagachhu Hydropower Project is a run-of-the-river hydropower project with a net head of 282 m, which will be sufficient to provide an installed capacity of 114 MW with approximate annual energy production of 500 GWh. A concrete gravity diversion dam of 20.5 m height above the riverbed with a crest length of 18.2 m will be built on Dagachhu. This will create reservoir with live storage volume of 0.07 Million m^3 at full supply level. About 9.1 km headrace tunnel and channel will carry water from the reservoir to the powerhouse located underground near Babithang village in Khebisa geog. The powerhouse will be equipped with two turbines with installed capacity of 57 MW each. A total of about 0,59 m^3 million of spoils will be generated. The catchment area at the dam is 676 km^2. The

Dagachhu is fed by snow as well as seasonal monsoons, thus providing comparatively consistent supply of water for a run-of-the-river project.

The power produced will be transmitted by a 19 km transmission line from Dagana to Tsirang Dhajay from where it will be exported to India. Total construction time is estimated to be 4 years and mechanized construction methods are designed to be used. During the peak construction the project will employ about 1000 worker and the operating staffs would be estimated at 100.

The project is estimated to cost around Euro (€) 152.00 million (Nu 7904.00 million at

1 €=52 Nu).

The cost of environmental management plan has been worked out as Nu 101.12 million and included in the estimated cost of project.

Study of Alternatives

Dagachhu Hydropower Project has been selected by DoE, Government of Bhutan as a first large scale CDM project amongst 6 other hydropower options based on social, environmental and economic criteria.

Topography, hydrological, geological and power optimisation studies have shown that the proposed dam site and tailrace of the Dagachhu Hydropower Project are the most suitable ones. Hence, the project seems feasible from all perspectives.

It is seen that wind, solar and bio-gas are not proper alternatives to the DHPP. Wind and solar technologies for reliable power generation are at experimental stages and these technologies cannot replace a medium hydropower projects like the DHPP.

Thus, DHPP proposed at Dagana is more attractive compared to other alternatives.

Review of Policy, Legal and Institutional Framework

While pursuing economic development, Bhutan also has strong environmental policy to protect its rich environmental heritage. The important environmental policy document is “The Middle Path: National Environmental Strategy for Bhutan” (1998). This document is being updated by the National Environment Commission, which is anticipated to be out sometime late 2006, and the updated version of document will be called the National Sustainable Development Strategy.

The acts supporting the environmental protection are: (1) EA Act 2000, which establishes procedures for the assessment of potential effects of strategic plans, policies, programs, and projects on the environment, and for the determination of policies and measures to reduce potential adverse effects and to promote environmental benefits. It makes environmental clearance (EC) mandatory for any project/ activity that may have adverse impact(s) on the environment. The Regulation on the Environmental Clearance of Projects 2002 assists to implement the Act.

(2) The first environmental legislation to be passed in Bhutan was the Bhutan Forest Act 1969, which brought all forest resources under government custody with the intent to regulate forest utilization and control excessive forest exploitation. This law was repealed in 1995 with the enactment of the Forest and Nature Conservation Act (FNCA) 1995, in keeping with evolving conservation needs and to allow for community stewardship of forests. The objective of the FNCA is to “provide for the protection and sustainable use of forests, wildlife and related natural resources of Bhutan for the benefit of present and future

generations". It covers forest management, prohibitions and concessions in government reserved forests, forestry leases, social and community forestry, transport and trade of forestry produce, protected areas, wildlife conservation, soil and water conservation, forest fire prevention, and enforcement and penalties. Schedule I of the Act provides list of totally protected wild animals and plants species. Forest & Nature Conservation Rules 2000 assists in the implementation of the FNCA.

(3) The Biodiversity Act of Bhutan 2003 asserts the sovereignty of the country over its genetic resources, the need to promote conservation and sustainable use of biodiversity resources as well as equitable sharing of benefits arising from sustainable use, and the need to protect local people's knowledge and interests related to biodiversity. It lays down the conditions for the grant of access, benefit sharing, and protection, and describes various rights, offences and penalties.

And there are other Acts such as Mines and Minerals Management Act 1995, the Land Act 1979, and Dzongkhag Yargay Tshogdu Chathrim and Geog Yargay Chathrim, all geared to protect environment in Bhutan.

The National Environment Commission (NEC) is the apex body to oversee environmental protection in Bhutan. While projects could obtain environmental clearances (EC) from the competent authorities, when it relates to hydropower project, the authority to issue EC lies with the NEC.

The Department of Forest within Ministry of Agriculture is the custodian of the Forest and Nature Conservation Act 1995 and the Biodiversity Act 2003.

Baseline Environmental Information & Analysis

Physical Environment of Project Site

The project area is generally steep and narrow gorge with limited flat land. The most of the cultivated land with milder terrains are located far from the riverbed. No irrigation scheme is found along the Dagachhu banks owing to its location in deep gorge.

The climate in the project area is basically subtropical (hot and humid in summer) with heavy monsoon from June to September. The altitude measured at the river bed of the damsite is 823 m. The mean annual flow of Dagachhu at Daga some 6 km from the dam is estimated to be 25.42m^3/s. The Dagachhu has soft water quality with slightly acidic reaction. There is hardly any significant pollution due to human activities.

Geological conditions are generally consistent over the project area and consist mainly of metamorphic rocks of crystalline nature of the High Himalaya. High precipitation causes substantial chemical weathering of rocks and the mineral deposits in the area mainly of the colluviums. Soils range in particle size from sandy clay to loamy sand.

Biological Environment

The project area encompasses three eco-floristic zones; tropical, subtropical and warm broadleaf forest. In the tropical and subtropical, the vegetation is primarily of broadleaved while in the warm broadleaved area; patches of chirpine forest are also found.

The forests ecosystem within the project area are mostly disturbed and degenerated due to human activities and hence a poor wildlife habitat. However, two protected mammals and one globally threatened bird is known to inhabit the area.

Fish diversity is low, as only five species were recorded, and only one species is known to migrate upstream for spawning during the summer. None of the fish species found in Dagachhu are considered as rare or endangered.

Bhutan has rather few wetlands, apart from some river stretches that are found in central and southern foothills where valleys are wide and rivers flow slowly. Dagachhu and its tributaries are fast flowing, boulder-strewn torrents that cuts through deep, steep sided valleys with no significant wetland or flood plains.

Social Environment

The project area is mainly located in the Dagana Dzongkhag (district). It has eleven Geogs (blocks) with a population of 18,222 as per the Population & Housing Census 2005. The main commercial centres of the Dzongkhag are Dagana, Sunkosh, Goshing and Drujegang. Dagana town is an administrative centre with a population of 1000. The small satellite township of Sunkosh has about 130 people and is the gateway to the Dzongkhag.

The economy of Dagana and the project area is characterized with the predominance of people engaged in mixed subsistence to semi subsistence agriculture. The principal crops of Dagana are paddy, maize, millet, potatoes, mustard, and buckwheat (sweet and bitter). Cash income is obtained through sale of oranges, cardamom and dairy products. A survey indicates that the average monthly income of the project impacted areas is above the national average of Nu.1200.

Households in and around the project area predominantly owns dryland (kamzhing) as well as wetland (chuzhing). Almost all households own agriculture lands and most of these are owner operated.

Dagana has 17 schools including community, lower, middle, higher secondary schools and traditional monastic schools. None of these schools fall within the project area. Dagana does not have a full-fledged hospital but has 7 Basic Health Units (BHUs) and 9 outreach clinics.

39% of the households in the peripheries of the project area are connected with rural water supply scheme. However, in the directly impacted areas only 12 households out of 41 HHs are connected with water supply. Hence water borne diseases are common in these areas. More than 99 percent of households in the areas use pit latrines.

Bhutanese women and men share a far greater role of responsibilities within and outside household affairs compared to most of the neighbouring countries. There is no overt discrimination on the basis of gender. Women's role is as vital as men's in the rural and urban economy, and they are actively involved in all areas of economic, political and social life. The predominant inheritance rules are favourable to women and women heading the households are almost equal to men. In the project directly impacted area, about 41% of the households are headed by women.

No religious site or cultural monument has been recorded in the area likely to be impacted by the project.

Impacts and Mitigations

The project won't encroach into any the declared protected areas of Bhutan, nor will it undermine the rich cultural heritage sites of Bhutan. There will be some localized impacts due to construction as popular Bhutanese saying goes "If a fire is it is natural to see some

effects". These localized impacts could be mitigated or minimized if suggested mitigation measures are applied.

Following is a summary of the main impacts & mitigations of the EA study based on the field investigations and analysis provided in this report.

General

On the basis of physical, biological and social impacts identified and the scope for mitigation and enhancement measures, there is no obvious reason from an environment perspective not to advance the project to implementation.

The EA proposes measures to mitigate adverse impacts and measures to enhance positive impacts of the construction and operation of the DHPP. The enhancement measures should receive equal attention as the mitigation measures.

Sections of EA will require updating during preparation of Detailed Project Report (DPR) when all aspects of project implementation have become clearer and focused.

It is also during this DPR time that environment community unit (ECU) will develop practical and focused EMP as things have been become succinct and narrowed down. The wholesome EMP included/developed in this report will be the base document.

It is also suggestible that a catchment management plan (CMP) be developed for the Dagachhu watershed and implemented as part of the project to avoid unwanted consequence that will result by not attending to it. 10 million Ngultrums has been proposed for the implementation of CMP.

Physical Environment

The total of ***82.7 hectares*** (ha) of land is likely to be lost to different components of project, of which *12.8 ha* (31.7 acres) is cultivated land. The agriculture land ownerships lie with the communities. The Land Act 1979, which was revised in 1998, requires that all affected households are compensated as per the revised Land Compensation of Rates 1996.

All packages of civil contract of DHPP will need to incorporate all the required measures for slope stabilization, restoration of construction areas, camps and other disturbed areas. The standard mitigation measures for adverse effect due to construction of road, transmission line, power house, tunnel, dam& reservoir has not been taken separately and these should be the part of the respective tender documents and to be implemented along with the component.

GLOF has not been studied as a potential impact in this EA.

Air, Water and noise pollution from the construction can be minimized by taking proper measures. The Air, water and noise compliance standards are provided in environmental standards for Bhutan, NEC 2003.

Water quality of the reservoir would not deteriorate because water circulates relatively quickly.

Biological Environment

The project area is known to be visited by protected animal species. They are Rofous-necked Hornbill (avifauna) and mammalians are Golden Langur, Leopard, and Leopard Cat that are protected by the Forest & Nature Conservation Act of Bhutan, 1995. Monitoring of this important species have been elaborated in the main document.

In addition to above protected species, the project area also houses other species that come under the red list of International Union for Conservation of Nature (IUCN). They are Great Hornbill (avifauna), Serow, Asiatic Wild Dog, and Assamese Macaque.

The EA assessment recommends a minimum flow (ecological flow) release from the dam to the tune of 1.4 m^3/s (which roughly comes in the range of 5-10% of the mean annual natural flow) to support animal life, in particular fish migration from March to April (to spawning site) and from September to October (return to lower altitude for warm water). The basis for determining minimum flow has been drawn from the experiences of alpine areas such as Switzerland, France, and Austria applied for similar projects and environment. The calculation details are provided in section 4.4.1.

Further studies of aquatic ecosystem and fish population will be needed during the operation phase to determine the minimum acceptable release.

Downstream the outlet from the power station is of high importance to have a smooth increase and decrease in the stream flow, and hence in the water level when changing the load. This can be done by fixed start and stop procedure.

Further investigations will be necessary during construction phase to determine the need for building a fish ladder, with the present data on fish migration, construction of a fish ladder is not recommended.

The project does not encroach into any of country's protected and conservation areas.

Social and cultural Environment

At a national level the project will add great benefit to the country's economy through the sale of hydropower energy. Even for the communities surrounding project areas, the field investigations and analysis revealed that positive impacts outweigh negative impacts. Following positive social impacts are anticipated to result for the people around project areas: (1) All households will receive electricity that will drastically improve living conditions. Currently, 91 percent of HH use kerosene for lighting and 98 percent use firewood for cooking. As per study conducted by FAO Project BHU/99/005 National Strategy for Stoves and Other Alternative Energies, May 2001 the per capita consumption of firewood by people living between the altitudes ranging from 1200 – 2800m consumes 3.4kg/head/day. As there are about 4446 people living within project influence that is currently dependent upon firewood as main energy, the project will save cutting down of about 15,000 kg of trees per day by replacing with hydro-electric energy.

(2) The project will also improve sanitary conditions of HH through the income generated from the sale of farm products thus improving living conditions. Currently, 99 percent of the HH use pit toilets which results into chain of effects.

Furthermore there are lots of positive impacts that the communities can derive out of the project, which has been discussed section 3.4.

The project will result into very minimal negative social impacts. They are elaborated as the following: As per assessment it is likely that one household will need relocation due to siting of power transmission line. However, during actual construction period the project will attempt to avoid the relocation as much as possible. The project will also impact 41 households with their landholdings in a way or other. On an average the land losses per household account to about 16.2 percent of their overall landholdings, which the project will compensate as per the Land Act of Bhutan 1979 and Land Compensation of Rates 1996. The

procedure and timeline of compensation will be dealt in the Resettlement Action Plan (RAP) that will be prepared during Detailed Project Report preparation stage. The RAP will address amount of compensation, time schedule, responsibilities and monitoring mechanism.

The other social impact from the project is expected from the influx of about 1500 construction workers into the area, where subsistence agriculture has been the norm for centuries and where long established social and cultural institutions shape people's understanding. Thus, special attention should be given to program to mitigate adverse impacts of the interaction between the existing communities and the construction work force.

Labor and contractor's camp should be located as close as possible to various project sites to reduce the need of transport and unwanted interaction with local community. Cooking gas or kerosene stoves or any other alternative fuel should be provided to the camps by the respective contractor to avoid damage to the neighboring forest and also to thwart any outbreak of fire by using fire wood for cooking. Laborers to be encouraged for making meals jointly or using mess facility so that meals can be prepared on cooking gas or kerosene stoves since it is not feasible to provide every labor group with cooking gas facility.

ECU (Environment Community Unit) of DHPP should be established to co-ordinate between the project, government agencies and other organizations involved in implementing the social mitigation and enhancement program. The NEC should oversee the activities of ECU. The ECU should be fully funded by the DHPP Authority and should also continue as a permanent establishment with reduced staffs in operation phase.

Environment Management Plan (EMP)

As information, it is important to note that the EMP provided here covers all aspects of environmental issues in connection to project and project sites. In saying so one may feel that it is generic EMP, which is true in a way. However, it didn't leave anything unsaid which places the authority issuing environmental clearance in a safer position to issue EC. As usual with any other hydropower projects, the DHPP will also undergo preparation of DPR that will guide project implementation. It is also during this period where EMP will also be updated and focused EMP be prepared as things get narrowed down and all become clearer.

The EMP is arranged for all three phases of the project: viz. Preconstruction Phase, Construction Phase, and Operation Phase.

Issues that need to be addressed in the pre-construction phase are: (1) Environmental Clearance, that is mandatory to obtain as per the EA Act 2000 before initiation of any project activities; (2) Preparation of Resettlement Action Plan; (3) Incorporating of environmental requirements in project design particularly inclusion into contract clauses; and (4) Monitoring of RAP implementation.

Issues that need to be addressed in the construction phase are: (1) Setting up of Environmental Unit within project; (2) Coordination with engineering unit to incorporate environmental concerns into civil works contract; (3) Environmental capacity building including contractor's engineer; (4) Monitoring of civil works execution; (5) Monitoring of wildlife indicators; (6) Monitoring of social indicators; and (7) Reporting and rectifications.

Issues that need to be addressed during the post construction phase are basically monitoring and mitigating that includes: downstream flow variations; problems in reservoir management; downstream water quality management; and insect vector disease management.

Conclusion

Hydropower, a renewable energy, generated by the DHPP will contribute significantly to the socio-economic of the region in particular and to the country in general and will improve the standard of living.

The construction and operation of the DHPP will bring the following benefits.

- As project will be developed under CDM initiative a Green House Gas emission reduction certificates will be obtained as energy sold to India will replace fossil fuel energy contributing to reduction of carbon emission into the atmosphere. This certificate could be sold to industrialized countries to provide additional revenues for the Project, thus promoting the sustainable development energy in Bhutan
- An Annual electric power of approximately 500 GWh will be supplied.
- The construction and operation will have no impact on the environment.
- The project will earn annual revenue of approximately 750 million Ngultrum at the rate of 1.5 Nu/KWh.
- Implementation of DHPP complements the Bhutan 2020 document for harnessing the potential growth of hydropower production in the country for economic growth and improvement in socio-economic conditions.
- Bhutan is an energy surplus country and the hydropower could be the main resource for earning foreign currency by exporting to neighboring countries.
- By exporting energy to India the import – export disparity of Bhutan will be improved.
- The proposed generating facilities are essential to sustain the economic growth and improve the standard of living of this country.

Map 1: illustrate the Project Location

1 INTRODUCTION

1.1 Project Background

After the successful registration of 70kW Chendibji micro hydropower station in Tangsibji Geog under Trongsa Dzongkhag as the first ever Clean Development Mechanism (CDM) project, the Royal Government of Bhutan (RGOB) in 2004, has approached the government of Austria through Austrian Coordination Office (ACO) for assistance in the development of further yet bigger CDM project in Bhutan.

As a result, Dagachhu Hydropower Project, which is located in Dagana Dzongkhag, has been selected for detail feasibility studies. The Department of Energy under Ministry of Trade & Industry has contracted Bernard & Partner (hereinafter Bernard Engineers), an Austrian Consulting Firm to conduct a Feasibility study. The Environmental Assessment (EA), one of the components of the feasibility study was subcontracted to Bhutanese consulting firm, Bhutan Consultants & Research (BHUCORE).

1.2 Project Description

1.2.1 Objectives of the Project

The objectives of the project are as follows:

- The project will construct Dagachhu Hydropower Project of installed capacity of 114 MW and will be registered under the CDM as defined by the Kyoto Protocol;
- The power produced by the project will be exported to India, thereby displacing fossil fuel based electricity generation in the Indian power grid;
- As a result, emission reduction certificates will be generated which can be sold to industrialized countries to provide additional revenues for the Project; and
- Consequently, the sale of emission reduction certificates will contribute to the financial feasibility of the project, while promoting the sustainable development energy in Bhutan and reducing CO_2 emissions in India.

1.2.2 Location of Project

The proposed DHPP is located in central part of Dagana Dzongkhag (district) on Dagachhu about 10 km upstream of Dagachhu bridge in Trashiding Geog. It lies southeast of Dagana Dzong and mainly falls under geogs of Kana, Khebisa, Goshi, Tsendagang and Trashiding. The proposed power transmission line goes all the way to Tsirang Dzongkhag via Drujegang geog of Dagana. Map 1 illustrates the location of project.

1.2.3 General Layout of Project Facilities

The Dam site is located about 800 m upstream of Gewathang suspension bridge and about 6 km downstream of the confluence of Darachhu and Lomachhu. Just below the proposed dam site is the confluence of Dagachhu and Tanachhu.

The pressure shaft is located immediately below the agricultural land of Babithang village from where the water is channelled through the underground tunnel to the powerhouse located inside the rocky cliff. The tailrace is located near Churmuthang, an initially proposed switchyard area. Map 2 shows the location details of the project facilities.

1.2.4 Main project Data

DHPP is a run-of-the-river hydropower project with the net head of 282 m which will be sufficient to provide an installed capacity of 114 MW with annual energy generation of 500 GWh.

A concrete gravity diversion dam of 20.5 m high above the riverbed with a crest length of 18.2 m will be built on Dagachhu. This will create reservoir with live storage volume of 0.07 M m^3 at full supply level. About 7.8 km tunnel will carry water from the desilter to the powerhouse located underground below Babithang village. The powerhouse will be equipped with two turbines with installed capacity of 57 MW each. The salient features of the project are shown in Table 1.1.

Table 1-1 Salient features of Dagachhu Hydropower Project

Catchment Area	676 km²	
Water Resource	Dagachhu	
Specific Runoff	41.1 l/s/km²	
Annual Mean Flow	27.8 m³/s	
Firm Flow (95% availability)	5 m³/sec	excl.Residual Flow
Mean Annual Yield (usable)	733 mill m³	excl. Residual Flow and Flood
Type of Development		Run of the River
Weir/Intake Elevation	843.3 m	max. Water Level
Desilter Elevation	841.0 m	Operating Water Level
Tailwater Elevation	537.0 m	Centre Line Turbine Runner
Gross Head	304.0 m	
Net Head at full load	282.0 m	
Design Flow (maximum)	50.0 m³/s	
Design Flow (rated)	45.0 m³/s	
Installed Capacity	114 MW	
Mean Annual Energy Production	500 GWh	
Energy Production (90% dependable)	360 GWh	
Turbines	2 nos.	Pelton
Diversion Weir	27000 m³	Reinforced Concrete
Height above riverbed	20,5 m	Up to max. Water Level
Crest Length	18.2 m	Two Sections 2 x 9.1 m
Dead Storage	200 000 m³	
Design Flood	859 m³/s	
Flap Gates	2 nos.	9.1x 4.0 m (top of weir)
Radial Gates	2 nos.	9.1x 4.0 m (bottom of weir)
Desilter (surface)	3 chambers	240 x 30.5 x 11 m, incl. transitions
Connection Intake-Desilter	L=746 m	Channel L=270 m, Tunnel L=476 m
Headrace Channel	L=261 m	W=5.0m, H=4.5-5.3m
Headrace Tunnels (incl. Side Adit)	L=7795 m	Di 4.4-4.8 m
Surge Shaft	Di=21/H=45 m	
Pressure Shaft	Di=3.4/L=312 m	Vertical and horizontal
Powerhouse and Transformer Caverns	40 000 m³	Rock Excavation
Access Tunnel	L=250m	Horseshoe 4.0/5.7m
Emergency/Cable Tunnel	L=290 m	Horseshoe 3.3/3.6m
Tailrace Tunnel	L=679 m	Horseshoe 4.25/5.0 m
Transmission Line 220 kV	19 km	Powerhouse to Tsirang Substation

Access roads from Indian Border	114 km	Gelephu-Sankosh
	320 km	Phuntsholing-Sankosh
	62 km	Sankosh-Chineythang (Dagana)
New access roads to the Sites	19 km	

Construction Cost	152 million EUR	excl. 220 kV Transmission line
Transmiss. Line Cost incl. Substation Bay	2.95 million EUR	146.2+13.18 mill. Nu
Construction Time	4 years	

Source: Bernard Engineers, June 2006

Map 2 shows the location details of the project facilities

1.2.5 Study of Alternatives

1.2.5.1 Project Selection Alternatives

The Department of Energy selected DHPP as a large scale CDM hydropower project amongst six other similar proposed projects in the country using multi-criteria selection process. As per the CDM capacity development services report the evaluation was done based on the following criteria:

- Percentage of electricity exported to India (high percentage –high ranking)
- Time required for project realization (in order to utilize the Kyoto period 2008-2012 as much as possible; less time –higher ranking)
- Ecological and socio-economic benefits (e.g. local employment, improvement of living condition , etc.; high benefit-higher ranking)
- Additionality (which projects would likely be developed also without CDM; likely developed-low ranking)
- Accessibility of the project site (project sites near existing roads and power lines can be developed faster and have less negative environment impact)
- Economic aspects like expected unit costs of energy (project shall be nearly economically feasible without considering the sale of emission certificates)

The ecological and socio-economic benefits of the project were preliminarily assessed by the DoE as shown in the table 1.2.

Table 1-2 shows the selection of hydropower project based on social and environmental criteria, CDM report 2005

Sl.#	Particulars	Max. Score	13.090-Phochu (132 MW)	13.170-Dagachu (115 MW)	13.180-Dagachu (153 MW)	15.100-Chamkharchu (162 MW)	15.120-Chamkharchu (108 MW)	17.140-Gamrichu (109 MW)	24.080-Baranadi (105 MW)
	Road distance (km)		20	4	3	80	40	2	20
	Transmission line distance		25	15	13	20	25	25	20
1	**Project Type**		ROR	ROR	ROR	ROR	ROR	ROR	ROR
2	**Ecological Benefits**	60							
2.1	Project location in respect of Environmentally-sensitive area/protected area & biological Corridor.	10	10	10	10	10	10	10	10
2.2	Impacts on surrounding environment Physical, aquatic, biological etc.. Due to- project location and design and as well as due to approach road and transmission line construction.	15	7	11	12	5	4	10	8
2.3	Impacts on endangered species of plants and Animals.	15	5	10	11	3	4	10	6
2.4	Impacts on historical and cultural sites	10	8	8	8	8	8	8	8
2.5	Reduction in the consumption of fuel wood by the –local villager due to supply of electric from the project	10	5	5	5	9	9	5	7
	Total Score for 2:	60	35	44	46	35	35	43	39
3	**Socio-Economic Benefits**	**40**							
3.1	Total nos. of villages/household that will be benefit by the project	5	3	4	4	3	3	4	3
3.2	Infrastructural development like road, building, Schools, health clinic, etc. due to project	5	3	3	3	4	4	3	4
3.3	Upliftment of living standard of the people living around the project due to availability of employment opportunity, skill development, easy market access etc	5	4	4	4	3	3	4	3
3.4	Electrification of the villages located in and around the project site	5	2	2	2	4	4	2	4
3.5	Development of small scale industries in the area	5	4	4	4	3	4	4	3
3.6	Additional revenue leading to socio-economic development of the country as a whole	15	12	10	12	14	9	9	8
	Total Score for 3:	40	28	27	29	31	27	26	25
	Total Score (2+3):	**100**	**63**	**71**	**75**	**66**	**62**	**69**	**64**
	Ranking of Projects:		**6**	**2**	**1**	**4**	**7**	**3**	**5**

Source: CDM Capacity Development Services Bhutan, June 2005

Based on the ecological and socio-economic factors as well as the other factors as listed above, the Dagachhu hydropower Project, Project number 13.180, was selected most suitable for development under the CDM.

1.2.5.2 Site Selection Alternatives

This site selection alternative concerns only for Dam location and there are two options available for the decision.

- Option 1: Dam site 1A with open desilting chamber at Gewathang. This option has advantage over other, as Dam height will be shorter by 16m. This has therefore economic and environmental advantages compared to other. Map 3 shows the project alternatives. The energy capacity is about 500 GWh (Table 1.3).
- Option 2: Dam site 1 is located some 500 m downstream of dam alternative 1A. This will have higher dam height while the same level of energy will be generated (Table 1.3). Map 3 shows the project alternatives.

Table 1-3 Principal statistic of options for developing DHPP

Option	Basic Arrangement	Energy (MW)	Energy (GWh/a)	Dam Height (m)	Storage Volume (million M^3)	Size of Reservoir (km2)	Head (m)
1	DHPP with Dam site 1A	114	500	21	0.3	0.03	304
2	DHPP with Dam site 1	114	500	37	1.0	0.05	304

1.2.5.3 Technological Alternatives

Based on available hydrological data, a design discharge of 45m^3/s has been chosen (Feasibility Study, B&P) for Option 1/Damsite 1A. The option 1 has two alternatives turbine technologies – Francis and Pelton turbines. The detailed design data of two turbines are mentioned below in the table 1.4.

Table 1-4 illustrate the technological alternatives of the project

Sl No	Design Description	Francis Turbine	Pelton Turbine
1	Synchronous speed	428.57 [rpm]	272.73 [rpm
2	Runaway speed	697[rpm]	518 [rpm]
3	Runner Diameter	2572 [rpm]	3325 [rpm]
4	Runner height	1000 mm	-
5	Shaft diameter	590 mm	680 mm
6	Spiral casing inlet diameter	1590 mm	-
7	Maximum output per unit	57.8 MW	57.5 MW
8	Rated output per unit	52.3 MW	52 MW

Source: Inception Report on Feasibility Study, DHPP, 2005

Due to better partial load efficiency and easier maintenance works, the installation of the pelton turbine is recommended by Bernard and Partner.

Map 3 shows the Project Alternatives

1.2.5.4 Do Nothing Alternatives

This alternative assumes no project construction and keep the site as it stands now. This option is not feasible for the following reasons:

- The project site is ecologically not pristine as human habitation is visible all over the site;
- The site although has tourism potential for bird watching and cultural tourism the poor accessibility and services do not attract tourists. The project offers opportunity to enhance this sector;
- Not developing a project will deprive Dagana Dzongkhag from economic opportunities leaving people poorer;
- The Government will also be deprived of revenue generation as a consequence becoming foreign aid dependent;
- The local people will also have pressure on forest resources as firewood is the main source of energy;
- The hygiene of locals will remain backward compared to hygiene afforded by the electricity;
- The purpose of Kyoto Protocol will be defeated if CDM projects of this nature is not implemented; and etc.

In the light of above justifications, the Do-nothing Alternative is simply not feasible.

1.2.6 Access Roads

The project will construct temporary and permanent access roads according to the single lane National Highway Design standards. A total of 19.8 km of access roads will be built. The two road alternatives for access roads have been considered. The EA on Roads are **provided in Annex 9 of Volume II conducted as per the "Highways & Roads Guideline, Application of Environmental Clearance, NEC 2004".**

1.2.7 Power Transmission Line

The project will construct about 19 km of power transmission line. The 220 kV line will have Right of Way (ROW) of 40 – 50 m and width 3-4 towers per km line. The transmission line will start from the powerhouse access to a substation at Dajhay under Tsirang Dzongkhag.

The power transmission line details are provided in Annex 10 of report Volume II, conducted as per the "Transmission and Distribution Lines Environmental Assessment Guideline 2004".

1.2.8 Quarry Sites

Several quarry sites have been identified. The stone quarrys are located at the Dam site, at the right embankment of the Dagachhu and along the Daga road, while a potential sand and stone aggregate site is located at the confluence of Punatsangchhu and Dagachhu. The locations, have no probability of landslides and erosion. The stone crushing plants will also be set up here. Proximity of its location close to the river is ideal for the plant as dust pollutants could be controlled by spraying river water.

1.2.9 Staffing and Support System for Construction and Operation

It is estimated that 1000 labourers and 100 staffs will be employed during the construction and operation of the DHPP.

1.2.10 Project Cost and Funding Agency

The total cost of the project is estimated to be around Euro (€) 152 million (Nu.7904.00 million). Of the total project cost, environmental cost is Nu.101.12 million. The Project will be funded to a small extend through Clean Development Mechanism (CDM).

Map 4 shows the DHPP Access Road

1.2.11 Implementation plan and Schedule

The tentative implementation schedule is illustrated by Figure 1.1.

Figure 1.1: Tentative Implementation Schedule

S. N.	Activities	2005	2006	2007	2008	2009	2010	2011
1	Feasibility study							
2	Preparation of Tender documents							
3	Financial appraisal & finalization of contract modalities							
4	Tendering and contractor selection							
5	Project construction							
6	Sub-station & transmission lines							
7	Testing and commissioning							

Source: Department of Energy, 2006

From the above illustration it is evident that project construction will take about 4 years to complete. Tentatively the project will commission operation from early 2011.

1.3 Scope of EA

Environmental assessment study of Dagachhu Hydropower Project has been conducted under following scope of work or Terms of References (TOR):

- Review of Act, Policy, Regulations and guidelines relevant to hydropower development in
- Assess and analyze the potential environmental impacts in relation to project alternative and engineering design.
- Conduct environmental baseline survey according to NEC guidelines and OECD procedures.
- Assess social and cultural impacts arising from the project
- Assess the impact due to the access road and transmission line
- Evaluate the impact on upstream catchment changes from removal the removal of forest cover, catchment changes from development of river management infrastructure and construction of a reservoir.
- Evaluate the impact on downstream due its operations downstream hydrology on sediment movement, ground water and impact of riparian forest and aquatic life.
- Evaluate the impact on flora and fauna in general (Botanical and Zoological impacts) in the project area (damsite, desliting chamber, side adit, pressure shaft, powerhouse, and switchyard).
- Assess the project location in terms of national protected area system.
- Assess and evaluate the impact due to excavation, tunnel spoil deposition.
- Assess the possible impact on mines and minerals

- Assess the change of aesthetics due to implementation of project
- Conduct consultation with affected people.
- Develop mitigation measures for above the environmental problems resulted due to project
- Prepare management plan and monitoring program on environmental and social issues for three stages of project period viz. pre-construction, construction, and post construction period.

1.4 Methodology

The study team composed of Karma Jimba (Backstopping EA expert), Karma Chogyel (Environment Specialist cum GIS expert), Ugyen Dorji (Environmental Chemist), Nidup Peljor (Sociologist), Phuntsho (Forester and Wildlife Biologist), Singay Wangchuk and Lacha Dhendup as enumerators, gups of Kana, Khebisa, Goshi, Tsendagang, Trashiding, Drujegang and Rangthangling Geog.

Table 1-5 shows the EA Team composition

Sl No	Name	Qualification	Responsibility
1	Karma Jimba	MSc. Environmental Engineering	EA Specialist (Backstopping)
2	Karma Chogyel	BSc. Zoology & Botany, MSc. in GIS & RS	Team Leader (Environmentalist)
3	Prakash Kumar	B.E (Civil), P.G. Ecology & Environment	Environmental Engineer
4	Ugyen Dorji	MSc. Environmental Science	Chemist
5	Nidup Penjor	MSc. Natural Resource Management	Sociologist
6	Phuntsho	BSc. Forestry	Flora & Fauna Specialist
7	Lacha Dendup	Certificate	Enumerator
8	Singye Wangchuk	Certificate	Enumerator
9	Nidup Tshering	Local Fisherman	Fish Expert

The methods applied are discussed in the following sections:

1.4.1 Literature Review

Following documents were reviewed:

The inception report on the DHPP submitted by Bernard & Partner;
Desk study of the exiting map;
Application for environmental clearance guideline for hydropower 2004 (NEC);
Application for environmental clearance guidelines for highways and roads 2004 (NEC);

Application for environmental clearance guidelines for transmission and distribution lines 2004 (NEC);
EA for the Mangdechhu Hydroelectric Project, 2000
EA for the Punatsangchhu Hydropower Project 2001;

Legislations of Bhutan such as: The Land Act 1979, the Forest and Nature Conservation Act 1995, FNCA Rules 2000, The road Act 2005, Vision 2020, Hydropower Master Plan 2003, Mines and Mineral Management Act 1995, Electricity Act 2003, and The Environmental Strategy 1998.

1.4.2 Preparation of Working Map

Using the available digital physical map layers (coverages) of the project area, a map prepared by Bernard & Partner was scanned and overlaid, which was computer screen digitized for all those items required. Trimming and editing was done to produce thematic maps that were used as a working map in the field.

1.4.3 Data Collection through Structured Questionnaires

The data collected through the questionnaires are mainly for the socio-economic parameters. More specifically they are described as below.

Socio-economic data for the directly impacted and indirectly impacted households, to gather village level information, and for Geog and Dzongkhag level information.

The questionnaires were pre-tested in two villages for practical applications. Revised the questionnaires based on pre-test experience.

1.4.4 Public Consultation

The views of the locals were solicited through open consultation organized in an informal manner creating conducive environment for the people to express their thoughts about the project. The team leader of the EA briefed about the project details for effective participation in consultation. A representative among the group facilitated the consultation thus providing equal opportunity in the consultation.

1.4.5 Data Collection through Structured Format

These structured formats were used to collect data on flora; fauna; physical conditions such as topography, existing landslides, land degradation and etc; and water parameters.

Transaction method was adopted to estimate the occurrence of flora.

1.4.6 Equipment Used

Following equipments were deployed for data collection:

Geo-Positioning System (GPS), *Garmin Etrex Legend*;
In-situ water sampling kit;
Clinometers for slope measurement;
Walkie Talkie for easy communication in the wild;
Measuring tapes; and
Digital Camera

1.4.7 Analysis

The main analysis tools used were Excel Spread Sheet and Geographical Information System. Specifically they are discussed as below.

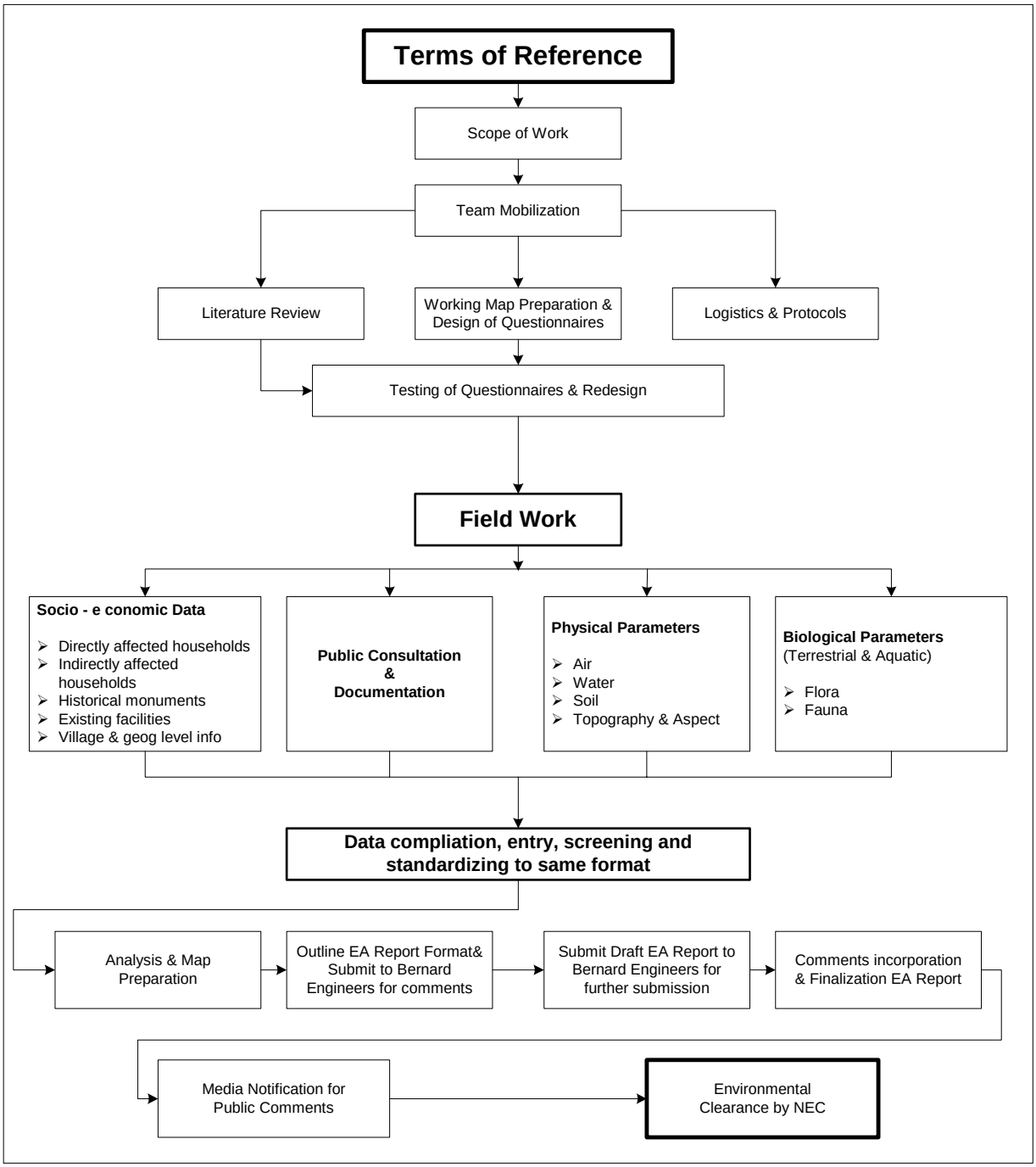
Excel Spread Sheet:

The socio-economic data was fed into Excel Spread Sheet. A database was created upon which specific requirements were drawn. Socio-economic indicators were derived through this analysis.

ARCGIS:

This geographical information system software was used to analyze the following: land uptake by the project, to calculate different land uses, to measure catchment areas, and for map illustration.

Figure 1-2 illustrates the Environmental Assessment Methodology employed by the team



1.5 EA Report Structure

The EA report has been grouped into two volumes. The volume I is the main report and volume II contains annexes.

Volume I, the main is arranged in 7 chapters:

Chapter 1: **Introduction:** Background, Project description, Scope EA, study methodology; team composition;

Chapter 2: Review of Policy, Legal and Institutional Framework for environmental management;

Chapter 3: **Baseline Environmental Information & Analysis**: includes Biological and social environment of the project site.

Chapter 4: **Impact Assessment and Mitigation Measures**: includes Impacts due to Project location, Design, Construction and Operation. This chapter also includes the mitigations measures against each negative impact.

Chapter 5: **Environmental Management Plan**: includes pre-construction stage; construction stage; and operation stage;

Chapter 6: **Conclusions and Recommendations.** And

Chapter 7: **List of References.**

Volume II, the list of annexes is arranged as following:

1. Public Consultation documentation
2. Detailed Social Report
3. Detailed Flora and Fauna Study Report
4. Summary Matrix of Floral species found in the Project Facility Sites
5. Summary Matrix of Faunal species
6. List of Fish species of Bhutan
7. List of Protected species of Bhutan
8. List of Officials met
9. EA for Access Road
10. EA for Transmission line
11. No Objection Certificates
12. Terms of Reference (Approved by NEC)

Map 5 shows the DHPP Transmission Line

2 REVIEW OF POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

This section reviews and summarizes key policies, legal and institutional framework concerning development of hydropower in Bhutan. This review is intended to provide at a glance the policies, legal and institutional aspects that the hydropower developer should observe thus erasing the confusions that may develop later stages of the project.

Furthermore, this review also attempts to provide insights over international financial institutional policies relating to hydropower development.

2.1 Review of Policy Framework

2.1.1 Overview of Policy Framework related to Hydropower

Hydropower development in Bhutan is accorded highest priority and it is considered as an engine of sustainable economic growth. *The Middle Path,* National Environment Strategy for Bhutan puts hydropower development as the first avenue, representing a sustainable and relatively clean source of revenue. In 1986, Chukha hydropower, a partnership project between Bhutan and India, first of its kind became operational. Based on this success, hydropower development then became the cornerstone of the Bhutanese economy and featured in almost all the policy documents including vision 2020.

Owing to the rich and intact environment with abundant fresh water flowing from high Himalayas of Bhutan to the plains of India is the enormous natural resources for Bhutan. The total hydropower potential is estimated to be 30,000MW of which only around 2% is harnessed as yet and it accounts for 45 percent of gross national revenue. In 2003-2004, Bhutan's GDP growth reached 6.8 percent during which power sector grew by 9.5 percent with 12.3 percent GDP share. It is expected to increase further with commissioning of Tala hydropower project and by building other mega projects that are in the pipeline. The development of hydropower is expected to have positive impact on the manufacturing sector, and thereby increasing national revenue and generating employment opportunities. It is in this light; RGoB has allocated 8.9 percent of total Ninth Plan outlay for the power sector excluding the major investments project such as the Tala, and Punatsangchuu Hydropower projects.

RGoB has formulated 20 years Power System Master Plan (PSMP) for sustainable hydropower development. The rationale for this PSMP is to enable orderly selection of hydropower projects for further development and selection for implementation to meet increasing demand of power from within and from India.

According to the PSMP, there are two markets that may be supplied from future hydropower projects in Bhutan: the domestic market and the market in India. At present domestic consumption is around 105MW against the total production of 445MW. However, it is expected to rise to 352 MW representing only small portion of the total production. The Indian market for power is vast (more than 170,000 MW peak demand expect in 2012) and suffers at present under chronic shortages both in terms of power and energy. The deficit situation is expected to prevail for many years to come, (2003 -2022 Power System Master Plan).

Hence, the feasibility study of Dagachhu Hydropower Project was initiated to be undertaken as the first major CDM hydropower project in the country, aiming towards fulfilling national objective of sustainable renewable energy development as a means to increase national

revenue. The sustainable development is one of the four pillars of Gross National Happiness (GNH), a development philosophy that is upheld in Bhutan.

2.1.2 Bhutan 2020

The vision states that hydropower will be the backbone of the country's economy. The development of hydropower is socio-environmentally acceptable for Bhutan. Every five year plan will be intend to achieve at one mega hydropower project if not more. Much of the power produced will be sold to India, which has huge power shortage that goes to the tune of 60,000 MW.

2.1.3 Water Resources Management Plan 2003

The Bhutan Water Policy is a reflection of the Royal government's intentions on the conservation, development and management of the country's water resources. It recognizes that water as a precious natural resource and a heritage, important to all aspects of social, economic and environmental integrity. Therefore, water resources shall be carefully conserved and managed in order to promote national development without compromising the integrity of the natural ecosystem.

2.1.4 Hydropower Master Plan (updated) 2003

RGoB has formulated 20 years Power System Master Plan (PSMP) 2003-2022, which is an update of an earlier hydropower master plan (1990 -2010) for sustainable hydropower development. The rationale for this PSMP is to enable orderly selection of hydropower projects for further development and selection for implementation to meet increasing demand of power within Bhutan and from India.

2.1.5 The Environmental Strategy 1998

The middle Path, National Environment Strategy for Bhutan puts Hydropower development as a sustainable and relatively clean source of revenue, which Bhutan needs in order to finance other aspects of both its development and conservation agendas.

2.2 Review of Legal Framework

2.2.1 Overview of Legal System in Bhutan

All the laws of the country and international conventions are enacted and ratified by the National Assembly, the highest legislative body in the country. The ever first conservation Act enacted was the Forest Act 1972, since then various conservation acts were enacted. The Environmental Assessment Act was enacted in 2000.There are several other laws regulating environmental impacts together with EA Act. They are as discussed in the following section.

2.2.2 EA Act 2000

The Act establishes procedures for the assessment of potential effects of strategic plans, policies, programs, and projects on the environment, and for the determination of policies and measures to reduce potential adverse effects and to promote environmental benefits.

It makes environmental clearance (EC)[1] mandatory for any project/ activity that may have adverse impact(s) on the environment. When applying for EC the EA document have no objection certificates (NOCs) and in this hydropower project, the NOCs are required from the Department of Forest, and adversely affected households.

Based on the review of environmental information submitted by the project applicant, the National Environment Commission Secretariat (NECS) or the Competent Authority (CA)2 may issue/ deny EC or determine the need for a full environmental assessment (EA). Where a full EA is determined necessary, the applicant will be asked to prepare EA documents according to the terms of reference (ToR) approved by the NECS. The NECS will review the EA report and accordingly issue/ deny EC.

The NECS or CA may issue EC when it is satisfied that: (a) the effects of the project on the environment are foreseeable and acceptable; (b) the applicant is capable of carrying out the terms of EC; (c) the project, alone or in connection with other programmes/ activities, contributes to the sustainable development of the Kingdom and the conservation of its natural and cultural heritage; (d) adequate attention has been paid to the interests of concerned people; and (e) the project is consistent with the environmental commitments of the Kingdom.

EC for a project shall be reviewed and may be revised and renewed at least every five years, unless a shorter period is stated. The NECS or CA may review and modify the terms whenever there is: (a) unacceptable risks to the environment resulting from the project which were not known at the time the clearance was issued; (b) availability of improved and cleaner technology; and (c) a need to bring the project into compliance with changes to the laws of the country.

Non-compliance with environmental terms specified in the issuance of environmental clearance makes the offender liable to penalties that may include compensation for environmental damage, fines, sanctions, and suspension or revocation of environmental clearance in part or full.

2.2.3 Forest and Nature Conservation Act 1995

The first environmental legislation to be passed in Bhutan was the Bhutan Forest Act 1969, which brought all forest resources under government custody with the intent to regulate forest utilization and control excessive forest exploitation. This law was repealed in 1995 with the enactment of the Forest and Nature Conservation Act (FNCA) 1995, in keeping with evolving conservation needs and to allow for community stewardship of forests. The objective of the FNCA is to “provide for the protection and sustainable use of forests, wildlife and related natural resources of Bhutan for the benefit of present and future generations”. It covers forest management, prohibitions and concessions in government reserved forests, forestry leases, social and community forestry, transport and trade of forestry produce, protected areas, wildlife conservation, soil and water conservation, forest fire prevention, and enforcement and penalties.

[1] Article 6.11 of the EAA defines Environmental Clearance as the decision, issued in writing by the NECS or the relevant Competent Authority, to let a project proceed, which includes terms (and conditions) to ensure that the project is managed in an environmentally sound and sustainable way.

[2] Article 6.2 of the EEA defines a Competent Authority as any agency of RGoB who has the power to issue development consent for a project.

Schedule I of the Act provides list of wild animals and plant species that needs full protection in Bhutan.

In accordance with the powers and duties conferred under the FNCA, the Ministry of Agriculture has promulgated the Forest and Nature Conservation Rules (FNCR) 2000, to allow for:

- preparation, review, approval, implementation, monitoring and evaluation of forest management plans;
- reservation of government reserved forests, allotment of land and land rights in government reserved forests, regulation of activities in lands allotted for private use, collection of forest produce from government reserved forests, compensation for acquired lands, prohibitions, restrictions and concessions in government reserved forests, and forestry leases;
- creation of private and community forests, including procedures for registration of private and community forests and effects consequent upon registration, management and use of community forest resources, and responsibilities and powers of the community forest management group and concerned government agencies;
- transport and trade of forest produce, including extraction and marketing procedures and inspection of forest produce in transit or in trade;
- declaration of protected areas, administration of PAs , and prohibitions in PAs;
- protection of wildlife and use of certain wild species;
- prevention of forest fires, land clearance, and activities potentially impacting soil, water and wildlife resources; and
- enforcement and penalties for offences related to all of the above.

2.2.4 Mines and Minerals Act 1995

The Mines and Minerals Management Act 1995, provides framework for exploring mineral resources in the country. This also complements the EA Act 2000 as it has provisions for environmental requirements. The relevance of this Act for the hydropower project is when the project requires quarries for sand or stone, this law is enforced to get the site clearance.

2.2.5 Bhutan Electricity Act 2003

Among others, the important part of this law is that it provides framework for licensing and regulating the operations of power companies. Under this law, the Bhutan Electricity Authority will be established as an autonomous body that will be custodian for enforcing.

Electricity Act provides power to acquire land and water (but in conflict, the Forest & Nature conservation Act of Bhutan prevails) for generation and supply of electricity.

2.2.6 Land Act 1979

The basis for land tenure is the Land Act 1979 (last amended in 1998). The general key points of the Act applicable for the hydropower project are:

As far as possible the government shall provide land substitution instead of cash compensation while acquiring land.

Allotment of all substitute land shall be from the same Dzongkhag.

In case the project acquires a house, the compensation for any category of house whether built with RCC/brick/stone masonry or in traditional style, shall be paid on the basis of

evaluation carried out in each case by a qualified engineer appointed by a competent authority. The Land Compensation Rate, 1998 governs the compensation.

2.2.7 Road Act 2004

The Road Act 2004 establishes framework to ensure balanced socio-economic development, promote social equity, define and establish an efficient system of road network.

According to the Act, the construction of access road for hydropower project falls directly under the jurisdiction of Ministry of Trade and Industry, which is termed as power road.

2.2.8 Rules and Regulation on Explosives

As the project will require huge quantity of explosives this rules and regulations is very important particularly pertaining to import, transportation and handling of explosives. The Department of Law and Order under the Ministry of Home and Cultural Affairs is the custodian of this Rules and Regulation.

2.2.9 Dzongkhag Yargay Tshogchung Chatrims and Geog Yargay Tshogchung 2002

The Chathrims were enacted to support the decentralization policy and empower locally elected community bodies (DYTs and GYTs) with the authority and responsibility to decide, plan and implement development programmes and activities, including those concerning environmental management. Powers and functions vested in the DYTs and GYTs in relation to environmental management are specified below.

Environment-related provisions in DYT Chathrim, 2002

Article 8 of the DYT Chathrim 2002 gives the DYT the power and function to:

- promote awareness and dissemination of national objectives (section 3);
- adopt procedures and rules to implement national laws, wherever relevant (section 10); and
- make recommendations on activities with major environmental impacts such as construction of roads, extraction and conservation of forests, mining and quarrying (section 13).

Article 9 of the DYT Chathrim 2002 gives the DYT the power and function to adopt and enforce regulations with respect to:

- designation and protection of monuments and sites of cultural and historical interests (section 1);
- designation and protection of areas of special scenic beauty or biodiversity, such as dzongkhag parks and sanctuaries (section 2);
- control of noise pollution (section 8);
- establishment of quarries and mines in accordance with Mines and Mineral Management Act 1995; and
- protection of public health as per prevailing national guidelines or Acts (section 14).

Article 10 of the DYT Chathrim, 2002, gives the DYT broad administrative power and function to give direction and approval on:

- construction of farm and feeder roads (section 5);
- forest management plan including extraction, conservation and forest road construction in accordance with the FNCA (section 8);
- protection of forests, tsamdo and all types of government and community lands from illegal house and similar construction and other encroachments (section 19);

- control of construction of structures, whether on national, communal or private lands, within 50 feet of highways, including enforcement of measures such as cessation of construction and demolition of the structures (section 20);
- choice of trekking routes and camps for tourists (section 22); and
- mobilization of voluntary actions in times of natural catastrophes and emergencies (section 26).

Article 13 of the DYT Chathrim 2002 gives the Dzongkhag Administration the powers and functions to:

- construct farm and feeder roads, in conjunction with the NEC (section 5);
- determine the choice of design, construction methods and building materials for forms, which do not have to follow standard designs in conformity with acceptable technical and structural norms (section 12); and
- approve allocation of timber permits as per the rules and regulations issued by the MoA from time to time (section 16).

Environment-related provisions in GYT Chathrim 2002

Article 8 of the GYT Chathrim 2002 gives the GYT the power and function to adopt and enforce regulations at the geog level with respect to:

- safe disposal of waste (section 1);
- control and prevention of pollution of air, soil and water (section 2);
- sanitation standards (section 3);
- control of communicable livestock diseases within the geog in accordance with the Livestock Act 2001 (section 4);
- allocation of safe and clean drinking water from water supply schemes (section 5);
- allocation of irrigation water, in accordance with the provision of the Land Act 1979 (section 6); and
- protection and harvesting of edible forest products in the local area in accordance with the Forest and Nature Conservation Act 1995 (section 8).

Article 9 of the GYT Chathrim 2002 gives the GYT broad administrative power and function at the geog level with respect to:

- administration, monitoring and review of all activities that are part of the geog plan, including the maintenance of community properties such as lhakhangs, goendeys and their nangtens, chhoerten, mani dangrem, water supply schemes, irrigation channels, footpaths, mule tracks, farm and feeder roads, suspension and cantilever bridges, micro-hydels, basic health units and outreach clinics, lower secondary school and community schools, and extension centers of the RNR sector (section 2);
- conservation and protection of water resources, lakes, springs, streams, and rivers (section 7);
- custody and care of communal lands, community forests, including sokshing and nyekhor tsamdo, medicinal herbs and prevention of illegal house construction and all other types of encroachments on land and forests (section 8); and
- prevention of construction of structures, whether on national, communal or private lands, within 50 feet of highways falling in local area (section 9).

2.3 Institutional Framework

2.3.1 Overview of Government Structure in Bhutan

Bhutan is a Monarchy, which continues to see dynamic change. The three arms of government viz. the Legislative, the Executive and the Judiciary function independently. The National Assembly is the highest Legislative Body and the Executive Power is vested in the Cabinet. The King of Bhutan is the Head of State. The government is represented by an elected Cabinet (Lhengye Zhungtshog). The chairman of the Cabinet is the Prime Minister, a post rotated among the ministers who win the highest votes in the National Assembly.

The Central Government is represented by ten ministries and the autonomous agencies. At the sub-national level, the country is administered through 20 dzongkhags (districts). The dzongkhags were sub-divided into geogs and there are 201 geogs (blocks). If the Dzongkhag size is big, Dungkhags are created for easy administration. The country's administration has been decentralised through the establishment of Dzonkhag Yargay Tshogchungs (DYTs) followed by the Geog Yargay Tshochungs (GYTs) in 1991. The decentralisation policy of the government is further reinforced with focus on geog based planning during the 9th Five-Year Plan. Figure 2.1 illustrates the Bhutanese system of Governance.

2.3.2 National Environment Commission

The National Environment Commission is an autonomous body serving and providing advisory services to the Royal Government on matters pertaining to the environment. This Commission is entrusted with the mandate to meet its long-term objective of defining policies, plans and actions whereby the sustainability of natural resources will be fully integrated into every aspect of Bhutan's social and economic development. The NEC is also responsible for implementation of national environmental issues and focal agency for international environmental conventions. The NEC is the custodian of the EA Act 2000.

2.3.3 Department of Energy

The Department of Energy within the Ministry of Trade & Industry is responsible for the power sector policy, planning & regulations. In addition, the Department is also responsible for generation, distribution, transmission, investigation & implementation of various projects.

One of the main objectives of Department is creation of enabling environment through formulation of hydropower policy guidelines to encourage possible participation of independent power produces and operators.

2.3.4 Department of Forest

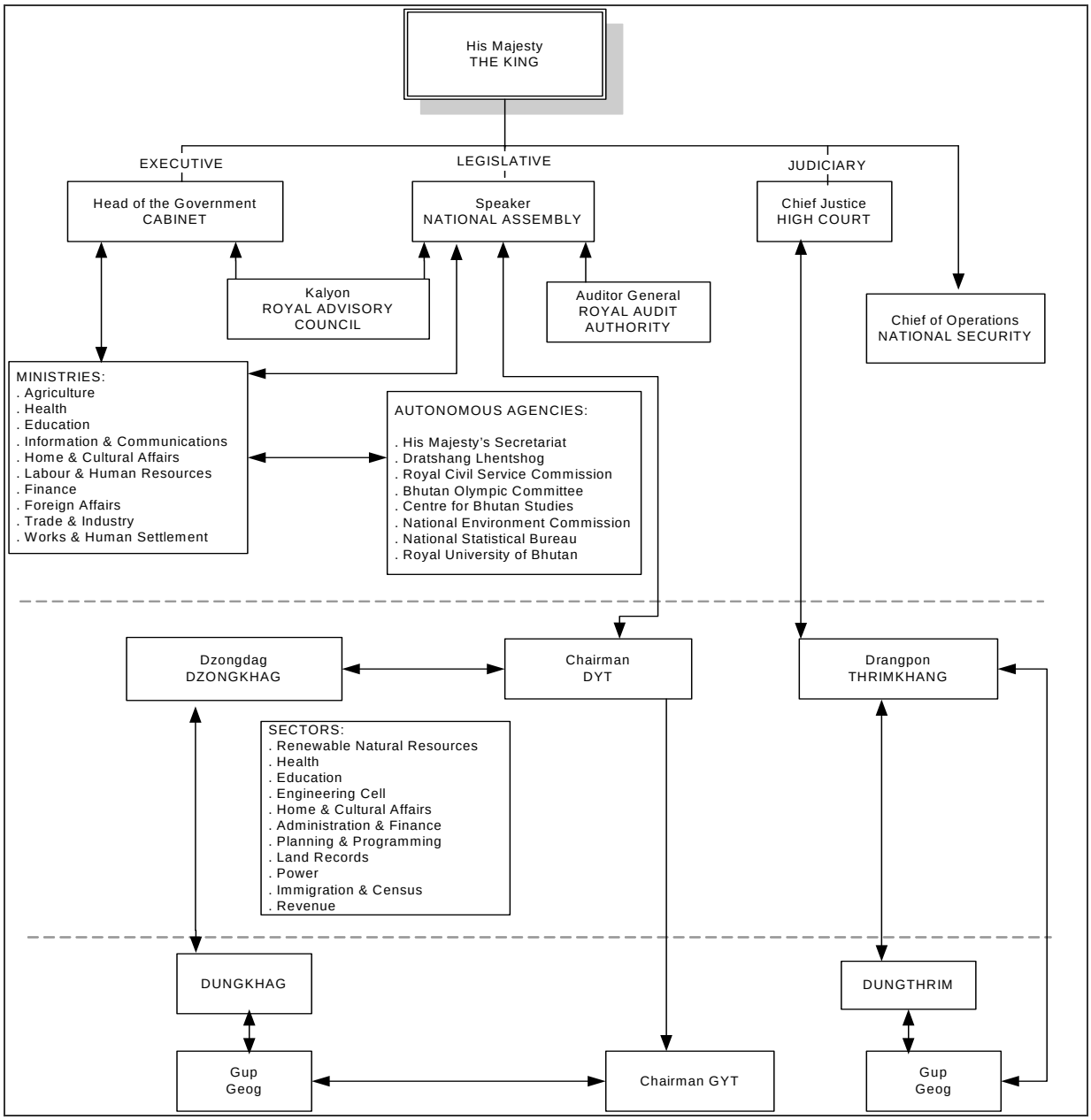
The Department of Forest (DOF), under the Ministry of Agriculture, is entrusted with the responsibilities of the management of the forest resources and biodiversity. The primary focus of the DOF is to ensure that at least 60 per cent of the country's area is maintained under forest cover at all times, and to conserve the rich biological diversity through the establishment of an effective network of Protected Areas. All projects that infringes into forestland has to seek clearance from this department. This applies also for this project.

2.3.5 Department of Geology and Mines

The Department of Geology and Mines is responsible for surveying, planning, investigation and implementation of mineral explorations. The department also monitors glacial lakes and

advises the government for possible mitigation measures in case of outburst threats. The Department is also the custodian of the Mines and Mineral Management Act 1995. DGM issues clearance of the quarry sites.

Figure 2-1 The Bhutanese system of Governance



2.3.6 Department of Roads

The Department of Roads (DOR) has the mandate to plan and construct road network in the country. The Department is the custodian for the implementation of the Road Act 2004. The construction of access road to the hydropower site need to sought clearance from the Department of Roads that need to be attached when applying for EC.

2.3.7 Bhutan Power Corporation

Bhutan Power Corporation was separated from the former Department of Power with a mandate to not only ensure that electricity is available to all the citizens but to also make sure that it is reliable, adequate and above all within the means of all consumers.

2.3.8 Dagana Dzongkhag

Dagana Dzongkhag Administration consist of following sectors; viz. Renewal Natural Resources, Health, Education, Engineering Cell, Home & Cultural Affairs, Administration & Finance, Planning & Programming, Land Records, Power, Immigration & census and Revenue sectors.

Under Dagana Dzongkhag, there are eleven geogs with their own administration headed by Gups (geog administrators). With the implementation of new *GYT Chathrim since 2004*, Gups are now directly elected by the people. These elected Gups are members of the DYT and the chair of the DYT is elected amongst them. In the DYT, Dzongdag (District Administrator) has only an observer status. This is the major shift from the old practice where Dzongdag was taking the lead in decision making process. It is a sign that the decentralisation has reached down to the grassroots. As project falls within this Dzongkhag, the project will have to coordinate very closely in the process of its implementation.

3 BASELINE ENVIRONMENTAL INFORMATION & ANALYSIS

3.1 Overview of Environmental Setting in Bhutan

His Majesty the King Jigme Singye Wangchuk has stated that:

"Throughout the centuries the Bhutanese have treasured their natural environment and have looked upon it as the source of all life. This traditional reverence for nature has delivered us into the twentieth century with our environment still richly intact. We wish to continue living in harmony with nature and to pass on the rich heritage to our future generations (RGOB, 1996)."

Bhutan ranks in the top ten countries in the world with the highest species density (species richness per unit area). It also has the highest fraction of land under Protected Areas and the highest portion of forest cover in relation other land uses. Bhutan is one of a very few biologically diverse countries in the world which have the opportunity to maintain its biodiversity largely intact in the coming decades (REID, 1996).

Today, the country has more than 70% of its area under forest cover (MOA, 2005). It is the stated policy of RGoB to maintain 60% of area under forests covers for all times to come (FANC, ACT 1995). Vis-à-vis Bhutan has followed a sustainable development policy which aims to maintain the balance between environment and development as stated in the *Middle path*, National Environment Strategy for Bhutan, NEC, RGoB, 1998.

3.2 Physical Environment of Project Site

3.2.1 Geology

3.2.1.1 General

The Bhutan Himalaya can be tectonically divided into three east west trending belts:

- The southern frontal belt which includes the lesser Himalaya and the foothills (Siwalik)
- The central crystalline belt which includes greater Himalaya and the lesser Himalaya
- The Tethyan belt, which includes portion of the greater Himalaya and portion of lesser Himalaya.

The southern frontal belt borders with India in the south and comprises a very narrow strip of Tertiary Siwalik rocks represented by sandstone, mudstone, siltstone and boulder conglomerates. The Lesser Himalaya north of the Main Boundary Fault/Thrust (MBT) are represented by the rocks of Permian-Paleozoic formations. These formations from south to north are the Damuda, baxa Group and the Shumar.

Damuda Formation consists of sandstones, shale with coal seams, felspathic quartzite and carbonaceous shale

Baxa Group consists of dolomite, variegated quartzite and conglomerates represented by different formations like Jainti, Manas, Phuntsholing and Pangsari.

Shumar formation consists of metasedimentry rocks represented by phyllite, micaccous quartzite with rare limestone bands.

The central Crysatalline Belt over thrusts the southern frontal belt through the Main Central Thrust (MCT). This belt covers most of the Bhutan Himalaya area, represented by high grate metamorphic and intrusive rocks of Paro Thimphu group (Pre-Cambrian to Tertiary). Rocks of Paro are represented by quartzite, quartz-mica schist, marble, calcsilicate and graphitic schist while rocks of Thimphu are represented generally by granite, gneiss, migmatites and occasionally by granite-mica schist, felspattic schist and amphibolite.

The Tethyan Belt covers portions of Northern Higher Himalaya range, Crystalline Belt of the central and eastern part of Bhutan Himalaya. It consists of various rock information's and is represented by sedimentary rocks (Pre-Cambrian to Cretaceous) intruded by Tertiary granites. The main rock types of this belt are shale, phyllite, slate, calearous phyllite, quartzite and limestone with intrusive granite.

3.2.1.2 Description of Project Area Geology

The geology of the project area is mainly crystalline complex of the High Himalaya and is dominated by metamorphic rocks. Slope instabilities of both active and dormant are recorded during the site survey. Majority of landslides are between the agriculture cultivated field and the river. Dormant slides are recorded; one landslide is at located north of Dam site #1A, one landslide opposite of Gewathang (below Khamay Village), north of the confluence of Panchhulumchhu and Dagachhu, one landslide in the north of the confluence of Lemechhu and Dagachhu, and another in the south of the confluence of Churachhu and Dagachhu. That makes total dormant landslides of four.

3.2.2 Topography

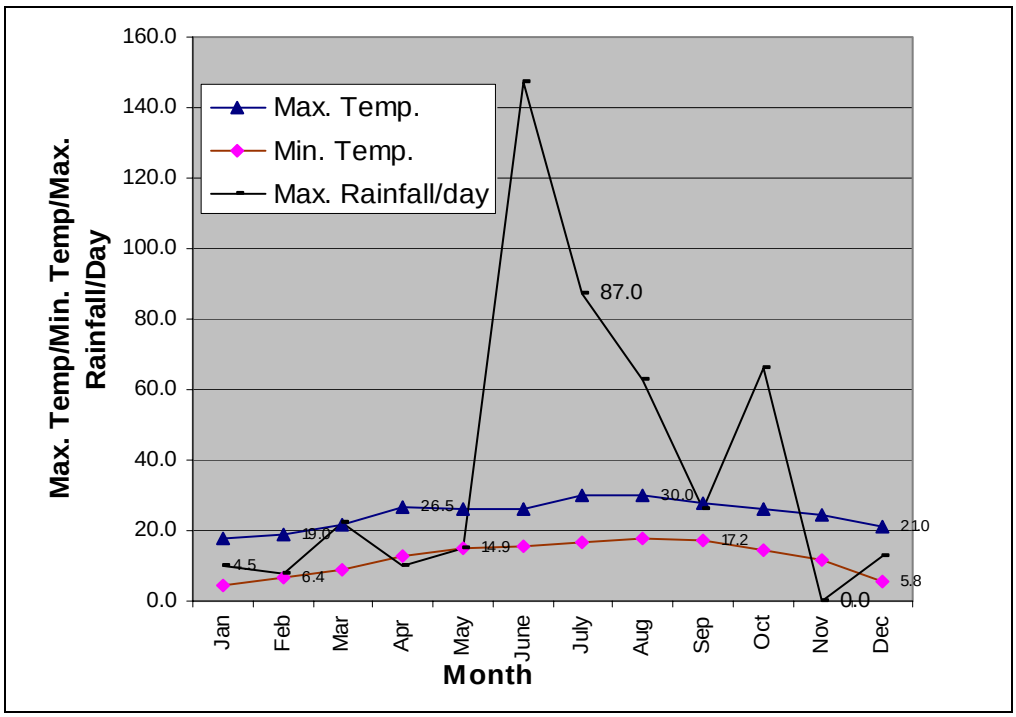
Project area fall under Dagana Dzongkhag which lies between Chukha and Thimphu Dzongkhag to the west, Wangdue Phodrang to the north, Tsirang Dzongkhag to the east and Sarpang Dzongkhag to the south.

Project area is generally steep and narrow with limited flat land. Large part of land within the project area has a slope more than 70 percent. Only the cultivated and inhabited areas have milder slope with an average slope of 50 percent. The slopes were terraced to suit cultivation. Most of the milder terrains which are inhabited are located far from the river bed or down towards southwest of project area. The river bed elevation at the dam site is 823 m asl. The dam site area is very steep and slope gradients at many locations are recorded at 100 percent. The powerhouse will be built underground inside the rocky cliff below Babithang village under Khebisa geog.

3.2.3 Climate

The project area falls under the subtropical climatic zone with hot and humid summers and cool and dry winters with heavy rainfalls. It is mainly influenced by monsoon airstreams that blows north from the Bay of Bengal which brings heavy rainfall to the area. Figure 3.1 show the temperature and rainfall pattern of 2003 recorded at Trashiding which close to the project area. There are four seasons while winter and summer are distinct of cold and hot.

Figure 3-1 Meteorological Record at Trashiding Station for 2003, source Hydrology & Meteorology Section, DOE



3.2.4 Hydrology

Dagachhu flows from the high mountains of west of Dagana to the east, meeting the north-south flowing river Punatsangchhu. Dagachhu constitute an important river basin of the main basin II with its dendritic drainage pattern with a catchment area of 676 km^2 (Bernard Engineers).

Dagachhu is a sixth order stream (Geology of Parts of Dagana, Thimphu and Wangdi Phodrang districts of Bhutan, 1980-81). It has several important tributaries, such as Lomachhu, Tanachhu, Sisilumchhu, Kegachhu, Gumlachhu, Lemichhu, Churachhu and Betlongchhu. Dagachhu together with its tributaries dissects Dagana forming steep gorges and narrow valleys. Table 3.1 shows the monthly discharge of Dagachhu.

Table 3-1 Water discharge shown in m^3/s, source Hydrology & Meteorology Section, DOE

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Max	9.7	9.2	8.9	10	30.2	81.5	49.3	133.8	40.7	23.1	15.2	11.1	133.8
Min	7.3	7.1	7.2	8.2	9.8	34.6	33.5	25.44	24.9	13.6	9.55	8.06	7.11
Mean	8.3	8	7.9	9.3	17.3	54.6	40.9	85.03	32.5	18.9	12.5	9.95	25.42

Source: Hydrology & Meteorological Section, DOE, 2003

3.2.5 Water Quality

The water quality study of Dagachhu done through this EA is of its first kind ever, as there are no earlier reports available for reference. The water samples were collected on a single day during the wet season (monsoon) due to time constraints. Thus, the water quality result generated may not represent the overall state of the river. There are no industrial effluents or major developmental activities in the area. Due to this, the amount of trace heavy metals and organic pollutants were not determined in the samples. The Dagachhu water quality is mainly influenced by minerals present in rocks and soils than any other

physical pollution. It is therefore, important to determine the baseline situation of the river to compare the emerging situation consequent with implementation of the project.

Table 3-2 Test results of the Dagachhu river water quality

Sl. No.	Parameter (Physical/chemical)	Sample site	
		Dam site	***Proposed tailrace***
1	pH	6.7	6.9
2	Conductivity	54.0 μs/cm	35.0 μs/cm
3	Turbidity	3.35 NTU	4.80 NTU
4	Temperature	18.0 o c	22.0 o c
5	Phosphate (PO43-)	0 mg/l	0 mg/l
6	Nitrate (NO3-)	not present	not present
7	Ammonia (NH4+)	not present	not present
8	Calcium (Ca2+)	4.2 mg/l	4.0 mg/l
9	Magnesium (Mg2+)	2.5 mg/l	1.2 mg/l
10	Sodium (Na+)	0.55 mg/l	0.50 mg/l
11	Potassium (K+)	0.5 mg/l	0.70 mg/l
12	Bicarbonate (HCO3-)	4.5 mg/l	3.0 mg/l
13	Hardness	12.0 mg/l as CaCO3	15.0 mg/l as CaCO3
14	TDS	45.0 mg/l	32.0 mg/l

Source: Field Work, 2005

The Dagachhu River has soft water quality. The total hardness of the water is about (12 - 15 mg/l) expressed as CaCO3 and thus falls in the category of soft water. One reason of this feature is the absence of rock types bearing mineral compounds mainly of calcium & magnesium carbonates and sulphates in the area. According to the inception report on the Dagachhu feasibility study 2005, the geology of the study area is largely a metamorphic sequence of quartzite, mica schist and gneiss. Due to presence of these weather resistant hard rocks, calcium and bicarbonate ions are dominant, but low in concentration (about 4.0 mg Ca/l) & (HCO3 - 3.0 – 4.5 mg/l), (refer table3.2). The influence of such rock types on the characteristic of water (particularly on dominant ions) is explained by Aswathanarayana, 1995. Magnesium (1.2 – 2.5 mg Mg/l), sodium (Na) (0.50 - 0.55 mg/l) and potassium (K) (0.5 – 0.7 mg/l) are also detected low in the sample. Due to moderately low concentration of ions, the total dissolved solids (TDS), is reported in between (32 - 45 mg/l) in the sample. The electrical conductance (conductivity) is about 35 – 54 μs/cm at 25° c.

The pH of sample ranges from slightly acidic to neutral (pH 6.7 – 6.9). The slightly acidic nature of the sample may be due to decomposition of dead plants that build up organic acids in soils. The turbidity (3.35 – 4.80 NTU) is attributable to presence of suspended solids in the water. The source of solid matter floating in the river is from the soil runoff when bare soils are exposed to rainfall. Suspended solids in the sample are mainly silt and organic matters.

Further, there is no indication of use of phosphate fertilizers and household detergents in the vicinity of the sampling sites that could enter the watercourse. Although, there are orange orchards along the sampling sites, but most of them have not been maintained well. In some, use of fertilizers has not been regular.

Ammonia (NH4) is absent in the sample as there are no human and animal faecal matters around the area. Nitrate (NO3) is also not present as agricultural fertilisation in the area is not intense.

3.2.6 Air

No data exist on the air quality situation in the project area. There are virtually no industry and very little traffic, which cause air pollution to any extent in the area. The only pollutant that could be observed during assessment is due to use of firewood and kerosene as the source of energy for cooking, heating and lighting.

3.2.7 Noise

There are no industries and vehicular traffic in the project area. Therefore the average noise level recorded at the site is 20 Db in the rural area. This noise is attributed to sound of insects, birds, rivers and streams, domesticated animals and human beings.

3.3 Biological Environment of Project Site

3.3.1 National Parks and Nature Reserves

Bhutan has four National parks, four wildlife sanctuaries and one strict nature reserve with biological corridor linking all these protected areas. The protected areas together account slightly over 26% and biological corridors about 9% of the country's land surface (BAP 2002).

The DHPP does not fall into any of the protected areas or biological corridors. The nearest protected area is Phibsoo Wildlife Sanctuary which is more than 30 km crow flight distances. Map 6 illustrates the protected area system of Bhutan.

3.3.2 Biological Diversity

Bhutan ranks in the top ten percent of the countries with the highest species density (species richness per unit area) in the world, and it has the highest fraction of land in protected areas and the highest portion of forest cover of any Asian country (BAP 2002). The flora and fauna described so far represent only a small portion of total species that exist in the country, thus placing Bhutan among least explored countries in the world.

According to BAP 2002, Biological inventories have so far recorded around 5,500 species of vascular plants, more than 770 species of avifauna and 165 species of mammals, with many species endemic to Bhutan. This rich species diversity indicates equally rich genetic diversity. The diverse flora includes many economically important plants such as medicinal herbs, horticultural crops and others yet to be identified. The rich biodiversity of ecosystem in the country is partly because of its location at the juncture of the Palearctic realm of the temperate Eurasia and the Indo-Malayan realm of the Indian subcontinent, and partly due to country's great geological relief and climatic heterogeneity.

The project area falls mostly within subtropical ecosystems. These ecosystems in the project area are already disturbed and degenerated due to human interventions. Biological survey

could list a floral diversity of 63 tree species, 50 herbs, 7 shrubs, 4 bamboos and 6 pteridophytes. Faunal diversity includes 17 mammalian species, 57 including three unidentified birds, 6 reptiles and amphibians, 9 invertebrates and 5 species of fishes.

3.3.3 General Eco-floristic Description of the Project Area

The forest of the project area can be divided into three eco-floristic zones based on altitudes. Each zone contains a distinct set of eco-zones as follows:

Tropical monsoon forest (altitude between 300 – 500m)
Subtropical forest zone (altitude between 500 – 1000m)
Warm broadleaf forest (altitude between 1000 – 2000m)

3.3.3.1 Tropical Monsoon Forests

The vegetation in the south eastern part of the project area, which are below 500 m consists of Tropical Monsoon Forest. Patches of subtropical broadleaf forest extends downward from the next zone. Dominant trees in the tropical monsoon forest include *Bombax ceiba, Callicarpa arborea, Duabanga grandiflora, Schima wallichi, Sterculia villosa, Talauma hodgsonii, Terminalia myriocarpa,* and *Terminalia tomentosa.*

Wildlife habitats in this zone include tropical monsoon forest, scrubland, and riparian forest along the Dagachhu.

3.3.3.2 Subtropical Forest Zone

This zone lies between 500m and 1000 m and consist primarily of subtropical broadleaf forest. Common trees in this zone consist of *Mangifera sylvatica, Polyaltha sp., Terminalia myriocarpa, Macaranga denticulata, Ostodes paniculata, Castanopsis lanceifolia, Cinnamomum spp., Phoebe lanceolata, Ficus spp., Duabanga grandiflora, Pterospermum acerifolium, Schima wallichi, Grewia spp.,* and *Ailanthus integrifolia.*

A wildlife habitat in this zone includes subtropical broadleaf forest, riparian forest, scrubland and patches of bamboo forest.

3.3.3.3 Warm Broadleaf Forest

This zone extends from 1000 to 2000 m and is characterized by subtropical and temperate broadleaf forests. Common trees include *Alnus nepalensis, Terminalia myriocarpa, Macaranga denticulate, Castanopsis indica, Castanopsis tribuloides, Quercus griffithii, Schima wallichi, Ostodes panniculata.*

Chir pine (*Pinus roxburghii*) forest, evergreen forest is usually evident in drier aspects and occasionally mixed with broadleaf forest in a sporadic manner.

Wildlife habitat includes subtropical broadleaf forest, temperate broadleaved forest, Scrubland, subtropical pine forest (dominated by *Pinus roxburghii*), and patches of bamboo forest. For detail studies of flora and fauna refer Annex 3 of volume II of this report.

Map 6 shows the Protected Area Systems of Bhutan

3.3.4 Ecological Description of Project Sites

3.3.4.1 Terrestrial Ecology

Reservoir/Dam Site

Flora

In and around the dam area, both broadleaf forest and chirpine forest types are observed. The west bank of the dam consist more of broadleaf forest than the east bank which has more of chirpine. Stands are significantly matured with optimum crown density ranging from 40 - 80% with little human interferences.

Chirpine *Pinus roxburghii* are stretching along and on the exposed ridge tops of the eastern side.

However, along the belt of river gorge, moist and shady conditions favour broadleaf vegetation. *Albizia chinensis, Albizia procera*, *Macaranga denticulata and Macaranga peltata, Bombax ceiba, Alnus nepalensis,* could be seen. Detail list of flora found in this area are shown in the Annex 4, Summary matrix of flora in Volume II of this report.

Photo 3-1 Illustrates vegetation composition around the proposed dam site

Fauna

The dam site or Reservoir area is relatively more intact than any other parts of the project area, mainly due to the inaccessible and rugged terrain. These types of forest are particularly rich in wildlife. The details of faunal species recorded are provided in the following sections.

Mammals

Owing to the intact forest cover, following animals are known to inhabit this area: Wild Boar (*Sus scrofa),* Barking Deer (*Muntiacus muntjak),* Goral (*Naemiorhaedus goral),* Monkey

(*Macaca assamensis) and* Leopard cat (*Felis bengalensis).* Detail list of mammal are provided in Table 5.1 of Annex 5, Summary matrix of Fauna.

Avifuana

Subtropical forests are richest in bird species among all the forest types. During EA survey 54 bird species are recorded and most of them are spotted between the Dam site and Desilting chamber, Gewathang.

Some of the birds that are either spotted or reported by our local guide during the survey are: Mountain Imperial Pegion (*Ducula badia),* Great Barbet (*Megalaima virens),* Blue-throated Barbet *(Megalaima asiatica),* Great Hornbill (*Buceros bicornis),* Himalayan Swiftlet (*Collacalia brevirostris)*, Oriental Turtle Dove (*Streptopelia orientalis),* Spotted Dove (*Streptopelia chinensis)*, Black Eagle (*Ictinaetus malayensis),* Crested Serpent Eagle (*Spilornis cheela),* Grey Treepie (*Dendrocitta formosae),* Scarlet Minivet (*Pericrocotus flammeus),* Ashy Drongo (*Dicrurus leucophaeus),* White-capped Water Redstart (*Copsychus saularis),* Slaty-backed Forktail (*Enicurus schistaceus),* Spotted Forktail (*Enicurus maculates),* Grey Bushchat (*Saxicola ferrea),* Red-vented Bulbul (*Pcynonotus cafér),* Black Bulbul (*Hypsipetes leucocephalus),* Striated Prinia (*Prinia criniger),* Oriental White-eye (*Zosterops palpebrosus),* White-crested Laughingthrush (*Garrulax leucolophus),* and Rufous-necked Hornbill (*Aceros nipalensis).* Detail list of birds are provided in Table 5.2 of Annex 5, Summary matrix of Fauna in Volume II of this report.

Reptiles and Amphibians

Due to lack of studies and research on reptiles and amphibians in the country, only few species could be identified with the help of local people. In general, forests of the area are known to have python (*python morulas)* and common cobra (*Naja naja).* During the field survey in and around the reservoir, EA team spotted water snake (*Enhydris sp.)* and common lizard.

Three species of amphibians, Bull frog (*Rana spp.),* common toad (*Bufo melanostictus)* and green tree frog (*Hyla arborea)* were spotted in the area. List of reptiles and amphibian are provided in Table 5.3 of Annex 5, Summary matrix of Fauna.

Endemic, Endangered/Protected Species

There are no evidences of endangered and protected plant species which are listed in Schedule I- Forest and Nature Conservation Act of Bhutan, 1995 is found in the area.

The endangered avi-faunal species spotted in the reservoir area is Rufous-Necked Hornbill (*Aceros nipalensis).* This species is listed as protected under Schedule I – Forest and Nature Conservation Act of Bhutan 1995.

A Leopard cat (*Felis bengalensis)* is reported by the locals to inhabit the reservoir area. This species is also protected under Schedule I – Forest and Nature Conservation Act of Bhutan 1995.

Desilting Basin

Flora

The area is basically Tseri dominated (slash and burn cultivation) with some subtropical forest towards south and north while chirpine forest is found to the northwest of it. The top canopy tree species found are *Daubanga grandiflora, Albizia chinensis, Albezia procera, Bombax ceiba, Ailanthus integrifolia, Terminalia alata, Macaranga denticulata, Macaranga*

peltata, Morus macroura, and variety of *Ficus spp.* Middle storey consists of *Callicarpa arborea, Ostodes paniculata, Rhus chinensis and Schima wallichi* along with variety of epiphytes. Ground layers consist of *Mikinia micrantha, Aresema, Eupatorium* and many weed species of the *Compositae, Cyperaceae* and *Gramineae* family. List of herbs are provided in Table 4.5 of Annex 4, Summary Matrix of Flora.

Chirpine is associated with *Emblica officinalis,* lemongrass (*Cymbopogon species)* and *Eupatorium odoratum* in lower and ground layers.

The gorges and depression are usually covered with broadleaf plant species that forms riparian ecology. Within this riparian ecology, trees, shrubs and herbaceous plants are found. Dominant trees are *Rhus chinensis, Trevesia palmate, Alnus nepalensis, Macaranga peltata, Ostodes paniculata, Tetradium fraxinifolium, Saurauia napaulensis, Debregeasia longifolia.* Shrubs include *Murraya Keonigii, Datura stramonium, Bambusa spp., Teinostachyum dullooa,* while herbaceous species include *Diplazium spp., Marsilea minuta, Arisaema spp., Saccharum spp., Colocasia spp., Tupistrea nutans, Musa spp., Girardinia diversifolia, Hedychium spp.*

Fauna

Since area is under the Tseri cultivation, there are no major animal species either spotted or reported. However, in the periphery jungles there are some common wild animals as reported below.

Mammals

In the peripheries of the desilting basin area, following animals are reported to inhabit: Wild Boar *Sus scrofa,* Barking Deer *Muntiacus muntjak, and* Monkey *Macaca assamensis.* These animals are considered nuisance to the farmers of Gewathang village for raiding their crops.

Avifauna

In the Tseri not many bird species were spotted. Some of the birds found are: Great Barbet (*Megalaima virens),* Blue-throated Barbet *(Megalaima asiatica),* Great Hornbill (*Buceros bicornis),* Himalayan Swiftlet (*Collacalia brevirostris)*, Oriental Turtle Dove (*Streptopelia orientalis),* Spotted Dove (*Streptopelia chinensis),* Black Eagle (*Ictinaetus malayensis),* Grey Treepie (*Dendrocitta formosae),* Scarlet Minivet (*Pericrocotus flammeus),* Ashy Drongo (*Dicrurus leucophaeus),* White-capped Water Redstart (*Copsychus saularis),* Slaty-backed Forktail (*Enicurus schistaceus),* Grey Bushchat (*Saxicola ferrea),* Red-vented Bulbul (*Pcynonotus cafer),* Black Bulbul (*Hypsipetes leucocephalus),* Oriental White-eye (*Zosterops palpebrosus),* White-crested Laughingthrush (*Garrulax leucolophus)* and Mountain Imperial Pigeon (*Ducula badia).*

Reptiles and Amphibians

No reptiles were spotted in the area.

However, near the village, especially in the Chuzhing (paddy field), Bull frogs and Common toad were spotted.

Endemic, Endangered/Protected Species

No endangered or protected plant, animal and birds are known to inhabit this area.

Side Adit

Flora

The intermediate access (side adit) is located in the rocky gorge of Churachhu south of Akhochen village under Khebisa geog. The area is steep and rugged forest land. Dense broadleaf forest is confined in the flat area by the river bank of Churachhu.

The inaccessible terrain prevented extraction of forest resource from this area. In the actual side adit area, there are only few trees, shrubs and bushes growing.

Main tree species in the surroundings are *Albezia spp, Bombax ceiba, Alnus nepalensis and Macaranga spp*. On the steep slopes of the river bank, *Pheonix acaulis* is fairly widespread. The exposed ridge, west of Churachhu is vegetated with chirpine *(Pinus roxburghii*) and lemongrass (*Cymbopogon spp.,).* List of flora is provided in Annex 4, Summary matrix of flora.

Fauna

Adit area has intact broadleaf forest due to inaccessibility created by its rugged topography. This intact forest support varieties of animals and bird species.

Mammals

Owing to the intact forest cover, following animals are known to inhabit this area: Wild Boar (*Sus scrofa),* Barking Deer (*Muntiacus muntjak),* Goral (*Naemiorhaedus goral),* Monkey (*Macaca assamensis)* and Leopard cat (*Felis bengalensis).*

Even a rare leopard, *Panthera pardus* is known to visit the area. List of mammals are provided in Table 5.1 of Annex 5, Summary matrix of Fauna in volume II of this report.

Avifuana

This forest is rich in bird species. Some of the birds that are spotted are: Great Barbet (*Megalaima virens),* Blue-throated Barbet *(Megalaima asiatica),* Great Hornbill (*Buceros bicornis),* Himalayan Swiftlet (*Collacalia brevirostris)*, Oriental Turtle Dove (*Streptopelia orientalis),* Spotted Dove (*Streptopelia chinensis),* Black Eagle (*Ictinaetus malayensis),* Grey Treepie (*Dendrocitta formosae),* Scarlet Minivet (*Pericrocotus flammeus)*, Ashy Drongo (*Dicrurus leucophaeus),* White-capped Water Redstart (*Copsychus saularis),* Slaty-backed Forktail (*Enicurus schistaceus)*, Grey Bushchat (*Saxicola ferrea),* Red-vented Bulbul (*Pcynonotus cafer),* Black Bulbul (*Hypsipetes leucocephalus),* Oriental White-eye (*Zosterops palpebrosus),* White-crested Laughingthrush (*Garrulax leucolophus)* and Rufous-necked Hornbill (*Aceros nipalensis).* List of birds are provided in Table 5.2 of Annex 5, Summary matrix of Fauna in volume II of this report.

Reptiles and Amphibians

This area is known particularly for Pythons (*python morulus)*. This big snake is encountered mostly towards the south of the adit area where there is ideal habitat. Few lizards were spotted during EA.

No amphibians are spotted in this area although habitat does look suitable.

Endemic, Endangered/Protected Species

No endangered and protected plant species as listed in Schedule I- Forest and Nature Conservation Act of Bhutan, 1995 is found in the area.

This area is also visited by Rufous-Necked Hornbill. Leopard (*Panthara pardus)* and Leopard cat (*Felis bengalensis)* are reported to frequent in this area as well. Both the species are protected under Schedule I – Forest and Nature Conservation Act of Bhutan 1995.

Pressure Shaft and Powerhouse

Flora

The pressure shaft area falls on a fallow land, with a patch of chirpine (*Pinus roxburghii)* forest along with lemon grass (*cympopogon species*) in the northern side while scrub forest dominates the immediate surroundings. Upper portion of the pressure shaft area is used as chuzhing and kamzhing by the people of Babithang. Broadleaf species such as *Albezia spp, Maccaranga spp., Alnus nepalensis and Ficus species* are recorded. Photo 3.2 illustrates the vegetation type around the powerhouse and pressure shaft.

Photo 3-2 illustrate vegetation types around surge shaft and powerhouse area

Fauna

Surge shaft area falls on fallow agriculture land with highly disturbed surrounding vegetations. The access to underground powerhouse has mostly riparian forest consisting of mainly broadleaf species but as habitat for wild animal it is limited because of rocky cliff. The details on fauna are discussed below.

Mammals

Due to highly disturbed nature of forest, only few wild animals inhabit this area. Wild Boar (*Sus scrofa),* Barking Deer (*Muntiacus muntjak),* and Monkey (*Macaca assamensis)* are few animals that inhabit the area.

Avifauna

Some of the birds that are spotted include Great Barbet (*Megalaima virens),* Blue-throated Barbet *(Megalaima asiatica),* Great Hornbill (*Buceros bicornis),* Himalayan Swiftlet (*Collacalia brevirostris)*, Oriental Turtle Dove (*Streptopelia orientalis),* Spotted Dove (*Streptopelia chinensis),* Black Eagle (*Ictinaetus malayensis),* Grey Treepie (*Dendrocitta*

formosae), Scarlet Minivet (*Pericrocotus flammeus),* Ashy Drongo (*Dicrurus leucophaeus),* White-capped Water Redstart (*Copsychus saularis),* Slaty-backed Forktail (*Enicurus schistaceus),* Grey Bushchat (*Saxicola ferrea),* Red-vented Bulbul (*Pcynonotus cafer),* Black Bulbul (*Hypsipetes leucocephalus),* Oriental White-eye (*Zosterops palpebrosus),* White-crested Laughingthrush (*Garrulax leucolophus)* and Rufous-necked Hornbill (*Aceros nipalensis).*

Photo 3-3 shows the Great Hornbill near the Powerhouse area

Reptiles and Amphibians

No reptiles were spotted in the area. However, two species of amphibian are spotted in the area - Bull Frog *Rana spp.* and Common toad *Bufo melanostictus* nearby the paddy field below Babithang.

Endemic, Endangered/Protected Species

No endangered and protected plant species as listed in Schedule I- Forest and Nature Conservation Act of Bhutan, 1995 is found in the area.

Powerhouse area with its matured and tall trees is special habitat to globally threatened, Rufous-Necked Hornbill (*Aceros nipalensis*), Bird of Bhutan, 1999. This threatened bird is listed as protected species under the abovementioned act.

Tailrace (former Switchyard area)

Flora

Switch yard falls in the registered Kamzhing, dry land agriculture. The area is barren and surrounded by thick broadleaf forests. The main species composition of the forest is *Duabanga grandiflora, Albizia spp., Bombax ceiba, Macaranga spp., and Alnus nepalensis*. The northern side is steep slope where bushes species of *Rubus spp.*, *Artemetia vulgaris*, *Jatropha curcas, Murraya Keonigii* and *Epatorium spp.,* are found. List of flora is in Annex 4, Summary matrix of flora.

Fauna

As it is located on Kamzhing but surrounding vegetation is quite dense providing a good habitat for wild animals including bird species. The details of animal species found in the area are discussed below.

Mammals

Periphery vegetation of the proposed switchyard area is good habitat for wild animal especially for Wild Boar (*Sus scrofa),* Barking Deer (*Muntiacus muntjak),* Monkey (*Macaca assamensis),* Porcupine (*Hystrix indica),* Tree squirrel (*Calloscirus macellandi)* and Leopard cat (*Felis bengalensis).* List of mammals is provided in Table 5.1 of Annex 5, Summary matrix of Fauna.

Avifauna

This forest is rich in bird species. Some of the birds that are spotted include: Great Barbet (*Megalaima virens),* Blue-throated Barbet *(Megalaima asiatica),* Great Hornbill (*Buceros bicornis),* Himalayan Swiftlet (*Collacalia brevirostris)*, Oriental Turtle Dove (*Streptopelia orientalis),* Spotted Dove (*Streptopelia chinensis),* Black Eagle (*Ictinaetus malayensis),* Grey Treepie (*Dendrocitta formosae),* Scarlet Minivet (*Pericrocotus flammeus),* Ashy Drongo (*Dicrurus leucophaeus),* White-capped Water Redstart (*Copsychus saularis),* Slaty-backed Forktail (*Enicurus schistaceus),* Grey Bushchat (*Saxicola ferrea),* Red-vented Bulbul (*Pcynonotus cafer),* Black Bulbul (*Hypsipetes leucocephalus),* Oriental White-eye (*Zosterops palpebrosus),* White-crested Laughingthrush (*Garrulax leucolophus)* and Rufous-necked Hornbill (*Aceros nipalensis).* List of birds are provided in Table 5.2 of Annex 5, Summary matrix of Fauna.

Reptiles and Amphibians

No reptiles are spotted. However, the villagers reported presence of common cobra *(Naja naja)*, Python *(Python morulus)* and variety of other snakes. EA team came across eggs of reptiles in the area.

No amphibians are spotted in this area although habitat does look suitable.

Endemic, Endangered/Protected Species

No endangered and protected plant species are found in the area. In the peripheries of switchyard area with its matured and tall trees is a habitat Rufous-Necked Hornbill.

Leopard cat is also reported to visit this area.

3.3.4.2 Aquatic Ecology

Aquatic Flora

Since Dagachhu flows rapidly and most of the riverbed is covered with gravels, detrital conglomerates and rocks, the surface of the stones and rocks are on the riverbed have been eroded with the rapid flow showing bare rocks. During the survey, few grasses and weeds (*Cyperus iria, Cyperus distans, Cyperus difformis, Paspalum distichum, Saccharum arundinaceum Saccharum spontaneum)* and an aquatic plant (*Marsilea minuta)* were noted close to the banks.

Invertebrates

Study or research on aquatic or freshwater invertebrates in Bhutan has not yet been carried out. However, the survey along the banks of Dagachhu and its tributaries has shown the existence of invertebrates of following Phylum and Orders.

Leeches (Phylum *Annelida*, class *Hirudinea*)
Molluscs (Phylum *Mollusca*)
Crustaceans (Phylum *Anthropoda*, Class *Crustacea*)
Insects (Phylum *Anthropoda*, Class *Insecta*)
Mayflies (Phylum *Anthropoda*, Class *Insecta*, Order *Ephemeroptera*)
Dragonflies and damselflies (Phylum *Anthropoda*, Class *Insecta*, Order *Odonata*)
Stoneflies (Phylum *Anthropoda*, Class *Insecta*, Order *Plecoptera*)
Beetles (Phylum *Anthropoda*, Class *Insecta*, Order *Coleoptera)*
Flies (Phylum *Anthropoda*, Class *Insecta*, Order *Diptera)*

Photo 3-4 shows the snail near bank of Betlongchhu (tributary to Dagachhu)

The aquatic leeches are mainly found in slow flowing to stagnant water. Snail (Molluscs) inhabits the moist riparian forest along the Dagachhu and its tributaries. The stagnant waters along the Dagachhu are home to insects like, stonefly nymph, water beetles, mosquito larvae and dragonfly nymphs.

Fish Species

In Bhutan, there are 49 fish species, of which 42 are native and 7 are introduced *(http://www.mongabay.com/fish/data/Bhutan.htm).* Only one fish species called the Golden Mahsheer (*Tort tor)* is a protected species under schedule I of Forest and Nature Conservation Act of Bhutan, 1995.

No past surveys of fish species has been noted for Dagachhu. EA team has hired expert local fisherman to assist in survey and identification of fishes in Dagachhu. The fish species of Dagachhu was then compared with the species of Punatsangchhu, since Dagachhu flow into Punatsangchhu. Punstsangchhu has 10 species of fishes (EA Punatsangchhu for Hydropower Project, 2001) whereas Dagachhu has five known species.

In Punatsangchhu, Mahsheer (*Tor putitora)* migratory species is known to inhabit while there are no evidence of its existence in Dagachhu. Table 3.3 shows the list of fish species found in Punatsangchhu.

Table 3-3 illustrates the fish species of Punatsangchhu, EA Report 2001

Scientific names	**Common names**	**Description**
Tor putitora	Mahsheer (Eng[3])	Migratory
Schizothorax progastus	Asala(Lh[4]) Menjai(Dz[5])	
Salmo trutta fario	Brown trout (Eng)	
Puntius titius	Punti	
Cirrhina lata	Gauma	
Barilius shaera	Hill trout (Eng)	
Labeo pangasia	Pangusia (Eng)	Migratory
Barilius vagra	Koksa	
Barilius barna	Puti	
Garra gotyla gotyla	Pattar chat/ Lohari	

Source: EA Report of Punatsangchhu Hydropower Project, 2001

Dagachhu has five known fish species, Asala (*Schizothorax progastus),* Katlay (*Barbodes hexagonolepis),* Baynya (*Glyptothorax pectinopterus),* Chinya (*Garra gotyla gotyla)* and Hulbuduna (*Garra spp).* Of the five, Hulbuduna (Garra spp.) is known to migrate in big groups towards higher altitude during the months of March and April for spawning in the upstream of Dagachhu and return downstream by the end of September. List of fishes are provided in Table 3.4.

Table 3-4 illustrates the fish species of Dagachhu

Scientific names	**Common names**	**Description**
Schizothorax progastus	Asala(Lh) Menjai(Dz)	Native
Barbodes hexagonolepis	Katle (Lh) Lopchem(Dz)	Native
Glyptothorax trilineatus	Kabre (Lh) Baynya(Dz) Catfish	Native
Garra gotyla gotyla	Buduna(Lh) Chinya(Dz)	Native, Seasonal Migratory
Garra spp.	Hulbuduna(Lh) Tortala(Dz)	Native Seasonal Migratory

Source: Field Survey 2005

3.3.4.3 Wetland

Bhutan has rather few wetlands, apart from some river stretches that are found in Central and southern foothills where valleys are wide and rivers flow slowly. The extensive marshes in Phojikha valley in central Bhutan are an important wintering ground for the globally threatened Black-necked Crane (*Grus nigricollis)*. According to Birds of Bhutan, 1999, two globally threatened wetland species occur regularly in Bhutan. The rare White-bellied Heron (*Ardea insignis)* breeds, frequents only those rivers and lakes in dense broadleaved forests

[3] English Name
[4] Lhotsham (Nepali) Name
[5] Dzongkha Name

below 1400m. Pallas fish Eagle (*Haliaeetus lecucoryphus),* which breeds and inhabits large rivers, also below 1400m

Dagachhu and its tributaries are fast flowing, boulder-strewn torrents that cuts through deep and steep sided valleys. There are no wetlands in the project area.

3.3.4.4 Use of Forest Products

Timber

Local people depend on the forest for construction timber, fuel wood and fencing posts. *Albizia spp., Morus spp., Daubangba grandiflora, Terminalia alata*, *Ailanthus grandis* and even chir pine *Pinus roxburghii* are used as construction timbers. Middle story broadleaf tree species like *Ostodes paniculata*, *Rhus species*, are used as poles and fuel wood.

Non Timber Forest Products

There are large numbers of non-timber forest products used by the local people. *Phoenix acaulis* is used as roofing material. *Thysanolaena maximum is* used as broom. A seed of *Oroxylon indicum* is used in religious ceremony and its flowers are used as vegetables.

Local inhabitants also collect wild vegetables from the forest. Some of the common wild vegetable used by the local people is *Diplazium species*, *Pogostemon amaranthoides*, *Tupistra nutans*. And among the wild edible mushrooms are *Auricularia auricular*, *Acanthocystisb geogenius*, *Pleurotus cornucopiae*, etc. are collected from the forest. *Elatostema lineolatum* is another wild vegetable which is used for preparing typical Bhutanese curry.

Indigenous treatments are still in practice using medicinal plants collected locally. *Dichroa febrifuga* is used to treat malaria sickness, fresh flowers of *Bauhinia purpurea* is used to cure diarrhoea and fever. *Rubus lineatus* is used to treat pneumonia.

In addition these, Cattle feeds are collected from the forest. Large variety of fodder species including fig trees (*Ficus roxburghii, Ficus semicordata, Ficus lacor*), *Grewia asiatica*, and *Rhaphidophora* (*epiphyte*), and many more unidentified palatable epiphytes, climbers, shrubs and herbs are grown and used in plenty.

Table 3-5 illustrates the Non Timber Forest Products found in project area

Scientific Name	Common Name	Part	Use
Bauhinia purpurea	Tanki	Fresh flower	Medicine for Diarrhoea, fever, & digestion
Bauhinia variegate	Koiralo(Lh)	barks	Medicine Diarrhoea, fever, & digestion
Dichroa febrifuga		roots bark	used for malarial treatment
Colocasia spp.	Rato many(Lh)	tubers	Medicinal
Rubus lineatus	Gyampay aeiselu	roots extracts	To treat pneumonia
Rumex nepalensis	Halelay(Lh)	root	treatment for wounds and cuts
Dioscorea hamiltonii	Borangjoktang(Sh)	tubers	Food or vegetable
Dioscorea pentaphylla	Phantang(Sh)	Bulb edible	Food or vegetable
Piper hamiltonii	Pan(Sh)	leaves	leaves edible with betel nut
Rubia cordifolia	Laneinaangroo	Entire plant	dyeing
Elatostema lineolatum	Dambur (Dz)	Shoot	Vegetable
Auricularia auricular	Jilinamcho(Dz)	Entire plant	Vegetable
Acanthocystisb geogenius	Jitsishamu(Dz)	Entire plant	Vegetable
Pleurotus cornucopiae	Selishamu(Dz)	Entire plant	Vegetable
Diplazium spp.	Nakay (Dz)	Shoot	Vegetable

Source: Field Survey 2005

3.4 Social Environment

3.4.1 Overview of Social Structure in Bhutan

Bhutan is nestled and landlocked in the Himalayas between two giant neighbours – India and China. As per the Population and Housing Census 2005 Bhutan has a total population of 634,982. Dzongkha is the official language of the country. Majority of Bhutanese in northern, central and eastern parts of the country are Buddhist and of Mongoloid origin, while in the south people are predominantly Hindus.

Bhutan is a Monarchy, which continues to see dynamic change. The three arms of government viz. the Legislative, the Executive and the Judiciary function independent of each other. The National Assembly is the highest Legislative Body and the Executive Power is vested in the Cabinet. The King of Bhutan is the Head of State. The government is represented by an elected Cabinet (*Lhengye Zhungtshog*). The chairman of the Cabinet is the Prime Minister, a post rotated among the ministers who win the highest votes in the National Assembly.

The Central Government is represented by ten ministries and the autonomous agencies. At the sub-national level, the country is administered through 20 dzongkhags (districts) and 201 geogs (blocks), the country's administration has been decentralised through the establishment of Dzonkhag Yargay Tshogchungs (DYTs) followed by the Geog Yargay Tshochungs (GYTs) in 1991.

The Geogs are the smallest administrative units and an elected member of the community called Gup is the Head of the Geog. The Gup represents the Geog community in civil administration and execution of development activities within the Geog.

3.4.2 General Description of Social Settings in Dagana Dzongkhag

The Dzongkhag or District Administration is based in Dagana, the biggest town and the Dzongkhag Centre. It has about 1000 inhabitants and is located 87 km from Sunkosh town. Almost all government sectors are represented in the Dzongkhag Administration, particularly those involved in the delivery of social and technical services such as health, education, agriculture, forestry, livestock, planning, finance, engineering and civil administration. The Dzongdag, representing the Ministry of Home Affairs is responsible for overall administration of the Dzongkhag and coordination of developmental activities.

The Dzongkhag has eleven Geogs with an estimated population of 18,222 (Population & Housing Census 2005) as of 2005 spread in 86 main villages. The main commercial centres of the Dzongkhag are Dagana, Sunkosh, Goshing and Drujegang. The small satellite township of Sunkosh has about 130 people and is the gateway to the Dzongkhag. Table 3.7 shows Geog details of Dagana including a Geog in Tsirang.

Table 3-6 presents the Geog details of Dagana and Tsirang

Dzongkhag	Geogs	No of villages	No of HH	Population	Geog Area (Km2)
Dagana	Total	86	3485	18222	1389
	Tsendagang	4	338	1729	76
	Trashiding	6	307	1636	39.5
	Drujegang	3	464	2121	57
	Kana	15	350	1964	140
	Khibisa	6	223	1212	96

Dzongkhag	Geogs	No of villages	No of HH	Population	Geog Area (Km2)
	Goshi	4	446	2187	26
	Lajab	8	165	863	95
	Gaserling	10	261	1340	140
	Tsangkha	13	257	1352	37
	Tseza	8	217	1106	565
	Dorona	9	149	754	117.5
Tsirang	Rangthangling	8	284	1447	24.5

Source: Population and Housing Census 2005

3.4.3 Public Consultation, procedures and Responses by the EA Report

The Environment Assessment Act 2000 demands that concerned people and organization are informed and consulted before the submission of the environmental assessment documents for the clearance. The objective is to obtain information, comments and dialogue throughout the assessment process.

In Bhutan, peoples' participation in decision-making picked up greater momentum after the RGoB has established the *Dzongkhag Yargay Tshogchung* (DYT) in 1981 and further establishment of *Geog Yargay Tshogchung* (GYT) in 1991. At the village levels there are also established mechanisms where people can express their views.

The team had consultations with Officials from Dagana Dzongkhag Administration and the affected local communities. *Details pertaining to these consultations are presented in Annex 1*. The idea of consultation was to invite views, concerns and values that the team should consider and account in the process of Project feasibility studies and EA.

The discussion themes and pertinent issues that emerged in the consultations include the following:

- The purpose of conducting EA and the advantages of taking up Project technical feasibility study and the environmental assessment simultaneously.
- The options for building the various components of the project especially pertaining to dam location, powerhouse, switchyard, road and transmission line alignments were briefed.
- The economic opportunities that would perhaps bring to the Dzongkhag.
- Given that Dagana does not have any full-fledged hospital to cope with presumably high number of casualties at the project worksite, a construction of a hospital may be required.
- Concerns about the land replacement and compensation during the project implementation.
- Possible danger to the road alignment due to presence of dormant landslide near Dagachhu 0km which has been abandoned by the Department of Roads while trying to realign and shorten the Sunkosh-Dagana Dzongkhag highway due to landslide.
- Roads passing through or below the chuzhing should have proper drainage and retaining wall to protect both road and chuzhing.
- Land required for all components of the project would be provided by the people as it would bring about numerous social and economic benefits to the project area and beyond. However, concerns have been raised as to the adequacy of land compensation by the existing official rates. Land substitution has been discussed as a better option to cash compensation.

The only concern that the affected households expressed is the compensation for the property lost to the project. The EA Report responded to it by stressing that Resettlement Action Plan (RAP) be drawn by the project during pre-construction stage where all issues relating to compensation, resettlement and monitoring mechanisms were dealt with. And affected compensated comfortably by the project before the construction.

3.4.4 Households located around the Periphery of Project Site, Indirectly Affected

The physical project location and its impact cover two Dzongkhags (Dagana and Tsirang), seven Geogs and 24 villages. These villages serve as home to 703 households and 4,446 people. This pertains to 19% of the population of Dagana and 1% of Tsirang respectively. Table 3.8 illustrates the population distribution in villages that are in the peripheries of the project area.

Table 3-7 Population distribution of villages that are located in the peripheries of the project area

Dzongkhag	Geog	Villages	Households	Population
Dagana	Kana	Tanabji	17	250
		Kanakha	26	200
		Jachema	6	50
		Lhaling	21	300
		Khagochen	51	255
		Khamay	17	91
		Chenathang	12	67
		Dalithang	26	208
	Khebisa	Akhochen	41	328
		Khebgangkha	30	180
		Gipsa	37	185
		Babithang	17	102
		Gewathang	4	32
	Goshi	Balaygangju	16	96
		Goshijug	14	112
	Trashiding	Namchela	22	110
		Tashiding	52	208
		Shamdalay	30	150
	Tsendagang	Tsendagangjug	50	300
		Gangzurjug	65	390
	Drujegang	Pangserpo	46	214
Tsirang	Rangthangling	Dhajey	63	378
		Nebiry	28	167
		Sauni	12	73
Total	**Project Area**		**703**	**4446**

Source: EA Field Survey July 2005

3.4.4.1 Description of Social Settings

Ethnicity

The population of Bhutan comprises of many ethnic groups such as sharchops from the east, Ngalongs from the west, Khengpas from mostly the central region, the nomads from the northern regions and Lhotshampas from the south. The household population in the peripheries of the project area is represented by almost all the major ethnic groups in Bhutan. It comprises of Ngalongs (11%), Khengpas (13%), Sharchops (8%) and Lhotshampas (68%). The Lhotshampa community in the periphery of project area comprises of Rai, Gurung, Mongar, Subbha, Sherpa, Pradhan, Bhawans and Chhetri castes.

Language and Religion

Because of the presence of a mix of ethnic groups, the people in the project area speak

many dialects. These include Khengkha, Dzongkha, Sharchop, and various dialects of Nepali. Most of the households are Buddhists forming 72% of the household population. The rest are Hindus.

3.4.4.2 Socio-economic Analysis

Cultural Heritage Sites

Important cultural entities within the Dzongkhags are Daga Trashi Yangtse Dzong and the Megalith of Dagana. Daga Dzong situated some 29 km upstream of the project area, is an impressive fortress over looking southern foothills. It was built in 1652 AD on a ridge that looks like an elephant's head below Shelto Goenpa. It was meant to subdue enemies of the southern frontier and address the spiritual needs of the region (On the Mule Track to Dagana, CBS, 2003). Like any other Dzongs in Bhutan, it too has annual Tsechu (Religious festival) performed by the monks during which people from different corners of the Dzongkhag come here to celebrate and witness the annual event.

Besides the Dzong there are also many other important Bhuddhist pilgrimage sites of which the three important ones are Dow Namgi Kaw, Dow Kelpai Genthey and Tha Namkhai Dzong. Dow Namgi Kaw or pillar of all rocks (20 m high) is believed to have flown from India and is located opposite to Dagana Dzong near Nyindugkha village. The other two megalith, Dow Kelpai Genthey (the rock steps of eon) is on the high slope of Tanabji around 1.5 km on the right bank of the proposed Dam site; and Tha Namkhai Dzong (the frontier sky fortress) in Drujegang geog 25 km southeast of the project area.

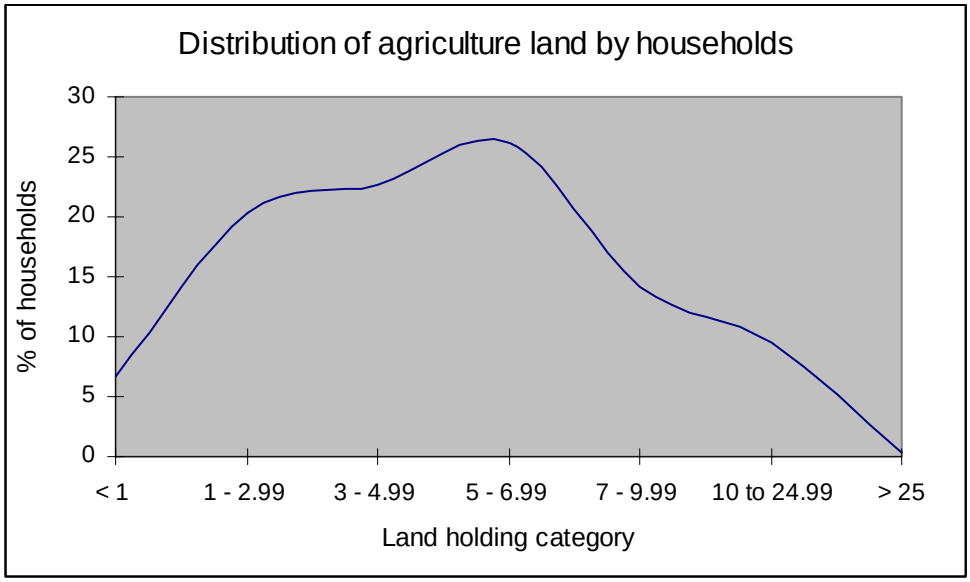
Land use and Tenure

Bhutan is predominantly an agriculture based country. The tenureship is based on the Land Act 1979. Almost 69.1% of the population lives in rural areas on subsistence to semi subsistence farming on less than 8% of the total area (Population & Housing Census 2005). Therefore judicious use of limited arable land is seen as an important strategy by the Government. Dagana has 82% of its land cover under forest, almost 13% under agriculture, 1% under pasture, 1% under horticulture, less than 1% comprises of settlements while rock outcrops, water bodies and landslips form about 3%. Significant improved pasture development has not gained grounds in the Dzonkhag although they have about 19173 ruminant livestock units. About 80% of the households own cattle. Other major livestock types are pigs and poultry birds owned by 51% and 79% of the households respectively.

Dagana geog has a total of 13,713 acres of agriculture land including Chuzhing, Kamzhing, Tseri, Pangzhing, Orchard, and Kitchen Garden. The dominant agriculture landuse in Dagana are dryland and wetland (irrigated or rain fed paddy fields) comprising of 52% and 23% of the total agriculture land in the Dzongkhag respectively. Map 7 shows the different land use types within the project area.

Households in Dagana own a mix of land use types. About 84% of all households own dryland while and 70% of them own wetland. The other important agriculture land uses are Orchard as owned by 34% of the households and Tseri or Pangzhing by 31%. The distribution of land among households is characterised by medium scale of land holdings. Almost 83% of the households in Dagana own from 1 to 10 acres of agriculture land. Only about 7% of the households own less than 1 acre while about 10% own more than 10 acres (RNR Statistics, 2000). The figure 3.2 shows distribution of agriculture land.

Figure 3-2 shows the distribution of agriculture land



Source: RNR Statistics 2000

Almost 85% of the 10,673 acres of wetland and dryland in Dagana are owner operated. The proportion of land leased is only 7% (3% leased-in and 4 % leased-out). A similar proportion of the irrigated and dry agriculture land is left fallow. Fallowing or leasing of land is a practise limited to dry land (Kamzhing). One of the main reasons for fallowing of land is the shortage of farm labour. According to a study on rural urban migration in Bhutan, creation of farm labour shortage is one of the most significant problems caused by rural to urban migration. The study reports that about 4% of the national migrant population comes from Dagana Dzongkhag (Rural-Urban Migration in Bhutan, MoA, 2005).

The average landholding of village in the peripheries of the project area is about 6.14 acres.

Farming System and Production

Mixed subsistence to semi subsistence agriculture is practiced in the peripheries of project area as is the case of overall Bhutanese farming system. Agriculture, livestock and forestry form an integrated farming practice at the household levels.

Dagana Dzongkhag has a total of 19,173 ruminant livestock units including cattle, horses, goat and sheep, buffalo, mules and donkeys. The most important livestock type in the Dzongkhag is cattle, forming 75% of ruminant livestock population followed by goat comprising 19% and sheep forming almost 4%. About 80% of households own local cattle, 44% own pigs and 85% own poultry birds compared to the national average of 72%, 44% and 55% respectively.

Assuming that a cattle unit would be equal to one horse unit, two sheep and two goat units respectively in terms of pasture requirements, the Dzongkhag has 17,001 cattle units. Given the availability 1706 acres of registered pasture area within the Dzongkhag, each every 10 cattle unit of ruminant livestock has about an acre of registered pasture land. Besides there are unregistered pasture land and homestead fodder plantations to supplement this pasture availability.

The main source of farm nutrients in all the agro-ecological zones is from farmyard manure and leaf litter from the forests. As in many parts of the country, farmers still grow

Map 7 illustrates the land use types in the project area.

traditional varieties of crops and follow a traditional cropping calendar that prescribes sowing and harvesting times according to astrology. Farmers strictly subscribe to the timings as they believe that crop damage from inclement weather and pest and diseases can be averted. On the whole, very little quantities of chemical fertilizers or pesticides are used.

Agriculture Products

The principal crops of Dagana are paddy, maize, millet, potatoes, mustard, and buckwheat (sweet and bitter). The Dzongkhag produces 8,516 MT of cereals contributing to 5% of national cereal production. At the Dzongkhag level maize and paddy production contributes to 51% and 43% of total Dzongkhag cereal production.

The Dzongkhag produces 1,727 MT of fruits comprising of apples, oranges, walnut, plum, pear, peach and Guava of which 93% includes orange produces. About 4% of national tree crop production is generated from Dagana. Orange is the most important tree cash crop and it forms 93% of tree crop production of the area. About 5% of the country's orange production comes from Dagana which has about 7% of the national orchard.

Livestock Products

The Dzongkhag produces 134 MT of milk, 68 MT of butter and 96 MT of cheese. These contribute to 5% of national milk butter and cheese production. It also consumes almost the same proportion of these commodities.

Almost one third of meat production from Dagana comprises of beef although it forms only 1% of the national beef production. About 43% of meat produced is locally consumed. The surplus meat comes mostly in the form beef and pork. The area consumes all its wool produced internally.

Water Resources

The four major rivers with their numerous tributaries that drain the country constitute the water resources potential of the country. The theoretical hydropower potential of the country is estimated at 20,000 megawatt (Bhutan 2020). The agricultural water requirements are met from tertiary and secondary tributaries of the major river systems. The demand for domestic water is by and large fulfilled by water from local springs and small streams.

Dagana Dzongkhag is mainly drained by Dagachhu. With an area comprising of about 4% of the national land cover, the Dzongkhag's water resources (Dagachhu) has a hydropower potential of 114 MW which works up to about 1% of the national theoretical hydropower potential. Various tributaries of the Dagachhu are tapped by local settlements for agriculture and drinking purposes. The only existing hydropower plant in the Dzongkhag is based near the Dzong tapping water resources from Darachhu (200 KW), a tributary of the Dagachhu. This stream joins Dagachhu about 6Km upstream of the proposed plant. Therefore, no significant impact or conflict is foreseen on the water use for the proposed power plant.

Poverty and Income

The monthly household income within the periphery of the project affected areas is estimated at Nu.1126 from the project EA survey, 2005. The average household income at the national level is around Nu.1200 per month. The household income levels in Dagana have remained almost the same form 1995 to 2000 (Poverty Assessment and Analysis

Report, 2000). The household income sources include farm and non farm enterprises. The non farm sources of income include remittance from household members working in non farm sectors such as civil servants, payment for labour in construction activities and small business ventures. Major proportion of the income, however, arises from sale of farm products in local markets and export of products such as butter, cheese, fruits (mainly orange) and pulses.

The quality of living in the project area is reflected also by the type of roofing the households use over their houses. Majority of the houses use corrugated iron sheet (CGI) roofing which indicates that these households can economically afford such an option. While 54% of the houses have thatch roofing, this does not necessarily indicate their inability to procure CGI sheets. This is a preference at the lower altitudes for its ability to regulate home temperature. The rest use wooden roofing.

3.4.4.3 Gender Equality Analysis

Bhutanese women and men share a far greater role of responsibilities within and outside household affairs compared to most of the neighbouring countries. At home most women throughout the country take a lead role household decision making process. This is particularly so in the northern parts of the country. Field data collected from 349 individuals representing their households in the project affected areas shows an equal proportion of the households headed by women and men. Inheritance practice often favours women to inherit family assets. In rural areas, the ownership pattern showed 51:49 - female/male ratio. Most property in the rural areas was received through inheritance (Gender Pilot Study, Bhutan, 2001). At the societal women take up increasingly greater role in Government and public affairs including the legislative branch of the Government.

There is no overt discrimination on the basis of gender. Women's role is as vital as men's in the rural and urban economy, and they are actively involved in all areas of economic, political and social life. Much of the retail trade is controlled and managed by them. In the political forum, women attend most public meetings and important district meetings. Their participation in the decision-making forums such as *Zomdus* (community meetings) at the grassroots level is as high as 70%, and they participate actively in the other decision-making forum like district and block level development committees is greatly promoted. The placement of women in the higher strata of government is being encouraged, with 9 women people's representatives in the National Assembly, the highest Legislative body of the country, being a clear indication of this.

3.4.4.4 Summary Matrix of Social Baseline Indicators

Table 3-8 illustrate summary matrix of Social Baseline Indicators of households in the periphery of the project area

Code	Category	Drujegang	Goshi	Kana	Khebisa	Rangthangling	Trashiding	Tsendagang	Av. weight (%)
1	Average HH size	8.50	5.77	5.76	8.09	9.48	7.50	13	8.30
2	Male to female ratio	47	50	47	51	43	52	54	49
3	% family members staying outside	37%	27%	18%	6%	38%	33%	8%	24%
4	% Lhotshampa	12%	91%	86%	59%	79%	50%	100%	68%
5	% Ngalong	0%	3%	14%	41%	21%	0%	0%	11%
6	% of Khengpa	88%	0%	0%	0%	0%	0%	0%	13%
7	% of Sharchogpa	0%	6%	0%	0%	0%	50%	0%	8%
8	% HH headed by female	57%	6%	51%	32%	14%	50%	100%	44%
9	% of dependency (<18 year old)	32%	50%	49%	44%	50%	60%	33%	45%
10	% of dependency (>60 year old)	8%	7%	9%	7%	14%	5%	8%	8%
11	% heads working in farm	75%	96%	92%	1%	85%	53%	96%	71%
12	% family members working in office	10%	4%	8%	0%	15%	15%	4%	8%
13	% male school goers	56%	52%	52%	55%	52%	0.50	57%	53%
14	% male working heads	47%	46%	46%	55%	46%	53%	46%	48%
15	% HH covered by RWSS	34%	0%	29%	9%	66%	0%	46%	26%
16	% HH owning 1 storey house	66%	31%	69%	59%	23%	75%	54%	54%
17	% HH owning 2 storey house	33%	55%	27%	41%	63%	25%	46%	41%
18	% HH owning 3 storey house	1%	14%	4%	0%	14%	0%	0%	5%
19	% HH owning cattle	92%	97%	17%	1%	97%	50%	92%	64%
20	% HH owning CGI roof	70%	0%	47%	44%	75%	25%	62%	46%
21	% HH owning goat	18%	83%	29%	56%	77%	25%	77%	52%
22	% HH owning Horse	11%	0%	0%	18%	0%	0%	8%	5%
23	% HH living in hut	43%	17%	66%	41%	10%	75%	8%	37%
24	% HH owning Talay house	5%	69%	22%	21%	59%	25%	38%	34%
25	% HH owning thatched roof	30%	26%	51%	32%	25%	25%	38%	32%
26	% HH owning Traditional houses	51%	14%	12%	38%	31%	0%	0%	21%
27	% HH responded that they are happy	100%	100%	100%	100%	100%	100%	100%	100%
28	% HH using firewood for cooking	97%	97%	88%	100%	97%	100%	100%	97%
29	% of HH using LPG for cooking	3%	3%	10%	0%	3%	0%	0%	3%
30	% HH using Kerosene for lighting	100%	60%	75%	100%	100%	100%	100%	91%
31	% HH using pit toilet	100%	100%	100%	100%	93%	100%	100%	99%

Code	Category	Drujegang	Goshi	Kana	Khebisa	Rangthangling	Trashiding	Tsendagang	Av. weight (%)
32	% of HH with water closet	0%	0%	0%	0%	7%	0%	0%	1%
33	% income from farm	76%	100%	74%	100%	85%	100%	96%	90%
34	% income from salary	9%	0%	8%	0%	15%	0%	4%	5%
35	% income from Business	15%	0%	14%	0%	0%	0%	0%	4%
36	% income from wage	0%	0%	3%	0%	0%	0%	0%	0%
37	% of HH using electricity	0%	40%	96%	0%	0%	0%	0%	19%
38	Av. Annual income per HH (Nu.)	10,007	12,829	17,813	10,176	6,049	18750	19,000	13,517.71
39	Av. Cattle owed by the HH	6.89	4.68	27.30	6.91	4.8	3.50	3.83	8.27
40	Av. goats owned by a HH	2.43	3.59	8.29	4.05	3.8	2.00	3.30	3.92
41	Av. Horses owned by the HH	1.10	0.00	0.00	1.17	0.00	0.00	1.00	0.47
42	Av. Land holdings per HH (acre)	5.00	4.00	3.00	5.00	5.00	10.00	11.00	6.14

Source: Field Survey 2005

Note: ***HH*** - households, ***Lhotshampa*** - Southern Bhutanese, ***Ngalong*** – People from western Bhutan, ***Khengpa*** – People from Zhemgang (South central Bhutan), ***Sharchop*** – People from eastern Bhutan, ***Talay*** – Traditional Southern Bhutanese house.

3.4.5 Directly Affected Households from Project

The project area covers Dagana and Tsirang Dzongkhags. The project impact in terms of land use changes from project road, transmission and power infrastructure in Dagana. However the physical impact in Tsirang is limited to impact from transmission lines alone. Therefore assessment of socio-economic conditions of Dagana has been emphasized in this report. However, in terms of direct impact from the alignment of transmission lines, adequate consideration has been taken care even in case of Tsirang Dzongkhag.

In total, the directly affected area includes 7 geogs, 14 villages and 41 HH. This pertains to a population of 257 people by the household records. However, only 193 people actually reside in these areas.

3.4.5.1 Social Situation, Cultural Awareness

Within this area, the ethnicity comprises of 21% Lhotshampas who speak various dialects of Nepali; 23.71% Ngalong who speak Dzongkha, 28.57% Khengpas who Khengkha and 5% Sharchops speaking Sharchopkha. Most of these people follow Buddhism. Only 5% of the households comprise of Hindus.

Currently, these people have limited access to public services. There are only about 118 km of motor road, which account 230 heads per km. The project is going to construct some 19.3 km which will increase the accessibility of the locals. The project affected population does not have access to telephone services, electricity and established reliable (treated) water supply. It is foreseen that project will create positive impact on this as well. Furthermore, although the Dagana has tourism potential, due to poor services and accessibility, no tourists visit the site. This scenario is anticipated to change as services will flow in along project.

The project will not create any form of resource use competition with the locals. For example: the water that will be used for project is located in narrow gorge with no utility at all to the locals. It will also not create any forest resources use competition as there are established rules and regulation which provides priority to the locality. As per law, all the construction agencies should procure timber from the saw-millers, which in turn gets logs supplied from the Forestry Development Corporation Limited, state owned Corporation.

The cultural setting is not anticipated to change due to influx of the foreign labours as that is temporary recruitment. Contrary it is anticipated that presence of labours will create business for the farmers to sell their farm products. The EA Report recommended establishing labour camps bit away from the local settlements to keep the cultural conflict away.

3.4.5.2 Socio-economic Analysis

Farming Systems

Survey carried out within the DHPP project area shows that all the directly impacted households own agriculture land. The average area of land owned is about 4.07 acres per household while the minimum landholding recorded is 1.32 acres.

In a situation where lease land and share cropping mechanisms are involved, acquisition of private land affects livelihood of a number of individuals and households. It affects the sharecroppers and lease land operators through loss of employment and income opportunities. Almost all agriculture lands in the project area are owner operated. Share

cropping and operation of lease land is not significant. Only 2 households in the project area were found to be completely dependent on sharecropping for their sustenance. These share croppers pay half their annual crop to the owner of the land.

Land use and Tenure

They own 195.8 acres of land including Chuzhing, Tseri, Kamzhing, Orchard and kitchen garden. Livestock population in this area comprises of 26 sheep/goat, 160 cattle and 15 horses. Besides this the households also own poultry birds used for households consumption of eggs and chicken.

About 16.2 % of total land owned by this group need to be acquired (31.7 acres) for the project as per the specification provided in the feasibility study report. This comprises of 3% of all Chuzhing, 4% of all kamzhing, 2% of all Tseri and about 3% of all Orchard of the directly affected area. These are areas that fall within the location of the desilting chamber, pressure shaft, switch yard and alignment of access road and transmission line. Most of it falls within the road alignment.

Only 9 % of the economically active members of this group are engaged in non-farm jobs. Therefore, agriculture is the main occupation of the people who are directly affected by the project.

Poverty Eradication

The average monthly income of the households in the directly affected area is Nu. 1229, slightly higher than the people within the periphery of the project affected areas whose average monthly income is Nu. 900 (project EA survey, 2005). The mains source of income include farm produces, significant among them, the sale of oranges.

The proposed DHPP will contribute towards poverty eradication objective of the country by generating annual revenue of Nu. 670 million or equivalent to US$15 million. In terms of the current GDP of Bhutan, the project will contribute approximately 2% of its GDP. The project will provide employment opportunities such as: skilled and unskilled about 1500 per day and staff and support system for construction and operation about 200 day.

As there are no other agencies involved in trading hydropower in Bhutan, the project will not create any kind of competitiveness in terms of business.

Infrastructure and Access to amenities

There are 88 children below 18 yrs. within the describe area, 60 % of which attend school in areas outside the area described here. The same goes to accessing health facilities.

12 out of 41 households have access to drinking water through rural water supply scheme. The rest of the households obtain water through private arrangement, most of which does not include proper tap water. The households in this area walk from 20 minutes to about 2 hrs to get to the nearest road head. Almost all the households use fuelwood or kerosene as the source of energy.

Most of the houses in this area use corrugated iron (CGI) sheet for roofing over their homestead. About 58.5% of the households use CGI roofing, 17.4% thatched roofing and rest uses other forms of roofing such plastics and wooden shingles.

3.4.5.3 Gender Equality Analysis

Generally the traditional practice of property inheritance goes to daughter. Except in few Lhotshampa communities the property in this project area is also inherited by Daughter. This means there is no visible gender gap. From the field survey it also revealed that about 47% the households are headed by women, which also consolidated the gender equality statement. 53% of the population residing in the directly affected areas comprises of male. 28 boys and 31 girls attend school. Furthermore most of the public gatherings were represented by equal number of female to male.

Photo 3-5 shows the general living standard within the project area

3.4.5.4 Summary Matrix of Social Baseline Indicators

Category	Drujegang	Goshi	Kana	Khebisa	Rangthangling	Trashiding	Average weight (%)
Average HH size	4.00	5.80	4.60	7.90	4	4.60	5.15
Male to female ratio	57	50	57	53	57	57	55.17
% family members staying outside	16%	12%	50%	31%	0%	43%	21.71
% Lhotshampa	0%	33%	67%	0%	0%	50%	21.43
% Ngalong	0%	0%	33%	100%	0%	33%	23.71
% of Khengpa	100%	0%	0%	0%	100%	0%	28.57
% of Sharchogpa	0%	0%	0%	0%	0%	33%	4.71
% HH headed by female	50%	17%	67%	56%	50%	33%	39.00
% of dependency (<18 year old)	23%	47%	14%	52%	23%	57%	30.86
% of dependency (>60 year old)	7%	0%	7%	11%	7%	7%	5.57
% heads working in farm	100%	86%	71%	87%	100%	100%	77.71
% family members working in office	0%	4%	14%	13%	0%	0%	4.43
% male school goers	60%	58%	50%	44%	60%	60%	47.43
% male working heads	54%	45%	71%	46%	54%	33%	43.29
% HH covered by RWSS	0%	67%	33%	3%	0%	0%	14.71
% HH owning 1 storey house	50%	50%	33%	75%	50%	100%	51.14
% HH owning 2 storey house	50%	50%	33%	25%	50%	0%	29.71
% HH owning 3 storey house	0%	0%	0%	0%	0%	0%	0.00
% HH owning cattle	75%	50%	67%	75%	75%	33%	53.57
% HH owning CGI roof	100%	100%	33%	44%	100%	33%	58.57
% HH owning goat	0%	33%	33%	44%	0%	0%	15.71
% HH owning Horse	25%	0%	0%	44%	25%	0%	13.43
% HH living in hut	50%	17%	33%	25%	50%	67%	34.57
% HH owning Talay house	0%	17%	33%	0%	0%	0%	7.14
% HH owning thatched roof	0%	0%	33%	56%	0%	33%	17.43
% HH owning Trad houses	50%	17%	0%	56%	50%	0%	24.71
% HH responded that they are happy	100%	100%	100%	100%	100%	100%	85.71
% HH using firewood for cooking	100%	33%	67%	100%	100%	67%	66.71
% of HH using LPG for cooking	0%	0%	0%	0%	0%	0%	0.00
% HH using Kerosene for lighting	100%	17%	67%	81%	100%	67%	61.71
% HH using pit toilet	100%	100%	100%	100%	100%	67%	81.00
% of HH with water closet	0%	0%	0%	0%	0%	0%	0.00
% income from farm	100%	86%	71%	100%	100%	67%	74.86
% income from salary	0%	5%	14%	0%	0%	0%	2.71
% income from Business	0%	0%	14%	0%	0%	0%	2.00
% income from wage	0%	0%	0%	0%	0%	0%	0.00
% of HH using electricity	0%	83%	0%	0%	0%	0%	11.86
Av. Annual income per HH (Nu.)	14,000	8,666	8,333	10,500	14,000	20,000	10785.57
Av. Cattle owed by the HH	8.00	4.80	2.30	7	8	1.00	4.44
Av. goats owned by a HH	0.00	0.00	1.00	1.71	0	0.00	0.39
Av. Horses owned by the HH	0.00	0.00	0.80	0.00	1.00	0.00	0.26
Av. Land holdings per HH (acre)	8.00	5.00	5.18	3.60	1.35	5.33	4.07

Source: Field Survey 2005

Note: ***HH*** - households, ***Lhotshampa*** - Southern Bhutanese, ***Ngalong*** – People from western Bhutan, ***Khengpa*** – People from Zhemgang (South central Bhutan), ***Sharchop*** – People from eastern Bhutan, ***Talay*** – Traditional Southern Bhutanese house.

4 IMPACT ASSESSMENT AND MITIGATION MEASURES

This chapter discusses the environmental impacts of the DHPP due to its location, design, construction and operation. And also in section 4.6 matrix of negative impacts and mitigation measures have been discussed. Section 4.7 narrates about the environmental benefits and how the project will contribute towards the overall sustainable development of Bhutan.

The General Environmental Impacts of hydropower projects have advantages as well as disadvantages but in most of the cases advantages outweigh the disadvantages. Like in DHPP the main general disadvantages are **-** construction of access roads, transmission towers, and operation of dam & reservoir.

The main advantages are availability of cheap power which supports the economic development and improves the quality of life in the vicinity of project area. Apart from this it provides employment opportunity and better access to roads & other services.

4.1 Impacts due to Project Location

4.1.1 Encroachment on Protected and Conservation Areas

The Dagachhu Hydropower Project does not fall on any national parks or nature reserves or its designated biological corridors. The nearest protected area is Phibsoo Wildlife Sanctuary which is about 30 km crow flight distance.

Hence impacts on protected areas are not relevant.

4.1.2 Dust Pollution

There are two identified quarry sites, one located at located at the confluence of Dagachhu and Punatsangchhu, and the other at the dam site (Alternative 1A). Both the quarries has location advantage for two main reasons: 1) far away from human settlement; and 2) proximity to the river. Some impacts associated to it are dust pollution.

4.1.3 Resettlement of Communities

The impact due to resettlement of community is negligible since none of the house hold is in the inundated areas. Only one household has to be resettled due to construction of transmission line. Hence there is negligible impact on resettlement cost for rehabilitation. Also there would be no impact on present gender equality of the area and it will remain same. In Bhutan the status of women is traditionally high since the land is inherited in the female line and the majority of households are headed by women, it is important that the women are taken in full consultation when it comes to compensation as well as proposed mitigation measures.

4.1.4 Encroachment into historical Areas

The historical Dzong of Dagana and other important monasteries are far away from the project site and none other historical monuments are in the vicinity of project area so there is no impact on historical areas.

4.1.5 Watershed Erosion

The watershed catchment area of proposed reservoir is about 676 km^2 and the watershed is full of dense vegetation with negligible human activity so there would be moderate impact

on the watershed erosion. However the dam site and reservoir area will be exposed to increased potentials for erosion and landslides, primarily through the construction of access roads and fluctuation in reservoir levels.

4.1.6 Impacts of Fish Migration

In the Dagachhu basin no long distance migratory fish species has been identified. Altogether 5 known fish species has been identified, which are native ones. 2 species are seasonal short distance migratory in the same basin. There would be some impact on seasonal migratory native local species in the beginning**.** Hence no serious impacts are anticipated.

4.1.7 Impacts on Land Use

The project is likely to occupy an area of 82.7 hectare (ha), which includes broadleaf, conifer, scrub and agricultural land. Total loss of agricultural land is 31.7 acres (12.6 ha) in 7 Geogs (6 in Dagana and one in Tsirang) for desilting chamber, pressure shaft, switch yard and alignment of access road and transmission line. The household directly affected by loss of agricultural land is 41 and the average landholding size is 4.07 acres. These households are losing about 16.2 % of their land holding and also this household's income largely depends on agriculture, so there would be significant impact on the livelihood of these directly affected households.

The breakdown of agricultural land loss per household is summarized in table 4.1.

Table 4-1 shows the details of agricultural land losses and owners (acre)

No.	Name of HH Head	Geog	Thram No.	Chuzhing	Kamzhing	Tseri	Orchard	Remarks
1	Kado	Drujegang	36	0	0.03	0	0.03	
2	Pema Zangmo	Drujegang	5	0	0	0.03	0.03	
3	Pokthem	Drujegang	31	0	0.03	0	0.03	
4	Lepchu	Drujegang	47	0.03	0	0	0.03	
Total Ag. Land losses (acre)		**Drujegang**		**0.03**	**0.06**	**0.03**	**0.12**	
5	Langa Drukpa	Goshi	NA	0.025	0.61	0	0.00	
6	Sonam Phuntsho	Goshi	457	0.025	1.32	0	0.00	
7	Birman Bomjan	Goshi	NA	0	0.28	0	0.24	
8	Bomlal	Goshi	NA	0	1.03	0	0.14	
9	Pema Dorji	Goshi	NA	0	0.6	0	0.49	
10	Laxman Darjay	Goshi	221	0	0.42	0	0.00	
11	Kumar Darjay	Goshi	NA	0	0.10	0	0.12	
12	Rinchen Chungwa	Goshi	NA	0	0.15	0	0.00	
13	Tshewang Dendup	Goshi	458	1.73	0.00	0	0.05	
Total Ag. Land losses (acre)		**Goshi**		**1.78**	**4.51**	**0.00**	**1.04**	
14	Suk Maya Singer Tamang	Kana	NA	0.00	0	0	0.50	
15	Lhaling Community	Kana	NA	0	2.26	0	0.00	
16	Tshering Choden	Kana	NA	0	0.00	0	0.25	Absentee
17	Purna Kumar Chettri	Kana	266	0.00	1.18	0	0	
Total Ag. Land losses (acre)		**Kana**		**0.00**	**3.44**	**0.00**	**0.75**	
18	Gyem Lham	Khebisa	47	2.60	0.00	0.00	0.00	
19	Lingkarm	Khebisa	94	0	1.20	0.00	0.00	
20	Wangchemo [Late]	Khebisa	147	0.30	0	0	0.00	
21	Lham	Khebisa	160	0.75	0	0.00	0.00	
22	Mindu	Khebisa	365	0	0.16	0.00	0.00	
23	Daw	Khebisa	360	0	0	0.17	0.00	

No.	Name of HH Head	Geog	Thram No.	Chuzhing	Kamzhing	Tseri	Orchard	Remarks
24	Paycha	Khebisa	374	0	1.20	0.00	0.00	
25	Sangay Khundu	Khebisa	35	0.30	0	0.00	0.00	
26	Hangma	Khebisa	139	1.00	0	0.00	0.00	
27	Karchamo	Khebisa	167	0	0	1.60	0.00	
28	Kangsum	Khebisa	147	0.30	0	0.00	0.00	
29	Rinchenmo	Khebisa	374	1.10	0.33	0	0.00	
30	Tashi Dem	Khebisa	372	0	0	0.33	0.00	
31	Oakchumo	Khebisa	52	0	4.20	0	0.00	
32	Tashi Lhamo	Khebisa	146	0.30	0	0	0.00	
33	Lam Migma	Khebisa	106	0	0	1.00	0.00	
34	Lham	Khebisa	370	0	0	1.00	0.00	
35	Gumla Anim	Khebisa	101	0	1.00	0	0.00	
36	Kencho Om	Khebisa	7	0	0	1.00	0.00	
Total Ag. Land losses (acre)		**Khebisa**		**6.65**	**8.09**	**5.10**	0.00	
37	Birkha Bdr Golay	Rangthangling	254	0	0.03	0	0	
38	Sha Bdr Dhal	Rangthangling	202	0	0.03	0	0	
Total Ag. Land losses (acre)				**0**	**0.06**	**0**	**0**	
39	Tulasi Maya Pokhrel	Trashiding	16/156	0.03	0.00	0.00	0.00	
40	Sangay Tshering	Trashiding	plot No38	0.03	0.00	0.00	0.00	
41	Yeshey Tshering[Late]	Trashiding	NA	0.03	0.00	0.00	0.00	Absentee
Total Ag. Land losses (acre)				**0.09**	**0.00**	**0.00**	**0.00**	
Grand Total Ag. Land Losses				**8.55**	**16.16**	**5.13**	**1.91**	**31.75**

Source: Field Survey, 2005

4.1.8 Other Inundation Losses

The project location does not have any valuable mineral resources; hence construction of reservoir would not inundate any mineral and other resources. There would be no impact due to inundation of reservoir areas.

4.1.9 Impact on Local Resources

The local resources account for sand, gravel, boulder, earth, timber, food and vegetables items and resources related to shelter for the construction labourers. Sand, gravel, timber and boulder may be found in the adjacent area. As there are many rivers flowing by and quarrying of these constructions material does not diminish the quantity as they are replenished by the nature every year. Food and vegetable items to be consumed by the labourers during construction phase of project shall be brought in excess by the local shops for consumption thus increasing the commercial activity in the area. Therefore there would not be any pressure on the local market. The tents, sheds etc. required for the camps shall be brought by the contractor from bigger town and thus has no effect on the local market. Hence the impact is positive due to increased commercial activities in the area.

Furthermore, the supply of timber for commercial use is controlled through the established system of timber trading. As usual timber for commercial construction is supplied from the saw-millers, who in turn gets raw logs supplied from the Bhutan Forestry Corporation Limited (FDLC), the state owned corporation. Therefore, the project won't create any resources use competition with the locals. The competition for non-timber forest products use from the presence of labours is not seen to be significant.

4.1.10 Wildlife

Biological survey of the project area reveals 17 species of mammals, 57 species of birds, 6 reptiles & amphibians and 9 invertebrates. Table below provides list of protected species by Bhutanese Law and International Union for Conservation of Nature (IUCN).

Table 4-2: Protected wildlife in the project area

Species Name	English common name	Type	Status as per (FNCA, 1995)	Status as per IUCN
Aceros nipalensis	Rufous-necked Hornbill	Bird	Protected	Vulnerable
Buceros bicornis	Great Hornbill	Bird	Unprotected	Near threatened
Capricornis sumatraensis	Serow	Mammalian	Unprotected	Vulnerable
Cuon alpinus	Asiatic Wild Dog	Mammalian	Unprotected	Endangered
Macaca assamensis	Assam Macaque	Mammalian	Unprotected	Vulnerable
Presbytis geei	Golden Langur	Mammalian	Protected	Endangered
Panthera Pardus	Leopard	Mammalian	Protected	Unspecified
Felis Bengalensis	Leopard Cat	Mammalian	Protected	Unspecified

Source: Field Survey, 2005, FNCA 1995 and 2004 IUCN Red list of Threatened Species

As was illustrated in the above table, four species existing in the project area are protected by the Forest and Nature Conservation Act 1995. As per IUCN categorization, three species fall under vulnerable category, one near threatened and two under endangered category.

4.2 Impacts related to Design

4.2.1 Water Rights

The total numbers of directly and indirectly affected households are 44 and 553 respectively and during field survey for EA assessment extensive public consultation has been made in these affected villages and the response is overwhelming in the favour of the project. Therefore no impacts are foreseen on water rights.

Dagana is mainly drained by Dagachhu. Various tributaries of Dagachhu are tapped by local community for irrigation and drinking water purposes. The only existing hydropower project in Dagana is Darachhu a tributary of Dagachhu about 6 km upstream of proposed plant. Hence no impact or conflict is foreseen on water use.

However proper planning in consultation with the community would be beneficial in multi use of reservoir for agriculture and fisheries.

4.2.2 Road Design

The project road includes two major access roads. One to the powerhouse including switchyard, adit and surge shaft while the other to the damsite.

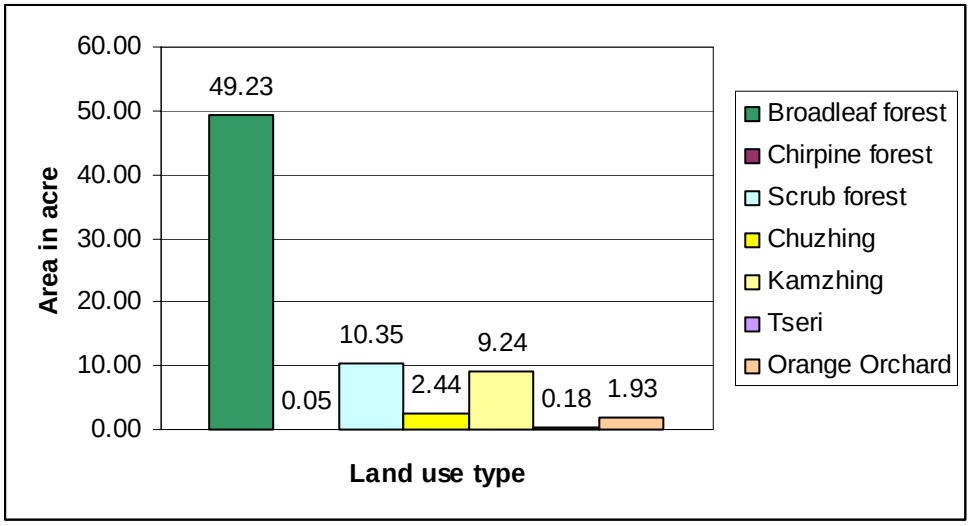
The access road to the powerhouse, switchyard, surge shaft and adit originates from Balaygang some 51km from Sunkosh – Dagana Dzongkhag highway. From the takeoff, the proposed road descends down to the riverbed near Churmuthang after making 10 zigs. There three crossings over Dagachhu –for switchyard, powerhouse, and to the surge shaft

or adit. Hence, the construction of one major bridge (40 m long) over Dagachhu will be required.

The access road for the damsite takes off near Chenathang some 62 km from the Sunkosh – Dagana Dzongkhag highway. From the takeoff the road descends after making 6 zigs till the valley. One stream and one river crossing is required along this access road.

All access roads together make a total length of approx. 19.8 km. This alignment will have impact on forest, wildlife and agriculture land. It is estimated that alignment will take up 12.3 ha of agriculture and 24 ha of forest land. However, the advantage is that, this alignment make uses of existing road infrastructure which reduces the need to construct new road by almost 6 km through fragile valley slopes which are potentially unstable. The type of land affected by construction of road is provided in graphic form in figure 4.1.

Figure 4-1 shows the type of land affected by road construction



Source: Field Survey, 2005

The details of impacts and mitigation measures are provided in Annex 9.

4.2.3 Dam (Weir)

The major biological impacts associated with the project will be the change in the lean season riverine aquatic habitat and ecosystem. There will be significant changes in the lean season water level, flow regime and sediment deposition patterns, which together will affect invertebrates as well as fish mobility and the conditions of natural fish spawning and nursery beds. The dam itself will be a barrier for the long distance migratory fish population.

And also the downstream migratory fishes may be lost if they are drawn in to the hydropower plant intake tunnel. The impact would be low since the Dagachhu basin does not have long distance migratory fish species and if further investigations confirm the presence of long distance migratory fish species then installation of fish screens/ladders/lift would be essential.

4.2.4 Power Transmission Line

About 19 km transmission line will be built from the switchyard in Churmuthang, Dagana to a substation at Dhajey, Tsirang. The 220 kV line will have Right of Way (ROW) of 40 – 50 m and width 3-4 towers per km line.

The transmission line starts from Churmuthang switchyard, crosses the Dagachhu and passes mostly through forest area below the villages of Goshijug, Tsendagangjug and

Gangzurjug before it reaches Shamdalay village under Trashiding geog. About 2 km route passes through agriculture land of Shamdalay before crossing over Dagachhu towards Pangserpo village under Drujegang geog.

Toward Pangserpo village, the route passes over two patches of agriculture land before crossing Chomchengang ridge from where 3.4 km route descend towards Punatsangchhu valley. On route from Chomchengang through a Pangserpo village, the route mostly passes the agricultural land before it reaches bottom of valley.

After crossing the Puntsangchhu and Ratekholachhu, about 2.5 km route ascend through a dense broadleaf forest area which is steep and rugged before reaching Sauni village. From Sauni the route continues to ascend to Dhajey through some agricultural field but again mostly through steep broadleaf forested area. Before connecting to substation at Dhajey, the route goes through a settlement and cultivated area.

The main impact of transmission line is associated with the crossing of 2.5 km route through a dense forest area which is steep and rugged. This line and corridor will impact forestry ecosystem. During implementation phase, temporary impacts like increased traffic, access roads or paths to the tower site may cause erosion.

Table 4-3 illustrates the transmission line details

Sl. No	Description	Details
1	Voltage level	220kV
2	Tapping point	Churmuthang (Powerhouse access)
3	Termination point	Dhajey
4	Estimated cost of the project	NU 146.2 Million
5	Percentage for environmental cost	2%
6	Total No. of Towers	65
7	Excavated Materials (m^3)	3000
8	Time to complete	1year

The detail assessment of impacts and mitigation measures are provided in **Annex 10**.

4.3 Impacts during Construction

4.3.1 Soil Excavation

The project during the construction will have large scale excavation activities at many places and the approximate quantity would be in the range of 520,000 cum. Excavation details as per project components are provided Table 4-4.

Table 4-4 illustrates the soil excavation details

Item	Excavation Volume (m^3)
Tunnel and adits	190, 000
Pressure shaft and surge shaft	23, 500
Powerhouse + access	54, 500
Tailrace tunnel	17, 500
Desilting Chamber	155, 000
Weir	50, 000
Other (connect. desilt., access area powerh.)	31,500
Total	**522,000**

Source: Bernard Engineers, 2006

Apart from this there would be excavation for access roads. And due to large scale excavation, areas prone to erosion and landslides will be created. Mechanical excavation causes more damage than manual excavation. The surface runoff will be substantially increased and will lead to downstream erosion. Also increased economic activity associated with the project will most likely increase the traffic and the existing infrastructure without proper extension will cause more erosion. The excavation has a significant impact and needs to be addressed on priority basis. The spoil deposition is a major activity and disposal sites have to be identified close to the excavation sites so that there would not be any major transportation involved for carrying it to disposal sites.

4.3.2 Construction Hazards

4.3.2.1 Safety of Workers

It mainly relates to the health, safety and wellbeing of the construction group. There is bound to be some or other type of accident during construction despite proper safety measures in place. The construction labourers are the most vulnerable groups in terms of minor injuries and other fatal accidents. The excavation for access road and other excavation works are major activity and may invite accidents since the terrain is difficult in some part.

4.3.2.2 Impacts resulting due to Construction

Climate: No adverse effects are anticipated.

Air Quality: Air quality impacts due to the construction of the DHPP, would be limited and localized to the different construction sites, transport routes and camps. Construction activities such as blasting, quarrying, excavation, site clearing and emission from trucks and construction equipment will generate airborne dust and particulate matter. These may lead to impacts on crops, animals, villages and nearby houses. Another potential source of air pollution will be from household cooking smoke in different camps.

Noise: Noise disturbance is foreseen to the people living near to the construction areas and roads due to the construction work, site clearing, excavation, blasting, quarrying, spoil dumping etc.

Water resources and hydrology: No adverse effects on water resources or hydrology are anticipated during construction, except for some minor diversion at the dam site and tailrace during construction of the various structures.

Water Quality: construction activities will generally increase the erosion load to the rivers within the project area. During the construction the population will increase, both due to the project itself and associated secondary development. The increase in population will increase the pollution load to the Dagachhu, giving negative impact on the water quality. At the damsite a temporary labour camp will be established, which may impact the water quality negatively, particularly by discharge of untreated sanitary effluents, which can cause health risk in down stream areas. The river furthermore may be affected by discharges of fuel, oil and other chemicals used during construction. During clearing of the reservoir area sediment load will occur. The pH of water may become high due to use of ammonium nitrate as blasting material.

4.3.2.3 Water Borne Diseases

There is a likelihood of spreading of water borne diseases due to mixing of untreated sanitary effluent into the stream. This can well affect the down stream areas where people

are using drinking water from the stream and the major affect would be on the population living in the vicinity of labour camps. The common water related diseases are Diarrhoea, Dysentery, Worms, fever and Malaria. The occurrence of malaria and diarrhoea would be common and the primary cause is unsanitary condition as well as use of untreated water for drinking purposes. During construction there would be many ditches that will act as the breeding ground for mosquitoes and also filthy atmosphere near to the make shift toilets becomes habitat for flies, which are prominent vectors that will carry the disease causing pathogens. The pathogens mainly consist of *salmonella typhae, shigella* and other bacteria as well as the eggs of *helminethes and worms.*

4.3.2.4 Solid and liquid Wastes

There would be wastes relating to packaging, lubrication of oil and grease from the construction equipment, and due to construction. These wastes if not managed properly could deteriorate surrounding environment mainly the land and water pollution thereby affecting health of both human as well as animals. These wastes need proper management and monitoring.

4.3.3 Other Impacts

4.3.3.1 Employment Generation Skilled/Unskilled

More than 1500 unskilled and skilled, and about 200 for staff and support system jobs would be created per day during the construction phase. Some of these jobs (50-100) will be retained during operation and maintenance phase on long term basis. The local and peripheral people can have an opportunity to work in the project and earn their livelihood. At the same time they can improve their workmanship and skills in construction sector. These jobs provide some opportunity to directly & indirectly affected households .The affected households must be offered opportunity on a preferential basis against the migrant or outside workers. The long term jobs should be first offered to the directly affected households after the enhancement of necessary skills during construction phase. Apart from this indirect employment will be generated in commercial establishments due to increased demand and expected availability of electricity. The magnitude of the impact is medium and positive.

4.3.3.2 Fire outbreaks from the Camps

There is a possibility of fire outbreaks from the various labour camps in the periphery of project site due to use of fire wood as a cooking medium and also from the mishandling of explosives. The outbreaks can destroy human lives; belongings as well as it may enter in to the forest area. If the fire enters in to the forest area then it becomes unmanageable. Hence the impact is negative and needs attention in the construction phase.

4.3.3.3 Poaching of Wildlife by Labours

The labourers may engage in poaching wildlife for food, feathers, and bones. This is more probable along the power transmission line and access roads.

4.3.3.4 Socio-cultural Impacts on locals due to Presence of Foreign Labours

Cultural Invasion: The extra requirement of labour would be met from India and few from the adjoining rural areas. The labourers from India can have little impact on the prevailing culture. It should not be a big impact, as the credible system is in good place.

Social values: The social values, norms and tradition are not established overnight. It takes centuries to establish, adopt and promote the social values. But behavioural change can be brought about in shorter spans of time also. This project is bound to bring about a positive change due to availability of electricity.

The experiences elsewhere also demonstrate depletion of forest resources within the vicinity of labour camps. This impact needs to be mitigated.

4.4 Impacts during Project Operation

4.4.1 Impacts due to Downstream Flow Variation

The Dagachhu stream flow between the Dam and Churachhu measuring some 6.6 km will be significantly reduced during the lean season. The lean season goes for almost nine months. There would be a minimum flow of 1.40m^3/s in this stretch that will sustain aquatic life, riparian forests and other wildlife therein. Reduced flows will enhance the possibilities for people and animals to cross the river. Sudden release can lead to loss of life. The ecological flow, which corresponds to minimum flow during lean season, is derived based on the experiences applied for Switzerland, France, and Austria where similar environmental aspects exist. As a general rule from the practices in the Alpine regions in Austria (Tirol), minimum flow estimations lie between 2-3 L/S/km^2. When this is applied to Dagachhu catchment, which has an area of 683km^2, the calculated flow corresponds to 1.4m^3/s.

Another rule used by the Swiss for ecological flow calculations (Mathey's formula) I to calculate ecological flow as a function of Discharge (Q_{347}). If this formula is applied to Dagachhu catchment, it would result in a flow of 2.11m^3/S. Table 4.5 provided below summarises different empirical formulae and rules used in Europe to calculate ecological flows and they vary from country to another.

Table 4-5 Ecological flow computations for Dagachhu catchment using different empirical formulae

Country	Rules for determining Ecological flow (Q_{min})	Applied for Dagachhu Catchment
Switzerland	Mathey's formula (ca. 20 % of Q_{347})	$Q_{min = 2.11\ m3/S}$
France	1/40 – 1/10 of Mean Annual Flow	$Q_{min = 0.69 – 2.8}$ m^3/s
Austria	2 – 3 L/s/km^2	$Q_{min = 1.4}$ – 2.0 m^3/s

Source: Bernard Engineers, 2006

The recommended minimum flow of 1.4m^3/s is well within the range of values listed in Table 4.6. This flow is sufficient to maintain the water quality and the river biozones with its ecological functionality. Another factor that can be taken into consideration is the presence of number of inflow streams down stream of hydropower plant, which could enhance the flow and some are perennial.

Downstream the tailrace the stream flow in the Dagachhu will undergo fluctuations due to the plant operation. Increasing the load on all two units from zero to maximum (114 MW) will increase the stream flow substantially downstream the tailrace. At the end of the peaking period there will be similar drop in the stream flow and hence the water level. Such sudden and heavy changes in water level can lead to serious impacts on activities taking place along the riverbank and even accidents can occur.

Table 4-6 shows the Powerhouse discharge in m3/s

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$Q_{average}$	12.80	11.00	9.83	9.74	11.71	29.61	59.28	57.30	57.24	35.13	23.09	16.42

To Powerhouse	11.40	9.60	8.43	8.34	10.31	28.21	45.00	45.00	45.00	33.73	21.69	15.02
Remaining	1.40	1.40	1.40	1.40	1.40	1.40	14.28	12.30	12.24	1.40	1.40	1.40

Source: Inception Report on Feasibility Study, DHPP, 2005

It can also affects the quality of water due to sudden surge and drop in stream flow downstream of tailrace and also due to trapping of nutrients in reservoir.

Sudden surge and drop of low turbid water may also fuel the erosion of downstream banks and river beds.

4.4.2 Problems in Reservoir Management

The dam site and reservoir area will be exposed to increased risk for erosion and land slides, primarily through the construction of access road and fluctuation in reservoir levels. Removal of vegetation along the shorelines of the reservoir will make the sediments less stable. There are however no significant hazard for landslides in the reservoir area as a result of water filling. Changes in pond level may cause development of slides along the shores. But due to moderate variation in water level the extent of slides would also deemed to be moderate.

4.4.3 Downstream Water Quality

Dam & Reservoir:

The water quality will be same as of upstream catchments. No major changes in water quality are expected to take place in reservoir itself. Inundation of vegetation is not expected to seriously cause anaerobic decomposition in the reservoir. The reservoir is not expected to stratify.

Downstream Dam- Churachhu:

The diversion of the water will reduce the flow in the river downstream of the dam up to Churachhu. In this zone due to less dilution ability, water will be more polluted than upstream and will not be suitable for drinking. Likewise the reduction in flow will reduce the biological production in the river.

Powerhouse-Tailrace:

Super-saturation of nitrogen and other gases will kill fishes. The permanent colony may affect this section of river due to leakage of waste water, fuel and oil

Downstream tailrace: Any changes in water quality caused by the upstream activities will also be reflected downstream of the tailrace.

Trapping of nutrients in reservoir may cause deficiency in water of essential minerals for downstream user. Water in the reservoir will be replaced at high rate so the degradation of water quality by eutrophication would be minimized.

4.4.4 Insect Vector Disease Hazards

Increases in waterside provide favourable habitats for the growth of vectors of various diseases and they are likely to increase the incidence of water related diseases including malaria. Preferred habitats for anopheline mosquitoes (malaria vectors) are stagnant or slow moving fresh water open to sunshine.

4.5 Mitigation Measures

Unless otherwise quoted, the mitigation measures provided in the following sections are basically from the consultants' perspective. Wherever mitigation measures are taken from the national laws it will be mentioned clearly.

The environmental mitigation measures are applied to abate or reduce the adversity of the negative environmental impacts and to augment the beneficial ones. But, generally the mitigation measures are applied to the negative impacts. It helps reduce the degree of adversity of the negative impacts. The mitigation measures can be both engineering and non-engineering. The engineering mitigation measures are generally included in the project design itself. These are also laid down in the code of practices, sector guidelines, regulations, specifications, terms and conditions of the contract and by-laws.

4.5.1 Project Location

4.5.1.1 Watershed Erosion

The watershed erosion is generally expected while excavating the area and also due to deforestation in the catchment area. Watershed erosion near the construction site is a short term phenomena and could be reversed by simultaneous execution of engineering and biological measures but the soil erosion/land slides due to deforestation is a long term serious concern and to abate this strict policy measures are required. Environmental measures should be also planned for protecting/re-charging catchment area for sustaining & improving the present yield. The suggested mitigation measures for minimizing the soil erosion/ land slides are as following:

- Excavation should be avoided during rainy days;
- Entire catchment area should be notified as watershed reserve forest;
- Extraction of trees should be banned in the catchment area;
- Animal grazing should not be allowed;
- Mining activities if any in the catchment should be banned;
- Artificial recharging of catchment area by rain water harvesting should be adopted;
- Intensive awareness campaign should be initiated by DHPP Authority to abate forest depletion and prevent pollution to the water sources, such as through street play and local songs to depict the importance of preserving natural resources;
- All natural small streams feeding the main stream should be cleaned before onset of rainy season;
- Environmental action network program to be started in nearby schools for assessment, awareness and action for environmental related activities like water, solid waste management, tree plantation, campaign for cleaning of water sources etc**;**
- Replication of other best practices used in other countries to conserve natural resources.

DHPP Authority to work innovatively and enhance their effectiveness by concentrating on following:

a. Respect of the natural environment
b. Inducement of technology with purpose
c. Optimization of key resources
d. Maintenance scale and capacity
e. Adoption of a systems approach

f. Responsiveness and pro-activeness
g. Value for diversity
h. Participatory planning and management for conservation of natural resources and abatement of land, air and water pollution.
i. Cultural and religious examples to be cited in favor of conservation of natural resources.

Engineering treatment: Stone masonry check dams, dry stone masonry in wire crates, RR stone masonry in 1:4 or 1:6, mix of dry stone & RR stone masonry, retaining walls. Props and supports at different places, construction of path way for maintenance and safety.

Biological methods: plantation of bushes and shrubs to check the land erosion.

These measures, if implemented religiously, will address both current environmental degradations and the long term problem of the ecology and environment concerning the watershed of DHPP and its likely effect on the sustainability of these natural resources.

4.5.1.2 Air Pollution

The only national standards for air as provided in the environmental standards developed by the NEC 2004 are: (1) emission standard for industry at stack; and (2) motor vehicles emission standard. The sources of air pollution in this case could mainly be related to quarries and crushing plants for which the suggested mitigation measures are: 1) As far as possible the quarries should be centralized; 2) water should be sprayed at regular interval over stockpiles to subside dust; and 3) Installation of air filters for the crushing plants should be enforced strictly.

4.5.1.3 Fish Migration

Change in dry season water levels, flow regime and sediment deposition pattern will affect fish mobility and the conditions of natural fish spawning. The dam would be the barrier for long distance migratory fish population.

The reservoir and river diversions will also have some impacts on fish migration but the initial investigations shows that there are only native local species and some of which are short distance seasonal migratory in nature. No long distance migratory fish species has been identified so during wet season it is expected that migration still takes place among short distance local fish species. If further investigations reveal long distance migratory fish species then a fish farm is recommended for sustenance of these species.

4.5.1.4 Agriculture

The 41 affected households are losing about 16.2 % of their landholding and this will have some impact on their living conditions. However the construction period of the project will be about 5 years and this will present these affected households for employment opportunities and also to pick up some other skills other than farming. These skills in long term will help them to secure employment and help them to improve their living conditions. Although the Land Act 1979 provides owners with compensatory rights as per the revised land compensation rates 1996, however, the cash compensation per acre does not exceed Nu. 35,000 per acre, which is relatively very small compared to the livelihood served by the land. Therefore, it is suggested that a priority should be given to land replacement so that the livelihood of these households does not deteriorate. Apart from this the DHPP authority may consider giving permanent jobs in the operation & maintenance period to one family member of directly affected households in line with the developed skill during the

construction phase. The detail of Land use Losses and indicative cost of compensation in Nu is provided in table 4.7.

Table 4-7 Details of Land Use Losses to the Project and indicative cost of compensation in Ngultrums

Ag. Land Use Category lost (acre)	Druje-gang Geog	Goshi Geog	Kana Geog	Khebisa Geog	Rangthan-gling Geog	Trashi-ding Geog	Total Losses (acre)	Rate of Comp. (Nu.)	Total comp. (Nu.)
Chuzhing	0.03	2.02	0	6.65	0	0.79	9.49	35,000	332,150.00
Kamzhing	0.06	3.61	3.44	8.09	0.06	0	15.26	20,000	305,200.00
Tseri	0.03	0	0	5.1	0	0	5.13	5,000	25,650.00
Total Losses of Land	0.12	1.05	3.44	19.84	0.06	0.79	25.3		
Orchard (number of trees)	12	210	220	0	0	0	442	589	260,338.00
Total Land and Orchard Compensation in Nu.									**923,338.00**

Source: Field Survey, 2005

Note: The Compensation rate is as per the prevailing Land Compensation Rate of RGOB, 1996.

4.5.1.5 Wildlife

The Rofuos necked hornbill (globally threatened bird species), and two mammalian species viz. leopard and leopard cat that exist in the project area are protected by the Forest and Nature Act 1995 as was listed in schedule I of the Act.

The survival of Rofous-necked hornbill (globally threatened bird) primarily depends on matured fruit bearing trees and tall trees found in the vicinity of project area. Therefore it is suggested that no fruit bearing trees should be cut in particular and tall trees in general.

For two protected mammals (leopard & leopard cat), there should be strict monitoring of encroachment into their prime habitats. The prime habitats of these mammals are thick forest, one up stream of reservoir and one near to the adit area. Labor camps should not be located near to these habitats.

4.5.2 Project Location

4.5.2.1 Road Design

All access roads together make a total length of approx. 19.8 km. This alignment will have impact on forest, wildlife and agriculture land. It is estimated that alignment will take up 12.3 ha of agriculture and 24 ha of forest land. However, the advantage is that, this alignment make uses of existing road infrastructure which reduces the need to construct new road by almost 9 km through a fragile valley slopes which are potentially unstable

Alignment should be such that it should not disturb the settlements and avoid cutting mature trees to the minimum. The construction should adopt environment friendly construct technique and prevent spilling of spoil downhill as much as possible.

Erosion control structures such as check dams and catch water drains should be constructed along with application of bioengineering techniques such as live stacking and sowing of seeds. Salvage soil to be used in reclamation land, biological treatment of disturbed slopes with stabilizing plant species. Adequate provision of storm run off and drainage in affected sections.

Dust control by sprinkling of water, scheduling of construction activities with local farming cycle so that local people can take employment.

4.5.2.2 Fish Screens

Construction of fish ladder is not recommended at present, but it would be considered later if further investigations reveal long distance migratory fish species of importance. It is expected that except lean season migration still can take place.

4.5.2.3 Transmission Line

About 19 km transmission line will be built from the switchyard in Churmuthang, Dagana to a substation at Dhajey, Tsirang. The 220 kV line will have Right of Way (ROW) of 40 – 50 m and width 3-4 towers per km line.

From the assessment although it is likely that one house at Dhajay Village will probably need relocation in the whole transmission line stretch, it should be attempted during construction period to save this house. In the event of worst circumstances, resettlement for the household should be done. Construction of pathways should be minimized. A path of 40-50 m will be selectively cut to remove obstructing vegetation. Trees and shrubs with height below 3 m will be left untouched. No uprooting of tree will be done. Central corridor and then left to grow back to 3 m height. No maintenance of clear zone between towers is required thus minimizing the long term clear zones and facilitate rapid recovery of cleared path.

4.5.3 Construction

4.5.3.1 Soil Excavation

Disposal of spoil material to the designated place mainly excavated from tunnel, powerhouse and access road. The excavated material is disposed in benching and on completion topsoil is added to enable vegetation growth.

Reuse of excavated material to maximum possible extent in other civil structures to reduce disposal quantity. Disposal sites have already been identified near the dam site, open desilting chamber, side adit, close to power house and below switch yard. The excavated spoil will be laid at the designated site in benching to provide aesthetic look and slope stability. Apart from this the disposal of spoil will be all along the access road supported by check dams/gabion walls so that spoil material does not spills in to the river and in the long run this will act as a bank to the river. Provision of toe protection of the retaining structure should be done. Storm drainage and run off control provisions should also be provided in disposal areas.

Afforestation and greening of slopes using locally available grasses should be implemented on the dumped materials after evening the surface.

4.5.3.2 Occupational Health and Safety

The occupational health of the labourers and others are generally threatened during construction phase and mostly at sites. The following mitigation measures are suggested to minimize the impact:

- First aid kits must be kept at each construction site.
- Proper construction gears like; helmet, gloves, goggles, masks, aprons etc. should be provided as per the need by the contractor.
- Emergency evacuation should be arranged by the contractor;
- Proper safety/danger signboards should be placed at sites of risk and vulnerability.

- Water supply, Pit latrines and proper bathing facilities should be provided to the workers by the contractor at the construction camps to ensure proper health of the workers.
- Fences and/or barricade should be erected at the places of risky construction works.
- Prevention of the workers from mosquito and leeches and helminthes should be given top priority by the contractor.
- The contract clause should spell above requirements under Occupational Health and Safety Heading.

4.5.3.3 Social Security

In Bhutan medical facilities are free for all including non-nationals. Furthermore, if the illness cannot be treated within the country it will be referred overseas at free of cost. Therefore medical care and expenses is not a concern for any people in Bhutan. Currently, under the royal decree a health trust fund was establish and the idea was to consolidate financial footings so that King's vision of free medical care for all at all times to come will be materialize ultimately. The sources from the Health Ministry said that the trust fund is reaching its target of US$ 20 Million.

In the event of accidents there are established life insurance schemes. All citizens are insured compulsorily under the rural life insurance scheme. For the civil servants and corporations there are established life insurance scheme based upon the job classifications/positions.

4.5.3.4 Air quality and Noise

A localized air and noise pollution may occur due to blasting, excavation, drilling, crushing and from other construction operations during the construction period. The impact can be reduced by applying the following mitigation measures:

Water should be regularly sprinkled on the dry spoil deposits to reduce the particulate pollution.
Cyclone filters to be installed at crusher location.
Proper maintenance of all construction vehicles and equipments.
Blasting operations should be limited to day time with advanced notice to local community.

4.5.3.5 Water Quality

Following measures should be taken to ensure that water quality should not worsen.

Adequate number of pit latrines to be provided at each labor camp.
Sewage should not be disposed directly in to the river.
Proper drainage system and soak pits to be constructed at labor camps.
Muddy water generated in tunnel digging should not directly enter the river.
Settling tanks to be constructed at dam site and power house site for collecting drained water from the crusher and also to collect muddy water from tunneling.
Sludge from settling tanks to be disposed off at 15 days interval at the solid waste site.
Regular monitoring of pH to be done.
Controlled use of ammonium nitrate in the blasting operation otherwise the pH may become high.
Extra precaution to be taken so that oil, grease, fuel and other chemicals does not spills in to the river.

4.5.3.6 Solid and Liquid Waste

Different type of wastes will be generated during construction and operation of the project. The waste products can be broadly classified into two – solid and liquid wastes. Solid wastes include papers and cardboard, organic materials, metals, rubber, plastics, glass, auto batteries, building rubbles and wood wastes. While liquid waste refers mainly to exhaust engine oil from the construction machineries and other transports vehicles. Both the wastes pollute land and water, thereby affecting both human as well as the animal lives. In order to mitigate such impacts following measures should be taken:

Designing and siting the proper landfill site which is away from the human settlements, water bodies and the critical habitats. This must be carried out during detailed project report (DPR) phase.
Solid wastes such as paper, cardboard, organic materials, will be disposed in the designated landfill site.
Wastes of metal, rubber, plastics and auto batteries are to be stored and reprocessed or disposed of at designated place.
Wood waste should be used for fuel and fencing works.
Saw dust to be used for soaking up hazardous liquid wastes such as spent engine oils
Liquid wastes particularly engine oils to be collected, stored and transported to recycling site or disposed of to designated site.

4.5.3.7 Water borne diseases

To curb the spread of water borne diseases following measures should be taken:

Drinking water quality should be regularly checked for fecal coliform in the water.
Drinking water to be tapped up stream of the settlement so that there will be less chances of contamination of water.
Proper and regular chlorination to be done so that residual chlorine should not be less than 0.3 ppm.
Water should be treated before supply by constructing slow sand filter.
Awareness program should be launched for using only boiled water for drinking.
All contractors should be required to prepare a health and safety plan, which should be approved by the project competent authority. This should be made part of the contract clause.

4.5.3.8 Fire Outbreaks

To prevent fire outbreaks,

Fire fighting equipment and trained firefighters should be present at all sites.
All explosives should be kept, transported and used with care and as Ministry of Home and Cultural Affairs Rules and Regulation on Explosives.
All labor camps should have common mess facility using cooking gas.
For cooking purposes fuel wood to be discouraged.
Rescue and evacuation plan should be developed.

4.5.3.9 Poaching of wild life by labourers

Enforcement of forest rules and regulations to prevent illegal felling of trees, illegal fishing and hunting and encroachment of forest areas.
For curbing poaching of wild life by work force, attention to be given to transmission line workers because the conditions are much easier for them to hunt.

Check post may be installed at labor camps to prevent poaching.
1 or 2 check posts to be installed along transmission line route also.

4.5.3.10 Depletion of forest and water resources

Due to presence of large number of labours, there are chances of depleting camp surrounding forest resources. To prevent such things, the contractor(s) should be made mandatory to provide fuel for their labours, both for cooking and lighting. This can be implemented by including the item in the contract clause.

Similarly, to prevent water pollution, all labour camps should have adequate toilet each camp equipped with garbage disposal pits. Open defecation should be monitored. This item should also be included in the contract clause to make it binding on the contractor's side.

4.5.3.11 Cultural Invasion

It mainly occurs during the construction phase of the project due to the mixing of the migrant labourers with the local people. The following mitigation measures should be followed to minimize the impact:

Separate labor camps should be constructed for the migrant laborers.
The construction schedule should be followed strictly to avoid larger stay of the migrant laborers.
Proper trainings should be provided to the laborers by the contractor regarding the local religion, culture, tradition, life style etc. so that they became aware of the local sensitivities.

4.5.3.12 Restoration of Camps and Quarry Sites

Generally the contractors used to have a tendency of leaving the camps and quarry sites unheeded after the construction is over. To prevent from such doing, the restoration of camps and quarries should be specifically brought into the contract document as a contract clause. For example no security deposit will be released unless restoration is carried out. The type of restoration include clean up, levelling of surfaces and plantation vegetation.

4.5.4 Project Operation

4.5.4.1 Downstream Flow Variation

Smooth increase and decrease in the stream flow from power station outlet.
Fixed start and stop procedure to be adopted for smooth increase and decrease in down stream flow.
Minimum compensation flow (environmental flow) of 5% of the discharge should be maintained for wildlife, fish, aquatic fauna, riparian forest and for livestock.
Restore the river's flow as closely as possible to its natural pattern of variability.

4.5.4.2 Reservoir Management

Operation of the dam and the reservoir during lean flow season and during the monsoon season is of importance.

To curb Localized increase in turbidity of river water from spillway releases and resulting potential scour effects on the natural river beds, proper design of energy dissipaters should be done to limit it.
Emergency warning systems to be installed for public safety concerns from emergency spillway release or gate opening during dry season when gates are normally closed or reservoir is filling.

Wide community consultations should be accorded top priority for using reservoir water for agriculture and drinking water so that there would be no conflict on using reservoir water for other purposes.
For maintaining minimum compensation flow in dry season if need be reservoir water should be used.
Removal of vegetation along the shorelines of the reservoir will make the sediments less stable and also changes in pond level may cause development of slides along the shores. To counter this shoreline of reservoir should be thickly vegetated.

4.5.4.3 Down Stream Water Quality

Downstream Dam-Tailrace:

- Minimum compensation flow to be maintained for increased dilution ability.

Powerhouse-Tailrace: The permanent colony should not discharge untreated sanitary waste, waste water, fuel, oil and construction chemicals should not be directly discharged in to the river.
Downstream tailrace: Any changes in water quality caused by the upstream activities will also be reflected downstream of the tailrace.
Water in reservoir should be replaced at high rate to minimize the degradation of water by eutrophication.

4.5.4.4 Insects Vector Disease Hazards

Malaria control measures should be taken to destroy their habitats and interrupt the lifecycle by physical, biological or chemical means.
First aid post should be installed at the construction sites.
Dispensaries should also be near the sites.
Development of proper surveillance system to be followed by mosquito control activities and health extension activities.
Regular sprays of insecticides in the areas where water is likely to be stagnant to prevent the growth of malaria larvae.
Frequency of monitoring should be fortnightly.

4.6 Matrix of Negative Impacts and Mitigation Measures

The matrix of negative Impacts have predicted in terms of their Magnitude, Extent, Duration and Permanency (Reversible/ Irreversible).

The **Magnitude** of the impact has been rated as High (H), Medium (M), Low (L) as per the severity of the impact.

The **Extent** of the impact has been ranked as Site Specific (S), Local (L) and Regional (R) as per the area it influences.

The **Duration** of the impact has been categorized as Long Term (L), Medium Term (M) and Short Term (S) as per the longevity of the impact.

The impact has been termed as (R) for **Reversible** and (I) for **Irreversible** owing to the permanency of the impact.

After assigning the attributes to all the possible impacts in terms of magnitude, extent, duration and reversible/irreversible; mitigation measures are defined separately for each negative impacts. The project has been recommended for construction because the beneficial impacts have by far outweighed the adverse ones.

Table 4-8 presents the Matrix of Negative Impacts

S. No.	Negative Impacts	Magnitude	Duration	Extent	Reversibility	Overall Impact
1.	**Project Location**					
1.1	Watershed Erosion	M	L	L	R	Medium negative
1.2	Fish Migration	L	M	S	R	Low negative
1.3	Agriculture	M	L	L	I	Medium Negative
1.4	Wildlife	L	M	L	R	Low negative
2.	**Design**					
2.1	Road Design	H	L	L	I	High Negative
2.2	Fish Migration	L	S	S	R	Low negative
2.3	Transmission Line	H	L	L	I	High positive
3	**Construction**					
3.1	Soil Excavation	M	M	S	R	Medium negative
3.2	Safety of Workers	L	S	S	R	Low negative
3.3	Air Quality & Noise	L	S	S	R	Low negative
3.4	Water Quality	M	L	L	R	Medium Negative
3.5	Water Borne Diseases	M	M	L	R	Medium Negative
3.6	Fire Outbreaks	L	S	S	I	Low negative
3.7	Pouching of Wild life	L	S	S	R	Low negative
3.8	Cultural Invasion	L	S	S	R	Low negative
4.	**Operation**					
4.1	Down Stream Flow Variation	M	L	L	I	Medium Negative
4.2	Reservoir Management	L	M	S	R	Low negative
4.3	Down Stream Water Quality	M	L	L	R	Medium Negative
4.4	Insect Vector Disease Hazard	L	M	L	R	Low negative

Note: Magnitude: *L=Low* *M=Medium* *H=High*
Duration: *S=Short Term* *M=Medium Term* *L=Long Term*
Extent: *S=Site Specific* *L=Local* *R=Regional*
Reversibility: *R=Reversible* *I=Irreversible*

4.7 Environmental Benefits & Sustainability

4.7.1 Power Benefits

The first hydropower project in Bhutan, with a capacity of 360 kW, was completed in 1967. Since then, Bhutan's hydropower capacity has increased to 485 MW by the end of 2005. Bhutan's peak load reached 105 MW during the 2004 winter. At present 70 percent of the energy generated is exported to India from the 336 MW Chukha and 60 MW Kurichhu hydropower plants. In this backdrop the planned DHPP with 114 MW (500 GWh/a) capacity is an asset as it could meet easily the Bhutan's peak load. At present hydropower generation constitutes more than 99 percent of the power production in Bhutan.

The earnings from the hydropower sector constitute 40 percent of the annual revenue of Bhutan. This share will increase once the 1020 MW Tala HPP is commissioned in 2006 and the total install capacity will jump to 1495 MW. In the near future, DHPP will contribute another 114 MW to Bhutan's national grid, increasing the total installed capacity over to 1600 MW and boosting the export potential of surplus power. India has a huge demand for power, most of which is at present met by thermal generating plants and long-term economic costs of thermal generation are certainly much higher. India is keen to promote renewable and clean forms of electricity for long term economic and environmental sustainability. The power demand in India is expected to increase by more than 150,000 MW by 2012 and needs at least 7500 MW of hydropower to its system annually. The large market that Bhutan has in its neighbourhood in terms of energy demand makes the hydropower ventures in Bhutan highly promising.

At a national level the project will add great benefit to the country's economy and environmental sustainability through the production and sale of hydropower energy.

4.7.2 Benefits through the Clean Development Mechanism (CDM)

The DHPP project is planned to be implemented under the Clean Development Mechanism (CDM) as defined in the Kyoto Protocol. The power generated will be sold to India where it will displace fossil fuel based thermal power generation in the Northern Indian power grid. The resulting reduction of Greenhouse Gases (mainly CO_2 emissions) is quantified and registered under the CDM.

As a consequence, Bhutan will obtain emission certificates (Certified Emission Reductions, CERs) that in turn can be sold to industrialized countries to provide additional revenues to the project.

CER revenues significantly increase the project's financial attractiveness by improving the key financial indicators and make it more resilient to various risks such as country risk, foreign exchange risk, PPA related risk, etc.

The financial benefit of the revenues obtained by selling CERs is significant:

- The Net Present Value of CER revenues accounts for approx. 6.6% of total capital investment of the project
- Reduction of the required resource availability from 107 % of designed electricity output to 100 % for financial break even
- CER revenues provide 0.14 INR/kWh of additional revenue stream to the project in order to make generation from DHPP competitive with alternative thermal power projects in India. The benchmark required to be achieved is 2.25 INR/kWh.
- The CER revenues make the project more resilient to any tariff changes by reducing the break even point from 2.39 INR/kWh to 2.25 INR/kWh.
- Due to the fact that the price estimations for CERs are very conservative because of the uncertainty about a post-Kyoto regime, the investment analysis shows a significant but not a tremendous effect of CDM on the financial viability. Nevertheless, an important factor of pursuing the proposed project activity under the CDM for the project developer is the upward potential of Carbon credits in case the worldwide cap-and-trade regime will be prolonged after 2012.

The possibility of CER sale under the CDM is critical to help the project overcome the investment barriers and reach financial closure due to the following effects:

- The revenues through the sale of Certified Emission Reductions (CERs) provide additional income for the project in "hard currency" (EUR or USD) from debtors with excellent credit ratings (e.g. Government of Austria). In order to have "state of the art" technology available for the DHPP project, some of the equipment will have to be supplied from industrialised countries. Due to the fact that the revenues from the sale of electricity will be in Indian Rupees, only the revenues from CER sale could provide the required security for loans in EUR or USD.
- Due to the high environmental and economic standards required for CDM projects, many financing institutions are specifically targeting CDM projects or at least prefer CDM projects over "regular" investment projects. The involvement of internationally reputable organisations in the CDM process (e.g. UNFCCC) improves the risk profile of the project.

4.7.3 Socio-economic Benefits

The field investigations and analysis revealed that the communities surrounding project areas have a number of benefits. The following positive social impacts are expected to result for the people around project areas: (1) All households (HH) will receive electricity that will

drastically improve living conditions. Currently, 91 percent of HH use kerosene for lighting and 98 percent use firewood for cooking. It could be anticipated that with shifting to electricity for lighting a drop in kerosene consumption, which is an imported (from India) fossil energy source, could lead to reduction in CO_2 emissions (4446 people living in the vicinity of Project area) as well as saving of valuable foreign exchange. However, an immediate shift from the use of firewood to electricity for cooking cannot be anticipated. (2) The project will also improve sanitary conditions; currently, 99 percent of the HH use pit toilets or open defecation which results in a chain of negative effects. With the development of the project they will have access to pipe-born water as well as better toilet facilities. (3) The HH with better irrigation facilities and improved farming techniques will have access to better income and improved living conditions.

In general, the DHPP project will improve the existing water supply and sanitation system in the affected and peripheral villages in phase-I and later on in phase-II these improvements should be extended to the other downstream communities. The DHPP project will take care of providing drinking water to down stream villages in the lean season. These measures will improve the living conditions of community and ultimately leads to better earning potentials for them.

4.7.4 Forestry/Watershed Management

A major positive benefit of the project is the potential of investment in forestry or watershed management. The project should be developed and managed in the context of overall River Basin Management (RBM) and regional development plans, including upland catchment area and areas downstream. For sustainable development of watershed/forestry an integrated management plan should be prepared and this will have a substantial environmental benefits. The plan should look into the every aspect of sustainable development of watershed, forestry and wildlife and establish such parks in the region as a part of project. The sensitive areas prone to recurring land slides and erosion may be notify as protected zone to prevent further deforestation and habitat degradation. Wildlife conservation plan should be given top priority.

4.7.5 Benefits through Increased Job Opportunities and Induced Socio-economic Development

These can be achieved through following actions:

- Rural Electrification
- Increasing social services in the project area
- Creation of new enterprises due to improved road access, market access, electricity supply and influx of skilled worker.
- Electrification of households will enhance the general health and hygiene of the population.
- Enhancement of skills by enterprises skill training from DHPP and also small scale business training to be given to local community for development of secondary employment opportunities.
- The DHPP project will provide job specific training to women
- Availability of new agricultural techniques, fertilizers and improved seeds.
- Improving water supply and sanitation

4.7.6 Overall Benefits

The overall project benefits can be summarised as follows:

I. The project will not cause unwanted loss in precious/irreplaceable natural or other resources.
II. The construction of DHPP will not result in unwanted hazards to endangered species. Bhutan has a very high priority for conservation.
III. The generation of hydropower does not lead or make unwarranted accelerated use of scarce resources in terms of short-term economic gains
IV. The project will enhance the foreign exchange gains of Bhutan as the excess power generated will be sold to India. Thus it will not neither depreciate the national energy quota nor create foreign exchange problems (it improves the balance of payments situation of Bhutan).
V. The DHPP is constructed in a rural area. When considering socio-economic aspects, as it is, it will not intensify undesirable rural-to-urban migration to an unwanted degree.
VI. The project will certainly help to decrease the 'income-gap' between the poor and effluent sectors.
VII. Water quality of the river: from the limited data available from chemical analyses, the water quality shows characteristics of a pristine, soft water mountain stream with low nutrient and mineral content. The production of hydropower will hardly influence the chemistry of the flowing waters.

5 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The Environmental Management refers to the effectiveness of the implementation of the mitigation measures as documented in the EA report. Monitoring is done in different levels with fixed schedule. The Environmental Management Plan includes a matrix consisting of impacts, mitigation measures, monitoring activities and indicators, responsibilities and time.

Although there are various types of monitoring; the following are the most important ones:

Pre-Construction Monitoring: Baseline and pre-construction monitoring has to be done to identify, collect and verify the additional environmental baseline data, which is scientific and sociological in nature, and needed to augment information on baseline conditions initially generated during the EA. Such information will be used to finalize the priority and details of specific mitigation measures for potentially significant environmental impacts.

Construction Phase Monitoring: This is subdivided in to two related activities:

i) *Compliance monitoring* is done to see whether the environmental mitigation measures are being carried out as per the Environmental Management Plan (EMP) of this EA document or not. NEC or DOE should oversee and ensure implementation of the mitigation measures.

ii) *Process monitoring* is done to see whether the set procedure of monitoring is followed during the implementation of the mitigation measures as per the EMP.

Operational Monitoring: Similar to construction monitoring, it is needed to assess the degree of ongoing compliance with NEC regulations and to assess the longer term impacts of the project on environment. The aim is to identify whether the mitigation measures that have been prescribed are sufficient and having the desired effect, and if otherwise then to provide further mitigation or enhancement activities.

5.1 Pre-construction Period

5.1.1 Environmental Clearance

As per the EA Act 2000, it is mandatory that hydropower should get environmental clearance from the environmental competent authority and here the competent authority is the NEC. This EA report is the basis for the issuance or rejection of environmental clearance (EC). The EC need to be obtained before any development activities is initiated. The EA Report should be accompanied with Forestry Clearance that will be issued by the Department of Forest. The No Objection Letter from the communities is attached to this report.

5.1.2 Preparation of Resettlement Action Plan (RAP) & Implementation

Only household that will need relocation fall within the transmission line corridor. The total land up take by the project is estimated at 31.7 acre, of which access road attribute to 13.79 acre, 2.78 acre by power transmission line, and rest by hydropower project components. Therefore, during this period there is need to prepare Resettlement Act Plan (RAP). RAP will clearly specify the number of affected households/people, amount required to compensate, the baseline indicators for measuring impact, the time table for completing compensation and resettlement, delineation of agency that will responsible to undertake the RAP, and timetable for evaluation of RAP implementation.

5.1.3 Incorporating environmental requirements in Project Design

During this stage the project will become more and more focused. All the requisite environmental requirements should be enumerated at this stage and will be included in the project design. This will primarily include mitigation actions and suitable interventions for acquisition of land for construction and operation of project, access road, minimum flow and transmission facilities. All the environmental conditions should be brought forward to the civil construction contract document in the form of the clause and work item.

5.1.4 Monitoring of RAP Implementation

The implementation of the RAP should be monitored and evaluated before the start of the project. This is to ensure that no hiccups drag on during the construction period and the project can use the land with its total ownership.

5.2 Construction Period

5.2.1 Setting up Environmental Unit within Project

For the effective implementation and monitoring of the mitigation measures, Environment & Community unit (ECU) has to be established within the DHPP Authority. This unit would be the focal point between project and community and oversee all the environmental works undertaken by the project for enhancement of environment and community welfare. ECU will assume the environmental responsibility of the project in totality.

The unit should be headed by an environment officer and other staffs as one community development officer, one community livelihood officer having general experience on campaigning for health & hygiene, and three technical staffs that will monitor environmental related civil construction works.

The general responsibility of ECU would be:

- Control of adverse social interaction between local communities and construction work force.
- Conducting safety and health related trainings.
- Development and enforcement of rules & regulations to prevent illegal felling of trees, illegal fishing and hunting and encroachment of forest areas.
- Security & community awareness program for work force.
- Arrangement for the provision of local infrastructure improvements such as sewage treatment, potable water supply, power, temporary housing for workers.
- Arrangement of increasing social services, school, health units.
- Training on risk and safety matter related to the project.
- Undertake monitoring of project impact and implementation of the mitigation measures.
- Preparation for detail plan for the environment enhancement measures.
- Regular sanitary survey of area and remedial measures.
- Testing of water quality and disinfectant dose regulation
- Further identification of fish species.
- Conducting regular health camps and distribution of essential medicines.
- Vector disease control
- Other related works.

5.2.2 Coordination with Engineering Unit to incorporate environmental Conditions in civil works contract

Before award of civil contract, all the necessary environmental mitigation measures envisaged by EA and prepared in detail by the Environment unit should be incorporated in the tender document. Environment officer should closely work with the respective engineering unit for incorporation of environmental conditions in the tender document. Environment officer has to be made one of the members of tender evaluation committee and authorize to give his remarks on the particular tender about the fulfillment of environmental conditions by bidder. The criteria for bid evaluation should have weightage for the best environmental execution plan submitted by the bidder.

5.2.3 Environmental Capacity Building

Regular training programme to be organized by DHPP under direct supervision of Environment Unit for dissemination of best environmental practices to project partners and community. Apart from this community awareness drive can be launched in the entire project area. These should also be depicted by street play, distribution of pamphlets, showing small films on video and other innovative methods. Environment unit can call resource persons for conducting training from other line departments importantly from forest, public health engineering, health department, public works department, agriculture department etc.

5.2.4 Monitoring of Civil Works Execution

Environment unit should ensure that all civil works are progressing as per plan and all the environmental measures in built in the civil contract are being executed properly. The environment unit should be given proper responsibility and power to monitor work and also to certify that the works have been implemented as per environmental mitigation plan.

5.2.5 Monitoring of wildlife Indicators

As per the available data the project and its surrounding areas does not have much of wildlife. But decrease in number of wildlife will be an indicator for monitoring. Following measures to be taken:

Sample survey before and after construction for species and signs count along sections of the watercourse.
Labor camps not to be constructed near the thickly vegetated area to minimize the disturbances to wildlife.
Strengthening of reporting and enforcement mechanism.
Preparation of wildlife management and conservation plan with active support from community.
All sightings reported by the public or the project workforces can be reported to a designated officer monitoring the wild life management and conservation plan.
Provision of barriers and check posts in active wildlife habitat areas.
A program of information on wildlife protection for the community and the project work force should be implemented.
Persons to be fined heavily if caught for illegal hunting and should be deported immediately.

5.2.6 Monitoring of Social Indicators

The people shall be healthy and the cost for medical treatment shall come down and the people will have prolonged healthy periods for earning their livelihoods. Hence, the

household income shall rise and the quality of life shall become better. There are baseline social indicators established under the Chapter 3 which will be basis for social monitoring. Those social parameters should be monitored during this stage to visualize impacts and for arranging possible mitigation.

5.2.7 Monitoring of water, air and noise

Water, air and noise need to be monitored during project construction. The baseline data for monitoring water is presented in section 3.2.5 in Table 3-2. Air and noise is presented in section 3.2.6 and 3.2.7 respectively.

5.2.8 Reporting and Rectifications

Appropriate mechanism for communications to be set up at important places to make monitoring effective. This can be achieved by installation of WLL phones in all directly affected villages and some in peripheral villages to serve cluster of villages. These could be installed at Gup's residence.

All gathered information should be transmitted immediately to the officer concerned for rectifications.

The environment unit staffs should regularly visit the affected villages and peripheral villages and also the project area to collect information and to transmit them to the respective officers for immediate intervention.

In all villages community point man to be identified for seeking information on ongoing activities. This information will help the environment unit in proper monitoring of project concerns.

5.3 Post Construction Period

DHPP authority should have primary responsibility for the management and implementation of the environment and the watershed mitigation activities during the operation phase of the project.

5.3.1 Monitoring and Mitigating

The environment and community unit with reduced staff should work in post construction period for monitoring the mitigation measures.

5.3.1.1 Downstream flow Variations

In the river diversion section, minimum flow rates to be maintained always to minimize the adverse effects on aquatic biology. And also periodic dry season releases to flush and clean downstream spawning and nursery beds for fish.

- Smooth increase and decrease in the stream flow from power station outlet.
- Fixed start and stop procedure to be adopted for smooth increase and decrease in down stream flow.
- This start and stop procedure should also be adjusted as per experience.
- Start and stop procedure should be followed by a warning system.
- Warning system should cover the river 5 km downstream.
- Pollution control monitoring should be given top priority in the diversion section, where flow is less.

5.3.1.2 Problems in Reservoir Management

Regular monitoring of dam & reservoir area for erosion and landslides.

Operation of the dam and the reservoir during low flow season and during the monsoon season should require close monitoring.

- Emergency warning systems to be installed for public safety concerns from emergency spillway release or gate opening during dry season when gates are normally closed or reservoir is filling.
- For maintaining minimum compensation flow in dry season if need be reservoir water should be used.

5.3.1.3 Downstream Water Quality Management

Untreated wastes should not be discharged in to river.
Water quality survey should be conducted periodically at various points in the downstream of reservoir.
Water sample of reservoir and from diverted section of river to be periodically tested for following parameters for establishing the quality of water.

Table 5-1 illustrates the Water Quality Monitoring schedule

Sl. No.	Parameters	Frequency
A	pH, Total Dissolved Solid, Dissolved Oxygen, BOD, Faecal Coliform	Quarterly
B	Total Suspended Solid, Turbidity	Monthly

Water for drinking purposes should be treated and disinfected before supplying to community.
Regular testing of residual chlorine.
Information on water borne diseases in downstream villages.
Water sampling side should be 1 km upstream of dam, Reservoir, 2-3 places in diverted section of river and outlet of power house.

5.3.1.4 Insect Vector Disease Management

Malaria control measures should be taken to destroy their habitats and interrupt the lifecycle by physical, biological or chemical means.
One permanent dispensary should be developed in the area.
Development of proper surveillance system to be followed by mosquito control activities and health extension activities.
Regular sprays of insecticides in the areas where water is likely to be stagnant to prevent the growth of malaria larval.
Frequency of monitoring should be fortnightly.

5.4 Matrix of EMP illustrating impacts, Mitigation Measures, Costs & Institutional Responsibilities

5.4.1 Environmental Management Plan

The Environmental Management Plan includes a matrix consisting of impacts, mitigation measures, monitoring activities and indicators, responsibilities and time. The following table shows the EMP in concise form.

Table 5-2 illustrates the EMP Matrix

Sl. No.	Impact	Mitigation Measure	Indicator	Responsibility of Monitoring Activity	Time
		1. PROJECT LOCATION			
1.1	Watershed Erosion	Engineering and biological measures which includes plantation check dams, gabion walls, dry stone masonry, RR stone masonry, supports, wire crates etc. Monitoring areas requiring slope stabilization.	Exposed cut slopes, landslide, rate of soil erosion, sedimentation to water course	C, SIC, ECU	Monthly and after construction in Operation phase.
1.2	Fish Migration	Broad evaluation of fish populations, distribution of species, migration and spawning, measurement of water temperature.	Loss of fish species and problem in fish mobility.	ECU	Weekly, Monthly
1.3	Agriculture	Survey of agriculture production, better utilization of water, better availability of seeds and fertilizers, information about scientific farming.	Agricultural production	DHPP, ECU	Quarterly
1.4	Wildlife	No cutting of fruit bearing trees and tall trees for globally threatened bird species. No encroachment in to prime habitats for two protected mammals.	Decrease in number established by sample survey prior to construction.	ECU	Monthly
		2. DESIGN			
2.1	Road	Plantation of trees, shrubs and bushes in unstable zones, retaining walls, proper drainage for runoff, culverts, other slope stabilization techniques. Proper erosion control and slope protection measures should be implemented. Salvage soil to be used in reclamation land, biological treatment of disturbed slopes with stabilizing plant species. Adequate provision of storm run off and drainage in affected sections. Dust control by sprinkling of water .Scheduling of construction activities with local farming cycle so that local people can take employment.	Nos. of trees died and clearing of bushes and shrubs. Danger to bank stability, landslides and erosion	C, SIC, ECU	Monthly, half-yearly, Yearly, regularly in operation phase.
2.2	Fish Screen	Provision of fish lift/ladder for fish mobility and screen to protect entering of fish in to power house intake after further investigation of long distance migratory fish species in the river basin.	Loss of long distance migratory fish species and mobility problem to seasonal native species.	ECU	Further investigations.
2.3	Transmission Line	Slope stabilization techniques, revegetation, maintenance of no	Cutting of trees and clearing of	C, SIC, ECU	Monthly, half-yearly,

Sl. No.	Impact	Mitigation Measure	Indicator	Responsibility of Monitoring Activity	Time
		clear zone between towers, trees of height 3m should not be disturbed. Construction of pathways should be minimized. Slope stabilization in areas with steep topography and measure to control drainage. Involvement and awareness programme for local community.	shrubs and bushes, land slides and soil erosion.		Yearly, regularly in operation phase.
		3. CONSTRUCTION			
3.1	Soil Excavation	Transport to designated dump site, levelling, Storm drainage and run off control provisions should be provided in disposal areas. Afforestation programme to be implemented on the dumped materials. Minimum release of sediments in to the river so that water quality should not be worsened.	Huge pile of earth, dust storm	C, SIC, ECU	Weekly, Monthly
3.2	Safety of Workers	First aid, safety gears, fencing/barricades, safe water, toilet, mosquito control.	Accident, injury, waterborne diseases, fever.	C, SIC, ECU	Daily, Weekly, Monthly
3.3	Air Quality & Noise	Water sprinkling, proper maintenance of machines and construction vehicles, night blasting should be discouraged.	Dust storm, high level noise, blasting.	C,SIC, ECU	Weekly, monthly
3.4	Water Quality	Water quality sampling and analysis, temperature measurement.	pH, Turbidity, Dissolved Oxygen, BOD, Phosphates, Nitrates, Temperature	ECU	Monthly
3.5	Solid & Liquid Waste	Designing and siting proper landfill site which is away from the human settlements, water bodies and the critical habitats. Landfill site location must be carried out during DPR phase. Solid wastes such as paper, cardboard, organic materials, will be disposed in the designated landfill site. Wastes of metal, rubber, plastics and auto batteries are to be stored safely and to be exported for reprocessing. Wood waste should be used for fuel and fencing works. Saw dust to be used for soaking up hazardous liquid wastes such as spent engine oils. Liquid wastes particularly engine oils to be collected, stored and exported to India for reprocessing.	Land and water pollution Engine collected and exported for reprocessing	ECU	Weekly, Monthly
3.6	Water Borne Diseases	Periodical sampling of water supply sources, supply of treated water, use of disinfectant.	Coliform Bacteria in water and increase in number of water borne diseases.	SIC, ECU	Weekly, Monthly

Sl. No.	Impact	Mitigation Measure	Indicator	Responsibility of Monitoring Activity	Time
3.7	Fire Outbreaks	Better handling of explosives, fire fighting facility at each construction site, mock testing of fire fighting, cooking on gas.	Too much smoke in the air	C,SIC, ECU	As and when required.
3.8	Poaching of Wildlife	Barriers, check post, protected zones,	Decrease in number of Wildlife	ECU	Monthly
3.9	Cultural Invasion	Separate housing for workers, information to workers on local culture and way of living.	Local complaints.	C, SIC, ECU	Monthly
		4. PROJECT OPERATION			
4.1	Downstream Flow variation	Hydrological data collection and flow measurements, Maintenance of minimum flow in diverted section, fixed start and stop procedure for smooth decrease and increase in water level, Warning system, observation. River bed conditions and slope erosion downstream of dam and tailrace outlet. Assessment of effects on the downstream aquatic life by peaking operation.	Flow rate	DHPP, ECU, CEM	Monthly
4.2	Reservoir Management	Monitoring of shoreline for cracks, community consultation for alternative use of reservoir water. Minimum release of water from dam for sustenance of wildlife and riparian vegetation.	Large Variation in water level in the reservoir.	DHPP, ECU	Monthly
4.3	Downstream Water Quality	Untreated waste should not be discharged, Water quality testing, Water for drinking should be treated and disinfected, Testing of residual chlorine in drinking water, information on water borne diseases. Water quality sampling for sediments. Best practices for storage and disposal locations for oil, other hazardous substances and wastes. Better drainage and erosion support structures for functioning of drainage system.	Spread of water borne diseases, loss of fishes, Total suspended solids, total settleable solids, total non-settleable solids.	DHPP, ECU	Monthly
4.4	Insects Vector Disease Hazards	Malaria control measures, establishment of one permanent dispensary, regular spraying of insecticides, frequent monitoring.	Reported cases of malaria	DHPP, ECU	Weekly, Monthly

Note:
C= Main Contractor
SIC = Site In-Charge
DHPP= Darachhu HPP Authority
ECU= Environment & Community Unit of DHPP Authority
CEM= Central Environment Monitor/NEC

5.4.2 Institutional Responsibilities

The institutional responsibilities and involvement in the mitigation programme may be divided among following institutions/departments.

Dagachhu Hydro Power Project Authority (DHPPA)
Primary Contractor
Other Contractors
Dagana Dzongkhag Administration
Government Line Departments

Responsibilities of DHPPA:
DHPPA will fulfill the financial obligation for all mitigation and enhancement measures.
DHPPA will responsible for pre-construction and operation phase mitigation.
DHPP Authority should cover the costs of all mitigation measures including education, health, roads, electrification, revegetation etc.
DHPP Authority should implement all mitigation and monitoring activities and responsible for providing all status reports on the progress of these activities.
DHPPA to establish Environment and Community unit (ECU) for effective monitoring.

Responsibilities of Contractor:
The contractor will be responsible for implementing the construction phase related mitigation measures.
The contractor will be responsible for monitoring activities as per the conditions of bid.
Indicative table for the possible cooperation among various agencies in the mitigation and enhancement for DHPP is given below.

Table 5-3 shows the mitigation measures that could be carried out in cooperation with other line agencies

Mitigation Component	Potential Co-Operating Agencies
Compliance Monitoring for Environmental Protection	National Environment Commission (NEC)
Forestry, Fisheries	Department of Forest, Dagana forestry Division, Dagana Dzongkhag & Environment & Community Unit of DHPPA.
Watershed Management	NEC , ECU of DHPP Authority
Water Supply & Sanitation	Public health Engg. Unit, Health Department ,ECU
Policing of fish, wildlife and forestry regulation	Department of Forest, Dagana forestry Division, Dagana Dzongkhag & Environment & Community Unit of DHPPA.
Agriculture, Land Use, Pasture Land, Social Forestry	Department of Agriculture, DHPPA,ECU
Public health	Dagana Hospital, Dispensary set up by DHPPA.
Road Building	DOR, NEC, and ECU
Public Services	Dzongkhag Administration

The implementation capacities of these agencies are limited but their co-operation in finalizing action plan would be highly beneficial and to achieve this, coordination meeting to be held every month with representative from all line departments. The project should be implemented by creating a separate authority having all necessary powers and authority. The name should be Dagachhu Hydro Power Plant Authority (DHPPA).

5.4.3 Mitigation and Enhancement Programme Costs

The cost of environment management programme is normally developed during the detailed design. For the purpose of the EA, an indicative estimate of costs of environment mitigation and enhancement has been prepared.

Range of mitigation measures suggested for access road, transmission line, dam & reservoir, and other civil structures are standard mitigation measures which will be included in the civil construction contract. This implies that the requirements set forth in the environment management programme should be included in the civil construction contract and the contractor should incorporate the costs associated with the implementation of these measures in the bid.

5.4.4 Cost for implementing Environmental Management & Monitoring Plan

Table 5-4 shows the cost for implementing Environmental Management and Monitoring Plan

S. No.	ITEM	Cost (Nu Million)
1.	Land Compensation , Relocation of one house & Horticulture Crops Compensation	1.50
2.	Dagachhu Environment & Community Unit (ECU) Cost for ten years. Office accommodation and equipment is deemed to be included in the project's cost estimate. No annual increase has been considered. Environment officer@ 25000 per month = 300000.00/year Community Development officer @ 15000 per month =180000.00 Community Facilitator@ 12000.00 per month=144000.00 Community Livelihood officer@12000.00 per month=144000.00 Health & Hygiene officer@12000.00 per month=144000.00 3 technical staffs @ 10000.00 per month =120000x3=360000.00 Office Expenses & Travel= 500000.00/year Vehicle & Housing= 500000.00/year Consultancy support= 2 mm/year =100000.00/year Expatriate Consultants =2 mm/year = 200000.00/year Total for one year=2572000.00 Total for 10 years=25.72 Million	25.72
3.	Construction of settling tank at Dam site, Power house site and the access tunnel site. Total approximate cost would be in the range of Nu 200000.00 per settling tank Size of tank should be 5 x 2.5 x 1.5 Mtr.	0.60
4.	Sanitary facilities in labour camps. Construction of 60 community latrines and 6 septic tanks. Community latrine at the rate of 15000.00 per unit and septic tank cost at the rate of 150000.00 each.	1.80
5.	Control of air pollution during construction phase	2.00
6.	Solid waste collection and disposal during construction phase	3.00
7.	Compensatory Afforestation for minimum 100 Hectares at the rate of 30000 per Ha during construction phase.	3.00
8.	Wild life Conservation (including cost of surveillance) during construction phase.	3.00
9.	Establishment of Permanent Dispensary (Infrastructure cost of Dispensary and first aid post should be included in the project cost) Doctor 1 No. @ 30000.00 per month=360000.00/year Nurse 4 No. @ 10000.00 per month=480000.00 Attendant 4 No. @ 5000.00 per month=360000.00 1 Vehicle & driver@ 40000.00 per month=480000.00/Year **Total for 10 Years= 16.80 Million** 1 Health Assistant & 1 dresser for first Aid post-2 Nos.@ 2x2x5000.00 per month=360000.00/Year Running of first aid posts 2 Nos. =10000.00 per month= 120000.00 per year **Total for 5 years=2.4 million** **1 van for Mosquito control spray= 0.5 million** Recurring expenditure on insecticides, drug and medicines for control of diseases= 30000.00 per month=360000.00 Malaria control dosages of chloroquinine, blood testing, spray Of mosquito control=30000.00 per month=360000.00 **Total for 5 year=3.6 million** **One Ambulancce-1 million** Maintenance of dispensary including ambulance@ 240000.00/year= **1.2 Million for 5 years**	25.50
10.	Area development activities includes construction of footpaths in the villages, WBM roads for better access to the villages, communication facilities for better monitoring & obtaining information, better educational facilities ,improvement in water supply and sanitation, opening of Agriculture extension centre, upgrading BHU, equipment grant to Dagana hospital etc. during construction phase. Detail work plan to be finalized by ECU of project in consultation with community.	15.00

S. No.	ITEM	Cost (Nu Million)
11.	Dagachhu catchment Management Plan during construction phase	10.00
12.	Monitoring and studies during construction phase	1.00
13.	Cost of implementing Environmental Monitoring plan includes testing of soil sample from various locations in the catchment at least twice a year, testing of water sample as per the frequency mentioned in the EMP and other associated interventions including community training, health camps, awareness campaign. 400000.00 per year for 5 years	2.00
14.	Fisheries development and further investigations on the fish species including research during construction phase.	2.00
15.	Check dam or gabion walls for spoil deposition during construction phase.	5.00
	Total	**410**

The total cost estimate of environmental and socio economic mitigation measures is Nu 101.12 million as per above break-up. The cost of area development may go up or down during the finalization of specific plan with the community in construction phase.

6 CONCLUSIONS

Hydro power, a renewable energy, generated by the DHPP will contribute significantly to the socio-economic of the region in particular and to the country in general through export of energy to India and will improve the standard of living.

The construction and operation of the DHPP will bring the following benefits.

An Annual electric power of approximately 500 GWh will be supplied.
The construction and operation will contribute to a domestic economic growth
The construction and operation will have no great impact on the environment.
The annual revenue at the rate of 1.5 Nu/KWh will be approx. Nu. 750 million.

The proposed generating facilities are essential to sustain the economic growth and improve the standard of living of this country.

Following is a summary of the main conclusions and recommendations of the EA study based on the field investigations and analysis provided in this report.

6.1.1 General

On the basis of physical, biological and social impacts identified and the scope for mitigation and enhancement measures, there is no obvious reason from an environment perspective not to advance the project to implementation.
The EA proposes measures to mitigate adverse impacts and measures to enhance positive impacts of the construction and operation of the DHPP. The enhancement measures should receive equal attention as the mitigation measures.
Sections of EA may require updating as part of the detailed design.
A detailed EMP including detail description of the mitigation measures, monitoring plan and the environment community unit (ECU) should be developed during detail design.
A catchment management plan (CMP) should be developed for the Dagachhu watershed and implemented as part of the project. 10 million Ngultrum has been suggested to earmark for the implementation of CMP.

6.1.2 Physical Environment

Total permanent agricultural land take from community is about 31.7 acres.
All packages of civil contract of DHPP will need to incorporate all the required measures for slope stabilization, restoration of construction areas, camps and other disturbed areas. The standard mitigation measures for adverse effect due to construction of road, transmission line, powerhouse, tunnel, dam& reservoir has not been taken separately and these should be the part of the respective tender documents and to be implemented along with the component.
GLOF has not been studied as a potential impact in this EA.
Air, Water and noise pollution from the construction can be minimized by taking proper measures.
Water quality of the reservoir would not deteriorate because water circulates relatively quickly.

6.1.3 Biological

One globally threatened bird species and two protected species of mammals has been found in the area.

The EA assessment recommends a minimum flow release from the dam in the range of 5-10% of the mean annual natural flow in the diverted section of river.
Further studies of aquatic ecosystem and fish population will be needed during the operation phase to determine the minimum acceptable release.
Downstream the outlet from the power station it is of importance to have a smooth increase and decrease in the stream flow, and hence in the water level when changing the load. This can be done by fixed start and stop procedure.
Further investigations will be necessary to determine the need for building a fish ladder, with the present data on fish migration, construction off a fish ladder is not recommended.

6.1.4 Social and cultural Environment

Only one household is foreseen to get relocated.
The main social impact from the project is expected from the influx of about 1000 construction workers in to the area, where subsistence agriculture has been the norm for centuries and where long established social and cultural institutions shape people's understanding. Thus, special attention should be given to programs to mitigate adverse impacts of the interaction between the existing communities and the construction work force.
Labor and contractor's camp should be located as close as possible to various project sites to reduce the need of transport and unwanted interaction with local community. Cooking gas should be provided to the camps to avoid damage to the neighboring forest and also to thwart any outbreak of fire by using fire wood for cooking. Laborers to be encouraged for making meals jointly or using mess facility so that meals can be prepared on cooking gas since it is not feasible to provide every labour group with cooking gas facility.
ECU (Environment Community Unit) of DHPP should be established to co-ordinate between the project, government agencies and other organizations involved in implementing the social mitigation and enhancement program. The NEC should oversee the activities of ECU. The ECU should be fully funded by the DHPP Authority and should also continue as a permanent establishment with reduced staffs in operation phase.

6.1.5 Economy

Implementation of DHPP complements the vision 2020 document for harnessing the potential growth of hydropower production in the country for economic growth and improvement in socio-economic conditions.
Bhutan is an energy surplus country and the hydropower could be the main resource for earning foreign currency by exporting to neighboring countries.
By exporting energy to India the import – export disparity of Bhutan will be improved.

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