Private Sector Hydropower Development - 2

MANUAL TO ESTABLISH BASELINE INFORMATION, IMPACT ANALYSIS, AND MITIGATION MEASURES

Final Draft

December 2006

This is a draft publication of the Department of Electricity Development, HMG Nepal. Its function is to help the proponent prepare EIA/IEE documents within the framework of existing Acts and Rules. It is recommended but not mandated. If this manual and its contents contradict the provisions of the prevailing Acts and Rules; the prevailing Acts and Rules shall govern.

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MANUAL TO ESTABLISH BASELINE INFORMATION, IMPACT ANALYSIS, AND MITIGATION MEASURES FOR HYDROPOWER PROJECTS

2006

Department of Electricity Development, GON
in collaboration with
United States Agency for International Development
and
International Resources Group

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Manuals in this series:

- Manual for Preparing Scoping Document for Environmental Impact Assessment (EIA) of Hydropower Projects.
- Manual for Preparing Terms of Reference (TOR) for Environmental Impact Assessment (EIA) of Hydropower Projects, with Notes on EIA Report Preparation.
- Manual for Preparing Environmental Management Plan (EMP) for Hydropower Projects.
- Manual for Public Involvement in the Environmental Impacts Assessment (EIA) Process of Hydropower Projects.
- Manual for Developing and Reviewing Water Quality Monitoring Plans and Results for Hydropower Projects.
- Manual for Addressing Gender Issues in Environmental Impact Assessment (EIA) for Hydropower Projects.
- Manual for Conducting Public Hearing in Environmental Impacts Assessment Process for Hydropower Projects.
- Manual to Establish Baseline Information, Impact Analysis, and Mitigation Measures for Hydropower Projects. [Final Draft]

FOREWORD

In March 2000, the DOED, the National Environmental Impact Assessment Association of Nepal, USAID, and IRG organized a one-day interagency workshop. The objective of this event was to carry out a Strength-Weakness-Opportunity-Threat (SWOT) analysis of the EIA/IEE process for hydropower projects in Nepal. A major conclusion of the workshop was that the EIA/IEE process could be facilitated and streamlined by producing a series of manuals that would clarify the requirements at each stage in the process. The DOED, with USAID assistance through IRG, began developing working manuals for improving preparation of environmental documentation for the development of hydropower projects.

In 2002 four more SWOT workshops were held to address specific EIA/IEE issues in greater detail. A stakeholder workshop on establishing baseline information, impact analysis, and mitigation measures conducted in December 2002 in Kathmandu, concluded that a manual or guidelines should be developed to establish baseline conditions for a hydropower project that would facilitate impact prediction and analysis, and development of mitigation measures. Such a manual would assist in a focused analysis of environmental effects of a hydropower project and would assist the decision-makers in making better decisions. We will be able to develop more effective mitigation measures, and to make more focused environmental monitoring plans. In the long run, it will save a lot of time and money for the developer, and the project will gain acceptance from the project-affected people more easily.

A draft outline of the manual was developed during 2002 and discussed at length during the workshop in December 2002. The workshop participants consisted of senior representatives from GON agencies including the Department of Electricity Development, Environment Nepal, engineering and environmental consultants, independent power producers and developers, International Resources Group, Ministry of Environment, Science, and Technology, Ministry of Water Resources, Nepal Electricity Authority, SchEMS, United States Agency for International Development, Water and Power Commission Secretariat, and the World Conservation Union. Subsequent to the workshop, key professionals from IRG and SchEMS developed a draft manual for DOED's review. This final draft manual is the result of the dedicated effort of these participants and DOED staff.

I sincerely hope that this manual will improve preparation of EIAs and IEEs for hydropower projects in Nepal, by making the system more beneficial, effective, and efficient for achieving environmentally and socially sound and sustainable hydropower development in Nepal.

Director General
Department of Electricity Development
Kathmandu, Nepal
December 2006

ACRONYMS AND ABBREVIATIONS

DO	Dissolve Oxygen
DOED	Department of Electricity Development
EIA	Environmental Impact Assessment
FIP	Framework of Impact Prediction
GIS	Geographic Information System
GON	Government of Nepal
IEE	Initial Environmental Examination
IRG	International Resources Group
IUCN	The World Conservation Union
LRMP	Land Use Utilization Report
MOWR	Ministry of Water Resources
MW	megawatts
NGO	Non-Governmental Organization
PSHDP	Private Sector Hydropower Development Project
SWOT	strength, weakness, opportunity, and threat
TOR	Terms of Reference
USAID	U. S. Agency for International Development
VDC	Village Development Committee

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1. INTRODUCTION

1.1 Background

The Environmental Impact Assessment (EIA) is a process designed to develop adequate, relevant, and valid environmental information relating to a proposed action (project) to facilitate effective decision-making on project implementation. The EIA process involves identification, prediction, and assessment of the likely impacts of the construction and operation of the proposed project(s) on the physical, biological, socio-economic and cultural resources of the environment that may be affected by project implementation. The EIA process also involves development of appropriate mitigation measures to address potentially adverse effects of the proposed project(s). The process also provides opportunity and information for stakeholder involvement in the review of the proposed project(s) and realistic alternatives and assists the decision-maker(s) to arrive at a better decision on regarding the project implementation based on a balanced assessment of relevant economic, social, and environmental opportunities, challenges and resource constraints.

The EIA process comprises the following, generally sequential, steps:

- Identification of the Affected Environment of the proposed project and the likely stakeholders in the proposed project development
- Description of the Affected Environment including physical, biological, and human resources and geographic extent of the effects of a proposed project
- Environmental Screening to establish the need and level of environmental studies and assessments required to adequately determine the potential effects of a project on the affected environment
- Scoping exercise, a key activity that facilitates identifying the significant issues to be addressed in the EIA study, in consultation with the stakeholders
- Terms of Reference (TOR) for EIA studies developed on the basis of the scoping exercise which set out the basis for addressing the identified potential issues
- Environmental Analysis of the proposed project and reasonable, realistic alternatives as an accepted technical framework to assess predict potential impacts of the proposed project(s) and their significance on the affected environment;
- Mitigation Measures developed to avoid, minimize, mitigate, or compensate (in that order)for potential impacts of project(s), commensurate with their significance;
- Monitoring and Auditing programs developed to assess the actual impacts of the project in the field compared the predicted impacts and the effectiveness of the implemented mitigation measures to provide an opportunity for revisions of such measures, where necessary, during the life of the project.

To reasonably identify and predict the potential significant impacts of a project, adequate, relevant, valid, and reliable information on existing (baseline) conditions of the affected environment is necessary. Since 1998, U. S. Agency for International Development (USAID) has provided technical assistance to the Department of Electricity Development (DOED) of the Ministry of Water Resources (MOWR) to develop processes and procedures to prepare appropriate environmental documentation for hydroelectric projects in Nepal. International Resources Group

(IRG) is the implementing partner for USAID in this project titled Private Sector Hydropower Development Project (PSHDP).

Under an earlier USAID contract (PSHDP-1), IRG facilitated an inter-agency/stakeholder SWOT (strength, weakness, opportunity, and threat) workshop in March 2000 (MOWR 2000) that identified key issues with adequate environmental documentation for hydroelectric projects in Nepal. The SWOT workshop identified the following:

- Even though a good amount of baseline information is available at national and regional levels in Nepal, significant data gaps still exist at local/project level because of a lack of systematic maintenance and updating of reliable database of natural and physical resources. A lack of communication among Government of Nepal (GON) agencies and other stakeholders involved in collecting primary data also contributes to the issue.
- Poor baseline information and a lack of identification and evaluation of relevant and appropriate alternatives for the proposed project elements and activities lead to uncoordinated and sometimes, unnecessary and onerous mitigation measures, and monitoring programs. In several cases, an EIA report is prepared without fully comprehending its significance in the decision making process. Often, there is a lack of acceptable balance of technical, economic, and environmental constraints, which results in protracted negotiations among the stakeholders, delaying final approval of the EIA documentation and implementation of the project.
- Review of several EIA reports for hydropower development in Nepal has revealed that the information provided on the methods used to collect primary baseline data is often insufficient and the accuracy and reliability of the data are often questionable. There are indications that appropriate methodologies and techniques are not always used in data collection and analysis. Consequently, the information on the baseline conditions of the affected environment collected prior to project implementation is often inadequate.

Following on from the findings of the SWOT analysis, under PSHDP-2, IRG conducted a one-day workshop of EIA practitioners in Kathmandu in December 2002 to examine in detail the current practice for collecting and analyzing data to describe the affected environment, the procedures for impact identification, assessment of impacts and their significance, and approaches for developing and implementing mitigation measures. The workshop identified the following issues in the current EIA practice:

- The baseline information and anticipated impacts developed in the EIA reports are not usually coherent. Often, impacts are described without relevant, related information on affected environment;
- Anticipated impacts, including cumulative impacts, are often predicted in a generic manner without quantitative analysis. Thus, the characteristics and significance of impacts as well as the basis for selecting the best possible alternative project features and mitigation measures are generally vague, and
- Significance of impacts and corresponding mitigation measures are not often related. All identified impacts are generally treated equal leading to mis-

directed resource utilization and a lack of development of relevant and cost-effective monitoring and auditing plans.

Nepali laws require that an adequate EIA be prepared for hydroelectric developments with an installed capacity in excess of 5 megawatts (MW). For smaller projects above 1 MW, an initial environmental examination (IEE) is required. Annex 1 shows flow-charts for preparation of EIA and the IEEs for hydropower projects in Nepal.
It is important to emphasize that preparing a relevant and focused EIA provides an opportunity for the project proponent or developer (Proponent) to work with the affected communities and other stakeholders to develop project features that may enhance the value of the project to all the stakeholders including the Proponent and result in accelerated and unhampered project implementation.

1.2 Need for the Manual

The workshop of the EIA practitioners concluded that a user manual providing a framework of methods for collecting baseline information, conducting impact analysis, and developing mitigation measures would assist the Proponents to prepare good environmental documentation. Such documentation would make the EIA process more robust, effective, systematic, coherent, and assist and lead to expedient approval process.

1.3 Objectives of the Manual

This manual has been prepared based on the recommendation of the EIA practitioners and relevant GON agencies. The key objectives of this manual are

- to acquaint project Proponents, EIA practitioners, and other stakeholders of the concept of the EIA process in hydropower development;
- to provide guidance on how to establish baseline conditions, identify and analyze impacts, and recommend mitigation measures for a balanced resources utilization;
- to educate the EIA professionals and experts with recent practices in EIA analysis; and
- to enhance the knowledge base of the stakeholders in order to improve the quality of EIA reports

1.4 Who Should Use This Manual

This manual is developed to assist project Proponents, EIA practitioners, consultants, EIA report reviewers, and relevant Government agencies to structure the EIA study and prepare appropriate environmental documentation. A number of related manuals have been published by the MOWR/DOED. These are listed on the cover of this manual and in the References section and provide more specific guidance on related processes and procedures. It is expected that the users of this manual are knowledgeable of MOWR's above referenced manuals and applicable environmental and development laws of Nepal and that this manual is used in conjunction with the referenced manuals.

1.5 When to Use This Manual

This manual may be used from the beginning of the project development process to establish baseline conditions, identify and quantifying impacts to the extent possible, analyze and determine the characteristic and significance of each impact, and recommend plans to mitigate any adverse impacts. The manual is meant for use as planning and reference document.

1.6 Resources and Time

Adequate and appropriately qualified human resources, time and financial resources are needed for baseline information collection. Impact identification, assessment of their significance, and development of mitigation measures are analytical in nature and may sometime require extensive consultation with stakeholders. Ill-conceived and inadequate environmental documentation result in significant rework and delays in the review process leading to delayed project implementation. Project Proponents should clearly understand the need, value, and cost-effectiveness of conducting a valid, relevant, and adequate environmental assessment in the first instance to ensure expediency of the approval process.

1.7 Limitations of the Manual

This manual provides a framework for collecting, analyzing, and interpreting the multi-disciplinary resource data to assist in developing and establishing a baseline conditions, techniques, and procedures skills for data analysis, impact identification and prediction of effects, and for developing mitigation measures. This manual provides outlines of the methods supported by established theoretical basis. However, this manual does not provide detailed methodologies to deal with the field methods and laboratory analyses for each resource, nor does the manual provide detailed/specific guidance to estimate magnitudes and significance of project impacts. For more advanced treatment of such technical details, the user is advised to consult relevant references. A non-comprehensive list of such references is included in this Manual.

2. AFFECTED ENVIRONMENT

2.1 Introduction

The Affected Environment in case of a hydropower project will include the river basin and the physical area or region where the project is located. The socio-economic effect of such a project, particularly if large, will transcend the river basin and the local area to regional and national levels. Baseline condition is defined as *the description of existing conditions in the affected environment at a point in time against which subsequent changes attributable to the proposed project are identified or predicted and confirmed by monitoring*. In other words, baseline condition provides the pre-project record. If a proposed project would affect existing resources that may be impacted by on-going project(s) in the vicinity, care should be taken to establish the affected environment accordingly to facilitate assessment of only the project impacts clearly. The EIA should address the cumulative impact of the proposed project on top of those impacts of the on-going projects on the existing conditions. Impact assessment of a project is generally presented as a comparison of the post-project conditions to pre-project records or the comparison of the effects of implementation of the project to conditions if the project were not implemented.

Baseline study refers to the collection of background information on the existing physical, biological, socio-economic and cultural environment of a proposed project area, including changes that are expected with projects already planned for implementation or under implementation. The following two broad methods are used to collect/supplement baseline information:

- Review and analysis of published literature (secondary data collection) and
- Field investigations (primary data collection).

Typically, project pre-feasibility or field reconnaissance and resource inventory studies, environmental documentation for similar projects in the vicinity or comparable areas, National and Regional Water Plans, National Master Plans for development and river basin studies provide valuable information on existing conditions at a hydropower project site. A review of published material is made to identify if any major legal, regulatory, environmental, or social issues or concerns would summarily preclude the development of the proposed project prior to initiating a detailed feasibility study for the project. If no fatal issues are identified, an environmental reconnaissance is made in conjunction with field studies for the project feasibility to gather necessary site specific information. Informal discussion with local communities and stakeholders (MOWR, 2001a) are conducted at this time to assist in developing the project features to identify and avoid potentially significant environmental impacts. The need for additional collection of data to establish baseline condition for a project should be clearly defined and implemented to provide the necessary information required to adequately address potentially significant issues in the EIA. A conscious effort should be made to justify the scope of work for field investigations to ensure the best use of the limited financial and technical resources available to the Proponents, GON agencies, and other stakeholders.

Typically, baseline information should be presented in a form that is useful to the decision-makers. The structure and contents of the description will vary according to the information collected, but the following guidelines apply in terms of their presentation (*Morris and Therivel, 1995*):

- Adequate, up-to-date, and reliable maps are generally useful and in some cases essential;
- Good photographs can be informative and may provide more information without large text;
- Analytical charts, graphs and tables can be very informative;
- Description of data collection methodologies, time of sampling, etc, add to the quality and reliability of information base and should be provided;
- Large volumes of primary data (e.g. local species lists) should normally best be placed in Appendices to promote flow of EIA report; and
- Data should be presented in a simple and, to the extent possible, in tabular fashion for ease of understanding by the stakeholders.

2.2 Description of Affected Environment

A description of affected environment includes the characteristics of the area in which the proposed project activities (during construction and operation) take place. This description should cover the study area, within which all effects, impacts, potential compensations and rehabilitation efforts would be made. The level of detail in the description of the study area should be concise and sufficient to convey to the stakeholders, reviewers, and decision-makers, the nature and condition of existing environmental resources that may be potentially affected by the proposed action. It is necessary to include, to the extent possible, changes that are reasonably expected to occur in the existing environment, prior to the initiation of the proposed action, so that effects of the proposed action may be better assessed.

An approach commonly adopted in describing the Affected Environment in an EIA is the subdivision of the environmental setting into key resources. Data regarding each resource is commonly included in EIA. Typical resources described in the EIAs include, but not limited to, the following:

2.2.1 Physical Environment

a) Topography: General gradient of the river, slope of the banks of river, general terrain condition of the project area. Refer, topographical maps, LRMP, satellite imagery, district maps etc.

b) Geology: Geological setting, geological units and status of geological stability or instability, characteristics of surface deposit. Soil mapping and soil properties such as texture, depth, and permeability, and soil erosion.

c) Meteorology and Hydrology:

<u>Meteorology</u>

Climatic regimes, temperature, humidity, rainfall, and similar relevant data that may affect or be affected by project construction and operation

Hydrology

- Hydrological Cycle and Water Budget (Water Use)
- Water Depths, Regime Changes; flow duration data; flood data
- Surface water: Drainage basins and sub-basins, hydrological characters, water bodies and watercourses, classification of water bodies, flow regimes, identification of existing permitted discharges into surface waters.
- Ground Water: Distribution of water bearing formations, recharge area and potential, locations and depths of existing wells and consumption of ground water.
- Water Quality**:** Water quality of ground and surface water

d) Air Quality: Ambient air quality data,

e) Noise: Existing noise levels and sources of sound, vibration level and its sources.

2.2.2 Biological Environment

a) **Terrestrial Biotic communities:** Spatial arrangement of vegetative community types, , plant species abundance listings, major habitats and ecosystems, wildlife species abundance listing, records of rare, threatened, protected and endangered plant and animal species[1]

b) **Aquatic communities:** Nature of aquatic habitats, species abundance, listings for aquatic flora and fauna, macro invertebrates, fish communities, and ecological indexing of aquatic community data.

2.2.3 Socio-economic and Cultural Environment

a) **Demography:** Estimated population, Population characteristics, recent trends and projection for future population etc.

b) **Social setting:** Social structure of communities (caste, ethnicity, religion), social practices, housing and settlement pattern, in and out migration

c) **Gender Issues:** The role of women in society, their responsibility and the existing pattern of their participation.

d) **Infrastructure:** Roads, tracks, bridges, houses, telecommunication, post offices, electricity, water, sewerage etc.

e) **Institution:** Institutions and organizations (NGOs, CBOs, Govt. offices) and their functions

f) **Education:** Literacy level, education facilities and level etc.

g) **Community Resources:** Resources commonly used by the local community

h) **Economic Characteristics:** Income, expenditure, skill level, occupation, employment, market,

i) **Health and Sanitation:** Basic health and sanitation, nutrition levels, diseases and epidemics and health care facilities, drinking water supply, toilets etc.

[1] Avian community is often included under the heading of wildlife

j) **Cultural Resources and Practices:** Location and characterization of cultural resources (archaeological, historical, cultural landmarks, etc.) and cultural practices.

k) **Agricultural Practices: F**armland, type of agricultural productions and practices,

l) **Water Use Rights:** Existing and proposed **c**onsumptive and non-consumptive uses of river water (e.g. irrigation, municipal use, water mills, rafting, navigation, existing hydroelectric plants and others),

m) **Land Use:** Existing land use patterns (farmland, barren land, settlement, forest land) in sufficient detail to facilitate assessment of potential changes in land use because of the project implementation.

EIA practitioners often spend substantial efforts in collecting baseline information without their need and relevance to the project at hand. It is recommended that the practitioner collect baseline data that is clearly required to satisfy information needed to assist in the analysis to predict the impacts and to design mitigation measures. The TOR is developed to identify such information that is needed and should be collected; however, in certain cases, data mentioned in the TOR may not be sufficient for specific analysis or to assess new impacts not identified during scoping. Only in such cases, additional data collection may be justified. Thus, it is imperative that scoping exercise should be conducted based on as much information as is available and relevant. The scoping exercise should be thorough and complete to identify most relevant information that needs to be collected during the EIA study.

2.3 Approach and Methods to collect Baseline Information

2.3.1 Physical Environment

a) Topography

Much of the topographic data of project area would be collected generally during the engineering feasibility study of the project to design road access, land clearing and earthwork efforts, potential slope stability, landslides, and soil erosion within reservoir areas, near settlements, in river channels, and along and near project structures. Baseline data on slope stability, particularly in the Siwaliks and lower hills, may be important for transmission line alignment and would help in assessing potential effects of the project. Data such as topographical features, slope type, landslide prone areas, erosion pattern, rocky cliff, and river crossings would be helpful in EIA analysis. Only when necessary, additional information may need to be collected at specific locations to assess environmental impacts of project activities.

b) Geology

The baseline study on geology may be divided into three major tasks: desk study, fieldwork, and laboratory testing. A literature survey is usually made should determine whether the soils and rocks are likely to be in their natural state and if their characteristics would adequately provide foundation conditions needed to support proposed project structures and the reservoir that may be formed. If the area under consideration is rural, agricultural activity, deforestation, and site clearance may trigger erosion or landslides. In an urban environment, it will be important to determine if industrial wastes may have affected any part of the site. This kind of

information will be important in assessing the potential effect of project activities. Regional and local soil maps can be very useful in this regard. These maps are usually accompanied by explanatory booklets giving details of the local geology, vegetation and land use.

Field observation on color and texture provide clues to soil composition. For example: black or green-brown soil is likely to have high humus content. Yellow, orange, or red-brown soils may contain much iron. White soil may contain abundant silica, aluminum hydroxide, gypsum, or calcium carbonate. Professionals experienced in soil mechanics/geology would be able to identify such characteristics by simple observation and field inspection. Desk study and the fieldwork indicate whether there is a need for laboratory test.

Some measure of the water content of the soil will frequently be required. In practice, most workers use gravimetric analysis for soil moisture. Mineral soils will generally have 10-20% organic matter, while organic soils, such as peat, have 80% - 90% organic matter. The simplest method is to determine loss-on-ignition. High soil water contents and excess pore pressures are critical contributing factors to mass failures.

Much of the information is collected and studied to assess the engineering feasibility of the project structures, integrity of the reservoir and the river channels, and stability of embankments and slopes. From an EIA view point, it is necessary to determine at the scoping stage, the level of study needed to ascertain and assess project impacts. Sophisticated and specific measurements such soil P^H, Cation Exchange Capacity, soil nutrient status, heavy metals (e.g. lead, copper, zinc, cadmium, and chromium) and organic pollutants should be made only if they are required for specific impact analysis.

c) Hydrology

Hydropower projects usually do not have much consumptive use of water. However, hydropower projects require diversion of water from the river channel to the power house. Such diversions may involve intra-basin or inter basin water transfer. In all cases, river flow regime downstream of the project impoundment structure (dam, weir etc) is affected by the proposed project during initial filling of the reservoir and during operation if the project has daily, seasonal, or over-the year storage capacity. Also, stretches of the river immediately below the impoundment may experience permanent changes in flow regime affecting. Effect of such changes in water quality, quantity, and aquatic biota are important. Proposed project impoundment may also cause potential impacts upstream of the impoundment in the form of inundation of land, vegetation, settlements, and infrastructure (e.g. water intakes, fishing facilities etc), siltation of upstream areas and drainage channels, as well as cutting off natural river crossings and access for people and wildlife. Careful consideration should be given to collecting adequate site-specific data to assess project effects on resettlement, navigational, aquatic, and recreational resources while evaluating the socio-economic benefits of power generation, irrigation, and domestic and industrial water supply.

(i) Hydrological Cycles and Water Budgets

The land mass receives water in the form of *precipitation.* The land loses water by evapotranspiration to the atmosphere. Rainfall reaching the ground infiltrates into the

soil. However, if intensity of rainfall exceeds the soil's ability to absorb water, the excess water collects in depressions or runs down as *overland flow* through ditches and drains and into streams and rivers. Overland flow is a major cause of soil erosion. Individual land mass is open system with input and output that control water budget.

In many catchments in Nepal, the snowfields and glaciers are also significant storage sites. EIAs are largely concerned with *catchments* - a drainage basin bounded by a *watershed* (Miller, 2002).

(ii) Water Quantity and Water Use

Much of data on hydrology such as peak and low river discharges and monthly and seasonal distribution of river flows are collected as part of project feasibility. Usually, rainfall data from the nearest meteorological station and runoff data from nearby river gages are obtained for engineering study to estimate the power potential at a site. Data on daily, monthly, and seasonal low and high river flows as well as the probability of occurrence of such flows is required to conduct impact analyses in the main river stem and its channels and bypassed river stretches. Occasionally, site specific data is collected for engineering studies. Engineering studies also collect information on water uses such as abstraction for irrigation and water supply. This data is usually adequate for much of the environmental analysis of water quantity and water uses.

(ii) Water Depths and Regime Changes

Data on water depths in the stream and potential regime changes are required to assess effects of any hydropower project. For example, in case of a storage-type project, water discharged from the power plant to the receiving river may significantly decrease flood peaks but may increase flows particularly during lean periods, which may alter the riverine ecosystems and the aquatic habitats. Water depth measurements at sensitive sites such as by-passed channels, are necessary to analyze the effects on flora and fauna. Water depth data may also be useful to design location of mitigation measures such as fishing platforms, boating docks, swimming and other recreational areas.

(iii) Ground Water

Effect of large impoundments on local groundwater regime can be significant. Increase in groundwater levels because of impoundments may after foundations of existing structures but may likely improve agricultural production. In most cases, effect of impoundment is seen as possible increased flows through side sloughs and streams to the river channel downstream of the impoundment. Such effect may be minor in most cases except in case of significant reservoir level fluctuations or where significant existing settlements or sensitive agricultural lands are present near the proposed impoundment.

(iv) Role of vegetation in water budget

Water budgets are markedly affected by the vegetation canopy through interception, transpiration and infiltration. Coniferous forests and tall grass intercept 25-35 per cent of annual rainfall, broadleaved deciduous forests intercept 15-25 per cent and short and sparse vegetation intercept much less. Transpiration and interception together can

return over 75 per cent of rainfall to the atmosphere leaving 25 per cent to the ground (*Greig-Smith, 1983*). Infiltration capacity tends to be high where vegetation cover is good and low where vegetation is sparse (N. Robinson, 1990). Such data may be useful to assess potential high runoffs and low water flow where adequate flow measurements are not available.

(v) Watershed Condition

Watershed is a basic hydrologic unit and it is related to physical, biological and socio-economic components of the Environment. Proper management of the watershed is the concern of balancing of the utilization of the physical and biological resources for socio-economic development. Information on such parameters as drainage, silt load, forest cover, population density, and erosion potential would be useful for assessing specific impacts of the project. Such information may be obtained from topographical maps, land use maps, and satellite imagery and from site surveys (R.M. Solomon, 1982)

(vi) Water Quality

Development projects have considerable potential to pollute hydrological systems. While hydropower projects do not as a rule, contribute to pollution directly through discharge of effluents etc, effect of the project impoundment and operation on water quality parameters such as water temperature, dissolved oxygen, turbidity, suspended sediment and nutrient levels may cause potential impacts to upstream and downstream water users and aquatic biota. Consequently, water quality is an important issue to be addressed in EIAs for hydropower developments. The aspects of water quality that are most relevant in EIAs are briefly discussed below. Samples of water from strategic locations of the river should be collected for short periods during significant events (low flows, flood discharges etc) and analyzed in order to establish baseline condition on the physical, biological and chemical characteristics of the water quality of the river to facilitate comparison to predicted quality of water after the project implementation..

Oxygen Levels and Organic Pollution

Biological Oxygen Demand (BOD) is the amount of oxygen required for bacterial decomposition of organic wastes in water; usually expressed in terms of parts per million(ppm) of dissolved oxygen consumed over 5 days at 20ºC

Chemical Oxygen Demand (COD) is the measure of total depletion of Dissolve Oxygen (DO) in polluted water expressed as the equivalent amount in oxygen under fixed laboratory condition.

The level of dissolved oxygen (DO) in water has important implications for aquatic biological systems. Oxygen levels in natural water bodies vary considerably. Fast-flowing streams and rivers normally have high levels. Levels are lower in slow-moving water, such as in ponds and stagnant ditches. Large water bodies, such as lakes and reservoirs, have stratification of oxygen levels, with well-oxygenated water at the surface and lower layers with oxygen deficiency. Oxygen depletion can occur through organic pollution. Dissolved oxygen is consumed by the respiration of microbes that degrade the organic matter. Reduced oxygen levels indicate the increment of levels of potentially harmful substances. In hydropower projects,

potential depletion of oxygen in deep reservoirs due to heavy plankton growth and lower DO levels below the impoundment due to lack of aeration of power flows through long conveyance structures require proper assessments.

Thermal Pollution

Freshwater ecosystems have temperature regimes to which the aquatic life is adopted. Temperatures above the normal range can directly affect freshwater communities and can lead to oxygen starvation because increasing temperature promotes oxygen consumption by increasing the rates of animal and microbial respiration and reduces the amount of dissolved oxygen held by the water. In case of hydropower projects, thermal pollution arises from possible stratification of the impoundment and drawing water for power from low level outlets. Projects which draw water from well mixed lake surface would likely have low thermal effects on downstream users and aquatic biota.

Acidification

The pH of natural water varies considerably between sites. Acid deposition is now a major problem worldwide and many water bodies are currently highly acidic. The problem is aggravated through emissions of gaseous oxides of sulfur and nitrogen from fossil fuel, power stations and locally by deforestation. Low pH affects many freshwater animals directly. At low flows, the concentration of more dissolved materials tend to increase pH; whereas at higher discharges, rainfall or snowmelt, is rapidly converted into runoff and this reduces the concentration of base minerals, and thus decreases pH. Both alkalinity and pH should be measured to properly evaluate changes in water chemistry due to events such as erosion, variations in discharges, and human activities. Usually, acidification is a minor in hydropower projects with shallow reservoirs and run-of-river plants. However, care should be taken to collect such information as may be necessary to address any such potential impact from low level outlets.

Nutrients and Eutrophication

The main cause of environmental damage is Eutrophication. Aquatic systems become eutrophicated through the leaching of chemical fertilizers from soils, animal excreta, and effluents from sewage treatment works. Excessive Eutrophication may cause fish kills, increase drinking water treatment costs and since it usually favors the growth of algae at the expense of higher plants, it is generally perceived as an issue with standing waters (reservoirs) in rivers (*Good, 1987*). Reservoirs may result in eutrophication, particularly if significant vegetation/trees are not removed prior to reservoir filling. Hydropower projects also attract industrial and other users to the vicinity and the reservoirs are commonly the sources for municipal water supply and waste disposal. In designing data collection programs, care should be taken to ensure appropriate level of data collection to address potential issues of eutrophication.

Silt

Silt consists of fine organic and/or inorganic particles from agricultural and industrial activities. These may remain in suspension for some time or may sink to the bottom of the water body to become sediment. Silt, when present in high concentrations, can cause long-term effects. High deposition rates may progressively seal water bodies, isolating them from groundwater flows and changing the characteristics of the bottom

substrate. Fine sediment adversely affects benthic invertebrates, affects habitat availability to migratory fish species and increases hatchling and fingerling mortality. Reservoirs slow river flows resulting in siltation in the impoundment and upstream river reaches. Siltation in by-pass channels below the impoundment may affect benthic habitat. High concentration of suspended sediment can damage turbines in hydroelectric plants. It is usual practice to construct desiltation chambers to collect silt from power flows prior to passing the flows through turbines. These chambers are flushed clean periodically or continuously to dispose the collected silt into the downstream river or in land fills. Adequate data should be collected/generated to address these issues appropriately.

Heavy Metals

Metals like aluminum, cadmium, chromium, copper, lead, mercury, and zinc are concerns for aquatic ecology. Tolerance to toxicity frequently varies among species. Zinc, for example, is relatively non-toxic to humans but very toxic to a number of species of fish. Thus, levels of zinc acceptable in drinking water would be higher than those acceptable for fishery development. Most metals are more toxic at low pH and less toxic in hard water. Since, hydropower projects do not contribute such pollutants to the water, the impact of such pollutants is usually not significant except in cases where the river flows are naturally toxic and may exacerbate with storage. Usually, water quality tests to determine natural concentrations of heavy metals will provide adequate indication of potential issues, if any

(d) Air Quality

It is necessary to establish the baseline condition of air quality and climate in order to assess if they are likely to change in the future. Knowledge of baseline condition of air quality and climate are essential because development is likely to add some amounts of pollution in the area and these might exceed the air quality standards. This requires measurement of the ambient air quality at one or more locations in the study area so as to assess the amount of pollution present. Besides, data on activities that generate air pollutants such as burning of fuel wood and brick factories using coal need to be collected for assessing air pollutants.

The need to assess air and climate while carrying out an EIA is to know the levels and concentrations of chemical emissions, particulate matter, offensive odors, and any other climatic effects. There is a wide range of atmospheric pollutants with which the EIA may need to be considered. Pollutants commonly examined for their potential impacts include SO_x, suspended particulates (dust, smoke), CO, and NO_x. Ozone and volatile organic compounds (e.g. benzene) including polycyclic aromatic hydrocarbons, poly-chlorinated biphenyls, dioxins, and furans are receiving increasing attention, as they are toxic. Toxic chemicals (ammonia, fluoride, chlorine) and toxic metals (cadmium, lead) are of concern for specific industrial plants. Offensive odors can be a problem around proposed sewage treatment works (Buonicure and Davis, 1992).

The use of Respiratory dust sampler with an attachment of gas analyzer is common to investigate the ambient air quality and to monitor the levels of PM_{10} and TSP during pre-project stage, post-construction and operational stages and comparisons are usually made against these values with national and international standards.

Climatic indicators include temperature, relative humidity, solar radiation, precipitation, wind speed, and wind direction. All developments particularly the reservoir in the hills are likely to modify the microclimate to some extent, but in most cases the changes to local temperature, sunlight, and airflow are minor and are not considered in the EIA. Significant effects on sensitive environmental receptors can arise as a result of local changes in the frequency of weather extremes such as fog, frost, ice, precipitation and wind gusts.

In case of inter-basin water transfer and run-of-river type project, water temperature data are needed to assess the impacts of temperatures of mixed water on aquatic flora and fauna at the lower ends, if the water from the snow-fed river is transferred to the river originating in the lower hills and Siwaliks. This requires recording of daily water temperature, three times a day, at a couple of sites of both the rivers for at least one year. Mixed water temperature at the receiving river is then calculated on the basis of water discharge and the recorded temperatures. In case of hydro projects, air pollution is usually from restricted to construction activities and minor local climatic changes due to the impoundment and reduction of forestry that may cause reduced absorption of CO_2.

Table 1: Major Air Pollutants and their Sources

Pollutants	***Sources***
Sulfur dioxide (SO_2)	Coal-and-oil-fired power stations, industrial boilers, waste incinerators, domestic heating, diesel vehicles, metal smelters, paper manufacturing, fuel wood based cooking stoves
Particulates (dust, smoke, PM_{10})	Coal and oil and gas-fired power stations, industrial boilers, waste incinerators, motor vehicles, fuel wood based cooking stoves.
Carbon monoxide (CO)	Motor vehicles, fuel combustion, fuel wood based cooking stoves
Volatile organic compounds (VOCS), e.g. benzene	Petrol-engine vehicle exhaust, leakage at petrol stations, paint manufacturing
Toxic organic micro-pollutants and dioxins	Waste incinerators, coke production, coal combustion.
Toxic metals, e.g. lead, cadmium	Vehicle exhausts (leaded petrol), metal processing, waste incinerators, oil and coal combustion, battery manufacturing, cement and fertilizer production.
Toxic chemicals, e.g. chlorine, ammonia, fluoride	Chemical plants, metal processing, fertilizer manufacturing
Greenhouse gases, e.g. carbon dioxide (CO_2), Methane (CH_4) Ozone (O_3)	Fuel combustion, hydropower stations, coal mining, gas leakage, landfill sites Secondary pollution formed from VOCS and NO_x
Odors	Sewage treatment works, landfill sites, chemical plants, oil refineries, food processing, paintworks, brickworks, plastic manufacturing

Source: Department of Environment, UK, 1980

e) Noise pollution

Usually, noise pollution from hydro projects is likely during construction because of heavy machinery movement. During operation, noise pollution may affect operators working close to noisy rotating machinery.

Noise is defined as unwanted sound and consists of pressure variations detectable by the human ear. These pressure variations have two characteristics: frequency and amplitude. Sound frequency refers to how quickly the air vibrates or how close the sound waves are to each other (in cycles per second, or Hertz (Hz). For example, the sound from a transformer has a wavelength of about 3.5m at a frequency of 100H, and a television line emits waves of about 0.03m and whistles at about 10 KHz. The lowest frequency audible to human ear is 18 Hz, and the highest is 18,000 Hz. The human ear is more sensitive to 1 to 4 kHz octaves.

Amplitude is described in units of pressure per unit area expressed in terms of micro Pascal (Pa). Often the amplitude is converted into sound power, in picowatts (10^{-12} watts) or sound intensity (in 10^{-12} watts/m^2). Sound intensity is felt as the loudness of sound. A logarithmic scale of decibels (dB) is used.

The physical level of noise does not clearly correspond to the level of annoyance it causes, yet it is the annoyance caused by noise that is important in EIA (Morris and Therivel, 1995). The permissible standard of noise for the human ear is 70 dB.

Table 2: Sound Pressure, Intensity and Level

Sound pressure (Pa)	*Sound power (10-12 watt), or sound intensity level (10-12 watt/m2)*	*Sound level (dB)*	*Example*
200,000,000	100,000,000,000,000	140	Threshold of pain
	10,000,000,000,000	130	Riveting on steel plate
20,000,000	1,000,000,000,000	120	Pneumatic drill
	100,000,000,000	110	Loud car horn at 1 m
2,000,000	10,000,000,000	100	Alarm clock at 1 m
	1,000,000,000	90	Inside underground train
200,000	100,000,000	80	Inside bus
	10,000,000	70	Street-corner traffic
20,000	1,000,000	60	Conversational speech
	100,000	50	Business office
2,000	10,000	40	Living room
	1,000	30	Bedroom at night
200	100	20	Broadcasting studio
	10	10	Normal breathing
20	1	0	Threshold of hearing

Source: Morris and Therivel (1995)

The details of an EIA's baseline or ambient noise survey are usually determined from relevant legislation and discussions between the Proponent and the local people. A field survey would identify noise-sensitive locations and measure and describe the background noise in that area. Noise is primarily a local impact. Maps showing noise-contours may help to identify noise-sensitive locations (e.g. residence, hospital, school) in the area, but may need to be confirmed by a site survey (Canter, 1996). Information on vehicle movement and other sound producing activities are required to assess the level of noise at various sites. Typical operating noise levels for standard

construction equipment is available in the literature. A portable and battery-powered noise measuring equipment may be used for primary data.

f) Land Use

Prior to the project implementation, the existing land uses in and around the proposed project site has to be investigated to provide a through understanding of the effect of project implementation on the land uses. During investigation, it is worthwhile to estimate the area occupied by the crops, forest, rivers, or any other land use types in the project site. Since hydro projects may submerge large tracts of land under the reservoir and may require significant clearing land area for construction of project structures, it is necessary to collect adequate and accurate information on land use and ownership. For generating baseline information on existing land use patterns, the use of Land Use Utilization Report (LRMP, 1986), topographical maps and satellite imagery are recommended but for more detailed information, ground investigation, and consultation with land management personnel of Department of Land Reform of local government and the concerned stakeholders and land owners may be productive.

2.3.2 Biological Environment

a) General

The nature of the proposed development and its likely impacts, the size of the impact area, the time and resources available for investigation, and the degree to which environmental systems are being investigated are the major concerns of an ecological assessment. A desk study and site visit undertaken during the scoping exercise would provide assessments on:

- The direct and indirect impact area,
- The potential impact factors,
- Species, groups, habitats, communities, and environmental variables of EIA concern, and
- The methods of field investigation.

The impact area will depend on the location and nature of the project, and the surrounding area. In some cases, impacts may be confined to the project sites and the immediate surroundings, but factors such as air pollution, water pollution, and changes in the hydrological regime can have much wider implications.

A habitat survey seeks to provide a general description of habitat/vegetation types within a study area. Unless a good recent habitat survey already exists for the impact area, it will always be necessary to conduct a new survey.

A detailed survey seeks to provide further information, usually on selected sites. In a habitat survey, information on the species composition of communities is normally restricted to species lists. Although, these are useful, they give no indication of species importance in a community. For example, a species recorded on a site may be abundant or merely represented by a few individuals. A detailed survey involves the collection of quantitative data and information on the abundance of selected plants and animal species.

The investigation phase includes sampling and quantifying of the information available in the field. Information on the actual communities of plants and animals existing in the areas adjacent to the proposed project area should also be collected.

Table 3: Habitat Survey Methods

Aspects	Features
Aim **Scope**	Rapid survey to provide a record of natural vegetation and wildlife habitat. (a) Primarily designed for surveying large areas but applicable to specific sites and habitat types. (b) Largely restricted to vegetation and associated environmental features, e.g. of topography and substratum. Because animals are mobile, rapid surveys are considered practicable at this stage
Form **Survey methods**	Habitat classification and hierarchical types identified by standard color codes in maps. (a) Collection of existing information. (b) Field surveys based on Survey maps (1:10,000 or 1:25,000). Vegetation features, topography and substratum, ownership, management, and protection. (c) Aerial photography and satellite imagery.
Records retained	(a) Completed maps (usually 1:10,000 scale); and possible use of GIS. (b) A written report.
Limitations	(a) The maps are not 100% accurate. (b) Small sites may be omitted (c) Seasonal variations may be missed. (d) Species lists may not be complete and (e) Changes may have occurred since the first survey.

Source: Morris and Therivel (1995).

b) Sources of existing information

Habitat survey aims to make maximum use of existing information. The desk study is initiated at the scoping stage for baseline conditions. Potential sources of information are outlined below;

i) Maps

A good historical record can provide valuable information about the site. Historical information on sites may be available from the maps in libraries. Survey maps provide information on local topography, the location of forestland, and types of vegetation. Geological and soil survey maps can indicate the influence of substratum on land use, and on vegetation type in the area.

Aerial photographs and satellite images can help to identify land use patterns and vegetation types. Satellite images may also be available. LRMP can also be consulted.

ii) Published literature

Some information on plant and animal species and their distributions can be obtained from the Royal Botanical Garden and Natural History Museum. Further sources of information on certain species distributions, habitat requirements, and their conservation status (rare, protected, etc.) can be obtained from Department of National Parks and Wildlife Conservation (DNPWC), Department of Forestry (DOF), Worldwide Fund for Nature (WWF), The World Conservation Union (IUCN) and universities.

iii) Field surveys

It is essential that ecological fieldwork is conducted, or at least closely supervised, by an experienced ecologist who understands the principles and problems of sampling and is competent in identifying species. Mis-identification can be a major source of error, therefore different specialists may be needed for different plant and animal groups.

A field survey involves visual inspections to gain an overall impression of the habitats and communities. This can then be compared with existing information and be used to assess whether, where, and in what detail new survey work is needed. In many cases, an experienced ecologist can quickly decide the timing of fieldwork. Some groups (such as resident birds, aquatic macro invertebrates, trees, bryophytes, and lichens) can usually be sampled throughout the year. Accurate data on other groups can be obtained only during short sampling seasons, since most communities contain species that are short-lived, and some have components with distinctly different seasonality.

c) Vegetation

Assessments of the flora should include all vascular plants, bryophytes, thallophytes, lichens, algae, and fungi. The major vascular plants include a) plants with forestry values, b) plants with medicinal values, and c) plants with agricultural or food values. It is essential to employ experts who are both competent in the identification of the various groups and have some knowledge of their ecology.

Baseline studies of the flora should include information on both species and communities;

- all ecological assessments should include surveys in which major habitats and/or vegetation types are identified and described, and
- EIAs require more detailed data on the distribution and abundance of important plant species and plant communities, at least for selected sites.

Survey methods should aim to describe and classify vegetation as precisely as possible and provide detailed information on species and communities for future site monitoring and management purposes.

In principle, the study includes several community attributes such as vegetation and age structure, biomass, species composition, species diversity, species abundance and status of threatened, rare and protected species; but acquisition of new data on these often can be costly in terms of time and resources for majority of the EIAs.

Five important decisions should be made in planning a detailed field survey are: (sample size, sampling pattern, species abundance, relevant environmental factors, and methods of data analysis. The following descriptions provide useful sampling methods.

i) Sampling of Species and Communities:

Random Sampling: Observations are made at random points within the site or study area. Theoretically, it is the most statistically acceptable method and many

ecologists agree that it should be used whenever possible. It assumes that species have random distributions.

Systematic Sampling: This is the most cost-effective method for obtaining representative samples of a site or study area and for sampling community gradients.

Stratified Sampling: It involves the selection of study areas, and sampling each of these according to its size. It is useful particularly for large sites where adequate systematic sampling of the whole area is unnecessary or impracticable.

Selective Sampling: It involves the subjective selection of sampling points thought to be representative of a community type or to contain a special feature such as a particular species under study. This may be the only practicable method (*Greig-Smith, 1983*).

ii) **Number of Individuals**: Numbers are usually counted in quadrates and expressed as density (number per unit area) or population size (number in site or overall study area).

iii) **Cover (%)**: This is the percentage of ground occupied by a perpendicular projection into it of the aerial parts of the species.

iv) **Frequency (%):** This is the percentage of observations in a sample that contain the species.

Table 4: Vegetation Analysis

Basal Area (BA): Basal area is the space covered by the tree stem. The basal area of tree species having more than 4.5cm diameter at the breast height (DBH) is measured by using diameter tape. The estimation is made by computing the following formula;	
Basal Area (BA)	$= \pi r^2$ where r is $= DBH/2$ $= O.785\ (DBH)^2$
Basal Area Ratio	$\frac{\text{Basal Area of particular tree}}{\text{Total Surveyed Area}} = \text{x } 100$
Relative Density and Relative Dominance of Trees: The Relative Density (RD) and the Relative Dominance (RDO) are often analyzed in order to assess the current status forest condition.	
Relative Density:	$= \frac{\text{Number of individuals of the species}}{\text{Number of incividuals of all the species}}$
Relative Dominance:	$= \frac{\text{Total Basal Area of the particular species}}{\text{Total Basal Area of all the species}}$
Wood volume can be calculated by using following formula: Volume = ½ Basal Area x Tree Height = $\frac{1}{2} \pi r^2$ x Height (m^3/ha)	

Example of the vegetation analysis of the proposed project area included in EIA report are given in Annex 2 (size of the quadrate is 20m x 50m).

d) Wildlife

i) Terrestrial Communities:

In general, it is more difficult to sample animals than plants because animals generally move whereas plant is stationery. Consequently, quantitative study on animals are not attempted in many EIAs and hence they usually contain lists of mammals, reptiles, birds, butterflies and insects, and their habitats, seasonal movements, and status such as rare and endangered species present in the project area.

The ecological value of a site can be determined largely from the vegetation study, because most residents and visiting animals depend on vegetation for food and shelter. However, other factors such as climate also affect their distribution. Animals can influence plant communities. Rare, endangered, protected, threatened and endemic species of wildlife are often detectable only by a systematic faunal survey. Convention on International Trade on Endangered Species (CITES) and the IUCN's Red Data Book have developed criteria for threat categories; while the National Park and Wildlife Conservation Act *(1973)* has specified protected species in Nepal.

The types and quality of information on the fauna in an EIA are influenced by the nature of the development project and the types of habitat likely to be affected. Ideally, information gathered during the survey should include an accurate list of the species present, their location/distribution, the nature and extent of their dependence on the site and, if possible, an estimate of their abundance.

The fauna is usually diverse and often extremely abundant. A faunal survey must be selective. Compilation of animal species lists is requisite of habitat surveys. But, unless a site is already well-documented, even this can be a daunting task and neither existing data nor new surveys are likely to provide a complete list. A detailed study of animal populations is likely to be undertaken only in exceptional cases and a study of all the animal communities is not practicable in an EIA study

Field Survey Methods

Sampling insects and other terrestrial invertebrates can be difficult and time-consuming. Even a limited survey will yield many individuals and species. Specimens from a day's intensive sampling may require at least two days for identification, usually involving specialists if identification is necessary at species level. Techniques need to be carefully selected in order to document:

- full list of species,
- representative list indicative of all the communities present,
- list of notable species, and
- classification of animal communities as an indicator species.

Methods used for estimating Mammal population: Some mammals are protected by legislation. This should be checked before any survey is undertaken. For the purpose of an EIA, terrestrial mammals can be divided into two groups: large mammals and small mammals. Each requires different surveying techniques.

Large Mammals: It is possible to identify species by direct observation or by the identification of tracks, droppings, excavations, feeding, damage, and resting

locations such as sets, holes or nests. Some can be heard (foxes, deer) and others smelt (foxes). Within the scope of an EIA study, it is rarely possible to determine population sizes because this requires mark-recapture techniques. However, direct counting of communal groups can be achieved by recording the number of individuals emerging (*Begon, 1979*).

Small Mammals: The presence of small mammals is detected through nesting, burrows, feeding, fallen hairs, scales and spines, and by trapping them.

ii) Sampling methods for Avian Community:

Territory Mapping Method: This method can be used to determine densities, locations, and territories. It is best conducted during the breeding season when most species are territorial, and territories are often marked by signs, displays, and disputes with neighbors.

Transect Lines Method: This methods involves walking through transects of fixed length (e.g. 1 km., though this can be sub-divided) and locations (arranged randomly or systematically, e.g. as a grid), at a standardized speed (e.g. 2 km per hour).

Point Count Method: This method involves randomly located points from which observations are made. It can be useful in small sites and heterogeneous vegetation; and permits good analysis of the associations of bird species.

Plot Less Method: This method involves the selection of observation points in relation to specific aims. This can be useful in the study of scarce species that tend to be neglected by the other methods (*Bibby, 1980*).

iii) Aquatic Community

Rivers and Streams:

Most natural rivers and streams are characterized by three interconnected zones: the channel, the hyporheic zone, and the river corridor or floodplain. On the river system, there are seasonally drying streams, both vegetated and non-vegetated floodplain, backwater, swamps, marshes, secondary channels and ditches. Each of them has distinct habitat characteristics.

The channel is the most obvious part of a river and typically supports aquatic plants and invertebrates, which are restricted to flowing water habitats. Channel habitats, which are often poorly appreciated or ignored, include bare mud and shingle bars, backwater, riverside cliffs, and overhung or wooded sections. River channels are frequently an important fish habitat.

The hyporheic zone is a part beneath the river, an area where water flows through the gravels or rocks below the channel base. This zone is often neglected in river assessments. However, in many rivers, particularly those with a gravel bed, it can be a major habitat for invertebrates.

Natural and semi-natural river floodplains are rich and complex habitats, which can support a wide range of natural communities of plants and animals (*Morris and Therivel, 1995*).

Aquatic flora has three primary categories: a) free-floating or planktonic, b) plants attached to substrate and c) plants rooted into the substrate. Largely the physical features of the habitat determine the relative importance of these three categories. The aquatic flora components constitute phytoplankton, algae and macrophytes. Their species composition and distribution pattern are assessed in the EIA.

In addition, physical, chemical, and biological data are needed in order to understand how the freshwater ecosystem functions and to help predict the possible effects of the development. Many thousands of parameters could be measured for freshwater EIAs, so it is clearly important to choose those most relevant to the study area and the expected impacts.

Ponds and Lakes

Ponds are small man-made or natural water bodies. Many are important wildlife habitats, and they can have economic value as fisheries. The best ponds for wildlife generally occur in areas of semi-natural habitat. Ponds often support rich and/or distinctive communities of plants, invertebrates, amphibians and some contain rare or endangered species.

Like ponds, lakes may be man-made or natural. Lake communities may include a wide range of generalist species that can be found in many different freshwater habitats together with more specialized plankton plants and animals. The composition of these communities broadly reflects the nutrient status of the lakes. Lowland lakes are often nutrient-rich and can support a diverse fauna and flora. Unfortunately, many are now culturally eutrophicated, reducing their conservation value.

Survey data gathered about freshwater communities for EIAs is mainly intended to answer the questions such as "Is this area/site/species important or vulnerable?", “Is the project’s adverse or positive impact on the resources likely to be significant?” This typically focuses on e, assessments of fish stocks, their abundance and distribution, and habitat and flow requirements of rare and sensitive species that may be present at the site with a view to evaluate the floral and faunal conservation value, in terms of species diversity, rarity and community types and the effect of construction and long-term project operation on such resources.

For reference purpose, Annexes 3, 4, and 5 given in appendix provide the information on a list of protected plant species, a list of protected wildlife and a list of wildlife included in IUCN’s Red Data Book (1994).

2.3.3 Socio-economic and Cultural Environment

The baseline information on socio-economic and cultural environment is subdivided into the following;

a) Demography

While conducting the baseline survey, the following information on demography should be collected:

- Population size (including growth rate and density), structure, age group, sex ratio, and
- In and out migration patterns.

The above information should be related to the specific project area and then compared with the district as well as the regional level of information. Information on demography should either be extracted from recent census records, district profile or undertake house-hold survey to collect primary information of the proposed project area.

b) Social Characteristics

Information collection and analysis on social characteristics requires the following socio-cultural parameters;

- quality of life,
- social organization and structures,
- language, rituals, and general lifestyle,
- dispute-resolution institutions and processes,
- relationships between generations,
- value systems, and
- religion

MOWR, 2005 provides details of methods that may be successfully utilized to investigate the above social parameters,

Considerable socio-economic benefits accrue from growth and development and a key component of a country's growth and development is tied to its meeting its energy needs. Hydro potential is the only major, under-developed resource in Nepal. Its judicious development is a key to meet local needs as well as to earn precious foreign exchange through export of power. Hydro projects are generally located in remote areas away from large settlements and other developments. These developments open up green lands for development and may provide opportunity for remote settlements to be connected to their markets and to other developments. It is essential for the Proponent to appropriately assess the positive and adverse effects of a proposed project on the local communities as well as on major power demand centers.

The laws of Nepal require that socio-economic impact assessments of a project are incorporated in the EIA since people and their social relations and values are components of the environment and have strong linkages. Hence, the collection of information on population make up, social characteristics and their linkages with environmental resources is necessary, because social changes can affect physical and biological environment. Relevant characteristics that may be used to develop socio-economic profiles may include population make up in terms of ethnicity, gender and disadvantaged groups, their occupation, and economic status. Another aspect of collection of social information is to identify the resource utilization patterns. People utilizing resources in such an area can be broadly categorized into three resource user groups. They are;

- Long-term residents with stable, low-energy and sustained-yield production systems based on knowledge traditional knowledge and practices well adapted and compatible with the environment,
- New settlers with comparatively less knowledge of the resource base of the area and of sustainable resource-use practices who usually make excessive use of biophysical resources; and
- Non-resident or transient population who visit the area for work, exploitation of physical and biological resources, and are who may impose severe constraints on local facilities and services.

Special consideration should be made to investigate the numbers and the types of indigenous/tribal people, low-caste, ethnic minorities, and disabled or otherwise disadvantaged communities in the project area. The population's economic and social levels, technical trades and skill level should also be determined along with available infra-structure such as roads, schools for locals and transient population, local housing, boarding and lodging facilities, and medical services for large scale labor influx etc.

Religion may be one of the factors in a society that determines the composition and distribution of members of the community. While conducting social survey in the project area it is advisable to i) identify the religious groups, ii) the degree of their harmony to each other, and iii) possibility of conflicts arising in the matter of resource sharing.

c) Water Use Rights

A Proponent obtains an operating license from the MOWR to develop a hydropower project with installed capacity greater than one MW. The operating license provides the Proponent with water use rights for power generation. It is essential to ensure that the local water users are clearly identified and educated of their rights and the rights of the Proponent.
Typically, water users along a bypassed channel or along the downstream river stretch of a diversion may suffer reduced river flows in traditionally used stream stretches, particularly during dry seasons. During the baseline survey following information may be the most pertinent to collect:

i) Number of villages (with population) located downstream that are likely to be affected due to water diversion

ii) Per capita water requirement for domestic use

iv) Irrigation, drinking water, water mill and hydropower schemes that are in operation or under-construction or are being planned in near features with their water requirement for each

iv) Fishing activities

v) Other uses of water at downstream are cremation sites, religious bathing places, washing, drinking for animals etc.

If possible the quantity of water required for use by local people residing in the downstream area and the contribution from tributaries flowing into the main river,

that augmenting the river flow during the dry months, should be estimated. The analysis of this information would provide an indication of the amount of water that may need to be released down stream to ensure riparian rights are not compromised. In addition, Nepal's laws require that a minimum of 10 percent of dry season flow is required to be released in any bypassed channel to maintain fisheries below the impoundment. .

d) Cultural Resources

Cultural resources refer to resources with archaeological, historical, religious, cultural, and aesthetic values. Cultural resources are a part of the resource base; it is therefore important that the development options under consideration are screened for potential impacts on cultural properties. Land clearing for project structures as well as reservoir impoundment may affect existing/buried cultural and religious artifacts. As a first step in the EIA process, it is essential to check whether the area contains UNESCO World Heritage Sites or listed in national inventories of cultural resources. Agencies like museums, universities, the Department of Archaeology and other relevant agencies should be consulted (*UNESCO, 1972*) to provide relevant information. Site investigation may provide information on sensitive religious sites, cemeteries etc.

e) Health and Sanitation

The links between impact on health and impact on social environment are apparent. Often, environmental degradation is linked with impact on health. Impact on health depends on habitat changes causing increased vector densities and/or increased likelihood of contact between the vectors and human. A common example is an increased incidence of foreign disease resulting from the influx of a large construction labor force. But assessing impact on public health is difficult

It will be prudent to discuss with local community leaders, Non-governmental Organizations (NGOs), and health care facilities regarding local sanitation practices and capability of available health services to meet existing demands. These entities may also provide valuable information on concerns of health with influx of large construction labor. The information should be analyzed to assess the potential effect of the proposed action. For example, stagnant water pools can enhance the breeding of mosquito vectors, thus increasing the incidence of malaria in the area, and construction workers might bring in new diseases. In addition, the project construction may release waste oil and possible toxic pollutants into local water bodies and groundwater. The capability of existing hospitals and health centers to handle all kinds of possible diseases including accidents, should be analyzed.

f) Local Economy

In the baseline survey of the proposed project area, the primary sources of local economy should be identified. The economic bases in rural Nepal constitute;

- *local Industries*: In some of the cases, small industries are also present. Income generation from such industries, and the employment provided to the local people should also be noted,

- *employment*: Some indication of household income generated through the employment of the local people at local, regional, national levels, including the employment outside the country should be grossly estimated,
- *small businesses*: Shops, restaurants, hotels, and other forms of production from the local area generate substantial income for the local people and provide the employment opportunities to the local workers. This kind of economy of the local area should be investigated,
- *agriculture*: The land holdings of individual households, cropping patterns, types of the crops, vegetables and fruit trees, land ownership, manual or mechanized farming, type of irrigation, crop productivity, and yields should be investigated. The analysis should indicate food sufficiency for the local people, and
- *livestock*: In the majority of places in rural Nepal, livestock rearing is a common practice. Livestock produces manure for fertilizing crops. Farmers sell milk and milk products from cows, and goats and sheep for meat. While conducting the baseline survey, an estimation of the household income from livestock, type and number of livestock should be made.

The listing of the economic sources and estimation of the total income at the household level, and of the project area as a whole, becomes a benchmark of the status of the local economy of the project area (*Canter, 1997*).

It is essential to estimate the size of the labor force, the skilled manpower requirement, and the duration of their involvement. The requirement of manpower varies at different stages of project implementation. For example, the need for labor peaks at the mid-point of construction and then declines gradually. An estimation of capital expenditure on local materials and services is also required for economic evaluation.

A complete investigation of the labor force and the local economy requires information on: (i) the categories of labor available; (ii) the categories of labor that are in high demand and employed, not employed, or partly employed; (iii) estimation of unemployed labor; (iv) proportion of women looking for employment; and (v) the number and types of employment likely to be generated by project implementation. These data are required for analyzing and predicting economic impacts (Khadka *et al*, 1996).

g) Social Services, Facilities and Institutions

Social services and public facilities include local governments administration, services such as hospitals, drinking water supply, sanitation, schools and colleges, electricity and irrigation facilities, hotels, industries, trade and commerce, housing and security services, etc. Institutions are those, who provide the services to the local people. In the process of collecting baseline information, important social services, facilities, and institutions are to be investigated. Analysis of such services and institutions should be done in order to understand whether those services are efficient enough to cater to the existing local people, so that the proposition can be made for further extension of the services to accommodate the labor force coming from outside the project area during the project construction.

h) Community Forest

In most of the cases, the erstwhile designated national forests have been handed to the local forest community groups or Village Development Committees (VDCs) as community forest. Such action has transferred the control, management and utilization responsibility to the local forest community groups. While undertaking EIA, collection of some baseline information on community forestry located within or near proposed project site, is required to ascertain the following information:

1) The number and types of Community Forestry existing within the proposed project site,
2) The species of the trees and their harvesting status,
3) Number of people or communities involve in the operation, and the status of benefit and cost sharing,
4) The community forest groups willing to supply timber to meet project requirement at a reasonable price, and
5) Would the community forest groups need assistance from the project for tree plantation and protection activities

i) Gender and disadvantaged community issues

The concept of the gender and disadvantaged communities deals with sharing of the benefits and power among minorities and disadvantaged groups and emphasizes the partnerships and interdependence. Therefore consideration of gender and disadvantaged communities is important from beginning of EIA efforts. The following investigation and information collection are required;

1) Male and female, minority/majority communities ratio in the project area,
2) Total number of women/minority members capable of working (Age 15-59),
3) Literacy rate among the women/minority and number with higher education (above high school graduate) and skilled women/minorities,
4) Women/minority participation in decision-making project development and implementation,
5) The social attitude on the working of women/minority,
6) Women/minority organizations such as NGOs and Community Groups in the project area,
7) Women/minority willing to take the employment in the project,

MOWR, 2005 provides information on methodologies for undertaking baseline survey to address key gender issues in preparing EIA/IEE for Hydropower project.

3. IMPACT IDENTIFICATION

3.1 Introduction

Establishing appropriate baseline conditions of the affected environment facilitates the Proponent and stakeholders to identify the potential impacts of the proposed action. It is essential that the potential impacts of the proposed project on environmental resources are identified early in project assessment. The first step in identifying potential project impacts involves a desk analysis of the information collected from literature search, pre-feasibility studies, site reconnaissance, and informal discussions with stakeholders. A formal required step to identify and document the potential impacts and to assess their magnitude and significance is the preparation of Scoping and Terms of Reference (TOR) documents (MOWR, 2001b, 2001c, and DOED 2005).

It is important to note that impact identification is a core activity in the EIA process. Care should be taken to identify potentially significant impacts and not include sundry unimportant impacts since analysis of impacts and their significance (Sections 4 and 5) is based on the identified set of potentially significant impacts. The results of the analysis may get skewed if inadvertently a large number of insignificant or irrelevant impacts are identified. Qualified environmental professionals should undertake the task of impact identification (and assessment) to ensure complete and adequate identification of potential impacts and to facilitate stakeholders' acceptance of the effort. A number of methods are available to help in identification of environmental impacts of project development. Several of the methods provide a structured framework to identify and assess impacts.

3.2 Methods used to identify impacts

Typical methods used to identify a project impacts include use of a) checklists, b) matrices, c) networks, and d) overlay mapping. Checklists are simple to devise and easy to use and provide descriptive and subjective data. Matrices provide more complex inter-relationships of potential impacts from project activities on environmental resources. Network analyses represent a cause-effect description of project actions and effects. Care should be exercised in the selection and use of methods to identify impacts. It should be emphasized that experienced environmental scientists and engineers be consulted prior to developing checklists, questionnaires etc in order to focus on identifying relevant and realistic project impacts and avoid gathering information on non-significant resources and impacts.

3.2.1 Checklists

Checklists in different forms are very much in use as a data collection method for EIA studies. Usually, checklists consist of environmental factors, which may be affected by project activities or project components. Checklists can range from simple lists of items to more complex variations, which incorporate guidance on the scaling and weighing of impacts. Broadly, there are two types of checklists used frequently in impact identification.

a) Simple Checklist: These checklists contain only list of environmental factors and are very simple to use. The simple checklist focuses attention only on those factors, which have to be considered for EIA analysis. Their use ensures that a particular factor is not omitted from analysis. In essence, these checklists act as an *aide de memoir*. However, they do not give

any guidance on how impacts should be assessed, and they do not advise the type of predictive technique to be used and the type of data required. Typical checklist of resources that may be potentially affected by a development is given in Table 5.

Table 5: Typical Project Simple Checklist

Resources to be affected	Construction Phase			Operation Phase		
	Adverse Effect	No Effect	Beneficial Effect	Adverse Effect	No Effect	Beneficial Effect
A. Physical Environment						
a. Air/Climate						
b. River Hydrology						
c. Water Resources/Quality and Quantity (surface water and ground water)						
d. Geology						
e. Soils (Stability, Slides)						
f. Land Use						
B. Biological Environment						
a. Terrestrial Fauna/Wildlife						
b. Aquatic Flora and Fauna						
c. Vegetation/Flora/Forest						
d. Habitat/Biodiversity						
e. Rare, Protected and Endangered Species						
C. Socio-Economic and Cultural Environment						
a. Population and settlement						
b. Gender issues						
c. Ethnic/Tribal/Disadvantaged Groups						
d. Education						
e. Land Use and Crop Yield/Livestock						
f. Local Employment/Income						
g. Public Health and Sanitation						
h. Community Facilities and Infrastructure						
i. Local Level Institutions						
j. Local Culture						
k. Religion						
l. Cultural/Archaeological Resources						

Source: Rau and Wooten, 1980

b) Questionnaire Checklist: This method includes a set of questions to be answered. The questions are listed under generic categories such as "terrestrial ecosystem" and "disease vectors". Those assessing impacts must attempt to answer the questions in all categories. There can be three answers, depending on how much is known about the particular impact under consideration. For example, if it were known that an impact was likely or unlikely, then the appropriate answer (Yes/No) would be marked. However, if insufficient evidence is available for a definite response, the "Unknown" category should be marked. This indicates that further work is needed to ascertain whether an impact is likely. Table 6 shows a small section of a questionnaire checklist.

Table 6: Part of a Questionnaire Checklist

a)	*Are there known disease problems in the project area transmitted through vector species, such as mosquitoes, flies, snails, etc.?*	*Yes*	*No*	*Unknown*
b)	*Are these vector species associated with:* • *aquatic habitats?* • *forest habitats?* • *agricultural habitats?*	 *Yes* *Yes* *Yes*	 *No* *No* *No*	 *Unknown* *Unknown* *Unknown*
c)	*Will the project provide opportunities for vector control through improved standards of living?*	Yes	*No*	*Unknown*

Source: Khadka et al., 1996

3.2.2 Matrices

There are several types of matrices used in impact identification and analysis in the EIA process.

a) Simple Matrix

The simple matrix refers to a display of project actions or activities along one axis, with appropriate environmental factors listed along the other axis of the matrix. When a given action or activity is anticipated to cause a change in an environmental factor, this is noted at the intersection point in the matrix and can be further described in terms of magnitude and importance. Many variations of the interaction matrix have been utilized in EIA. Simple interaction matrix used in EIA process is shown in Annex 6.

b) Leopold Matrix (LM)

This method was developed by Leopold *et al*. (1971) and has been successfully used for impact analysis of a wide variety of development projects. In constructing the matrix, each action and its potential for creating an impact on each environmental item must be considered. Where an impact is anticipated, the matrix is marked with a diagonal line in the interaction box. The second step is to describe the interaction in terms of its magnitude (M) in the upper section and importance (I) in the lower section of each box. The magnitude of an impact is represented by a numerical scale; it is described by the assignment of a numerical value from 1 to 10. The value 10 represents the highest magnitude and the value 1 represents the lowest magnitude, and values near 5 represent impacts of medium magnitude. Assignment of a numerical value for the magnitude of an interaction is related to the extent of any change (for example, if noise levels in a village were expected to increase by 20 dB (A), this is a large increase at night and may score 8 or even 9). The scale of importance also ranges from 1 to 10; higher the value, higher the importance. Assignment of a numerical value for importance is based on the subjective judgment of the multi-disciplinary team working on the EIA. Plus (+) or minus (-) can be used to show whether an impact is beneficial or adverse. An illustration of Leopold Matrix showing magnitude and significance of predicted impacts on a scale of 1 to 10 is given in Annex 7.

c) Modified Graded Matrix (MGM)

Lohani and Halim used another grading system in which relative weights are assigned to each development activity (Canter 1996). If the relative priority of development activity is determined, the total value of a particular activity is the sum of the vertical column represented by that in the matrix, multiplied by the priority value. Finally, the total value of all the interactions is the sum of all horizontal values in the matrix. This method is particularly helpful in identifying major activities and in defining areas where attention is needed most in the process of analysis. (Annex 7)

d) Impact Summary Matrix (ISM)

An impact summary matrix can clearly identify the potential impact areas, predict the impact severity, specify the corresponding mitigation measures, and help in the identification of agencies responsible for implementing mitigation measures. This kind of matrix is simple, covers all the aspects, and provides a complete overview of the EIA in summary form. Additionally, it provides an easy guide for decision-makers. For example, environmental impact summary matrix of Arun III Hydropower project is illustrated in Annex 8.

3.2.3 Network Method

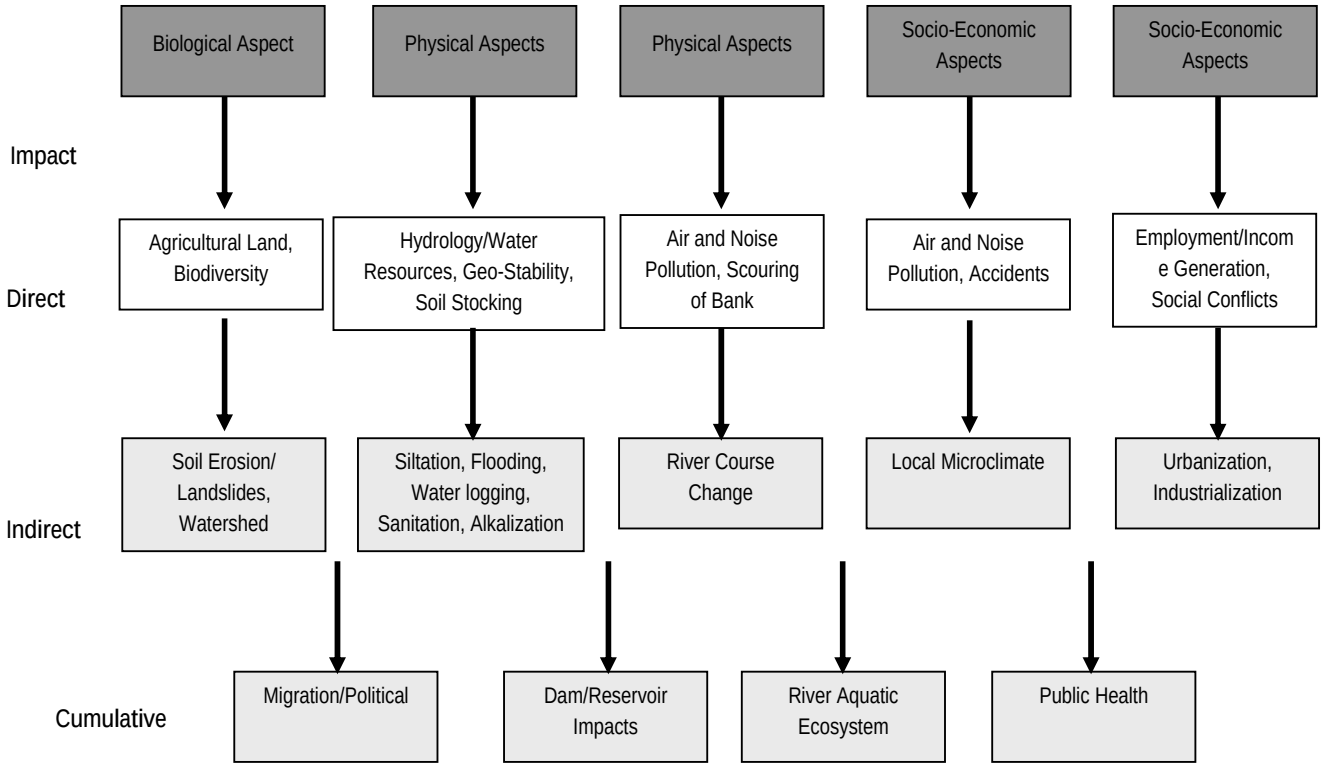
The network method of identifying project impacts begins with a list of project activities or actions and generates a network of cause-condition-effects (i.e., chains of events). This type of method is an attempt to recognize that a series of impacts may be triggered by a single project action. Hence, this method provides a "roadmap" type of approach to the identification of second and third order effects. The idea is to start with a project activity and then identify the types of impacts, which would initially occur. The next step is to a) select each impact, identify the impacts which may be induced as a result of the second order impact and b) select each of these impacts and identifies which may be further induced as a result. This process is repeated until all possible impacts are identified. Sketching this in a network form is commonly referred to as an "impact tree". One advantage of this type of approach is that it allows the user to identify impacts by selecting and tracing the events as they are expected to occur consequently, cumulative impacts could be predicted. (Table 7)

3.2.4 Overlay Mapping

Overlay mapping has a long history in a wide variety of planning activities. When EIA became mandatory in the United States in 1970, the potential of overlay maps to show the spatial distribution of impacts was soon recognized. McHarg (1968) first described the use of such a method of selecting highway routes by analyzing their impacts before the legal introduction of EIA in the United States.

This method was first used manually, now it is often computerized. A transparent overlay sheet is prepared as the base map, which shows the location of the project and considers the boundaries of the area in the impact assessment. A transparent overlay sheet is prepared for each feature that is to be assessed. The degree of the impact on each feature can be shown by the intensity of the shading taken from a specific black/white or color code. If an impact on a mixed deciduous forest were very serious, then the dark shading would be incorporated on the sheet. The forest may be used occasionally for recreation, and therefore the effect on recreation may be considered minimal. Consequently, the impact would be given pale shading, wherein it overlaps with the forest. Other areas used for recreation may be severely affected and would be given dark shading. The extent of an impact can be easily identified in the area covered by the transparency in particular shading. A representation of the aggregate impact of a project (impacts on all selected environmental features) can be obtained by overlaying each transparency on the base map. The aggregate impact on different areas is shown by the relative intensity of shading. The use of this method is gaining strength in the analysis of hydropower developments with the easy availability of Landsat imagery and computerized map. The method may become expensive for small projects.

Table 7*:* A Network of Impact Analysis of Road Construction in Nepal



Source: Khadka, R.B. et al., 1996

Table 8 shows a summary of the types of methods uses in the EIA process:

Table 8: Types of methods applied in EIA process and their relevance

SN	Process activity	Methodologies	Scope	Relative Usefulness
1.	**Description of the Existing Environment**	Matrices Networks Checklists	Simple Stepped Simple Descriptive	Low High
2.	**Impact Identification**	Matrices Networks Checklists	Simple Stepped Simple Descriptive	High Medium High Medium Medium
3.	**Impact Prediction and Assessment**	Matrices Networks Checklists	Simple Stepped Descriptive Scaling, rating, ranking	Medium Medium Medium High Low
4.	**Selection of the Proposed Action (based on evaluation of alternatives)**	Matrices	Simple Stepped	Medium Low
		Checklists	Scaling, rating, ranking Weighing-scaling, rating, ranking	Medium High
5.	**Study, Summarization and Communication**	Matrices Checklists	Summary Matrix Stepped Simple	High Low Medium

Source: Canter, 1997

4. IMPACT PREDICTION

4.1 Introduction

Prediction of impacts of a proposed action, of necessity, is based on the available data on affected environment including any field investigation conducted in accordance with the requirements of the TOR, project features, construction and operational information, and meaningful projections that may be done based on this data. Such prediction should be made in quantitative terms wherever possible based on an analysis of likely changes in the affected resources compared to their baseline conditions. In making such prediction, care should be taken to estimate the relevant future conditions of the affected resources if the proposed project were not implemented to ensure that impacts of the proposed project are assessed properly. Thus, project impact prediction should provide a comparison of environmental and social conditions with and without the proposed project. The "without project" condition is often termed as a "No-action" alternative. Such explicit comparison of potential project effects with a No-action alternative facilitates full appreciation of the project's beneficial and adverse impacts at a local, regional, and a national level.

4.2 Typical impacts of a hydropower Project

Typical impacts of a hydropower project comprising a high dam, powerhouse, transmission line and other infrastructure, include but not limited to:

<u>Anticipated Beneficial Impacts</u>

- Generation of power contributing to electrification of rural communities and fueling growth of local, regional, and national economy
- Creation of reliable water supply for drinking and irrigation, downstream fishery, navigation, improved water quality
- Creation of recreational opportunities in the impoundment and downstream
- Provision of downstream flood control
- Increase in economic activities in the local area during construction and operation of the project
- Increase in local, regional, and national job opportunities through industrial, commercial and other economic activities
- Infra-structure development such as roads, schools, and other facilities in the project vicinity (connecting producers and markets)
- Royalty payments to affected village and district development committees and the GON for focused developmental activities

<u>Anticipated adverse impacts</u>

- Displacement of local communities
- Loss of native fish species
- Loss of agricultural and forest lands

- Loss of wetlands, natural flood plains and wildlife populations
- Effect on endangered, threatened, and rare species
- Degradation of local water quality
- Decrease in river flow downstream because of changed flow regime
- Decrease/increase in downstream water temperature at different times in the year
- Change in silt load of river flows at different times in the year
- Decrease in concentration of dissolved oxygen in the reservoir and downstream flows
- Barrier to upstream fish migration
- Loss of valuable historical and cultural resources
- Decrease in aesthetic values
- Increase in seismicity

4.3 Characteristics of Impacts

Project impacts may be classified as reversible or irreversible. Reversible impacts are those where the original conditions of the affected resources are likely to be restored within a certain period of time upon the completion of project construction. Most impacts produced during construction of a hydropower project may be reversible. Irreversibility is the case where the resources impacted will not likely be reinstated or restored to the original condition; e.g. loss of habitat for endangered or rare species of fauna and flora, and land inundated by permanent reservoirs, land on which permanent infrastructure is constructed. The National Environmental Guidelines (NPC, 1993) are designed to assist with the prediction of the magnitude, extent, and duration of impact of a proposed action on the affected resources.

4.3.1 Magnitude of Impact

Magnitude of an impact is the scale, size, or level of impact on the affected resource. It may also indicate whether the impact is irreversible or reversible. A major adverse impact may be considered as one that would affect the potential subsistence, recreational, or commercial use of biophysical resources by reducing the value of those resources far below a publicly acceptable level. Moderate to minor unmitigated impacts may result in resources being still usable, but provide a lesser value to the public. The magnitude is often expressed as high (H), medium (M) and low (L) (NPC, 1993). The magnitude of an impact may not be considered high if appropriate and realistic mitigation measures are feasible. On the other hand, the magnitude of the impact may be considered serious if any adverse impact cannot be mitigated.

4.3.2 Extent of Impact

The spatial/areal extent or the zone of influence of the impact is an important characteristic that should be determined. An impact may be site-specific or limited to the project area; a locally occurring impact within the watershed of the project; a regional impact that may extend beyond the watershed; a national impact affecting resources on a national scale. The

extent of certain impacts may transcend national boundaries which for analytical purposes may be considered as having the impact at a national level.

4.3.3 Duration of Impact

Environmental impacts have a temporal dimension that needs to be considered in an EIA. Impacts arising at different phases of the project cycle also need to be considered. It is clearly not easy to categorize impacts as short-, medium, or long-term since the effects of different impacts over time is different. Impacts due to construction activities are generally considered short-term. An impact due to a temporary activity such as the filling of a reservoir lasting 1-3 years may be in some cases, may be felt for a longer term. Medium-term impacts may be classified as those that affect the resources over 8-10 years to attain stability through mitigation measures or natural recovery. Re-vegetation of cleared areas, adaptation of dewatered areas to new flow regimes etc may come under such classification. Mitigation measures including construction of improved infrastructure and socio-economic facilities may attain stability of operation during this period, where as the beneficial effects of such facilities may be permanent.

4.3.4 Significance of Impact

The assessment of the significance of impacts is the central requirement of any EIA report. It enables the Proponent to define and compare realistic alternatives and to provide a clear basis of choice of action for decision-makers. In order to make a systematic assessment of the alternatives, it is necessary to conduct a trade-off analysis, which typically involves the comparison of the preferred action and the realistic alternatives to a series of decision factors. The following approaches may be used to compare the alternatives:

- **Qualitative approach** where descriptive information for each alternative is presented
- **Quantitative approach** where quantitative information to the extent possible, for each alternative is presented.
- **Ranking, rating or scaling approach:** where the qualitative or quantitative information on each alternative is summarized through the assignment of rank, rating, or scaled values
- **Weighing approach where** relative importance of each alternative is assigned a weight for the decision factors
- **Weighing-ranking/rating/scaling approach** is a combination of the two approaches described immediately above where the relative importance of environmental factors or impacts is determined and numerical weights are assigned to each factor or impact. The assigned weightage is multiplied by the ranking/rating of each alternative; the resulting products for each alternative are then summed up to develop an overall composite index or score for each alternative.(Canter, 1996)

Despite the difficulty and variability of value assignment to natural and physical resources by different parts of the community and the nation, it is possible to assess relative significance of impacts using broad-based approaches that accept that

- Environmental impact significance is a judgment call in many instances;

- The significance of an impact on a resource depends upon the nature of the impact (type, magnitude, extent, and duration as well as the reversibility and sustenance of the resource for community use);
- The significance of impact is rated in terms of both physical, biological, and socio-economic and cultural values for today and longer-term future; and
- The significance of impact of the proposed project involves the amount of change to the overall environment perceived to be acceptable to the community in the context of cumulative changes that may caused by numerous development activities over time.

The purpose of impact evaluation is to assign relative significance to the predicted impacts associated with the project and, thus, determine the order of priority in which impacts are to be avoided, minimized, mitigated or compensated. This sequence is obtained from the perceived and real importance of the impacts to professional experts and stakeholders of the project.

The key elements for assessing impact significance include the level of public concern over the impact to specific resource, disturbance, disruption, or elimination of valued ecological systems or components of systems, the degree of beneficial or adverse impacts on social values and quality of life supported by professional and scientific analysis, where possible.

Evaluation of the significance of predicted impacts may be made in different ways, depending on a particular environmental resource or its component. For example, changes in the air and water quality can be assessed against established quality standards, whereas changes in land use, flora and fauna, or scenic conditions are more difficult to evaluate (*Sadar et al, 1994*). The key elements for assessing impact significance include:

- Level of public concern (particularly over health, safety, and loss of livelihood)
- Disturbance/disruption of valued and sensitive ecological and physical systems/resources
- Level of beneficial or adverse impact on social values and quality of life parameters
- National policy and vision for growth and development

A typical, non-comprehensive, list of criteria used to assess significance of resources is presented below:

Significance of physical, biological, and social resources depend on the perception and real values of existence of such resources as well as their value for the functioning of critical ecosystems and local and regional communities. Their significance is assessed in terms of:

- Effects on land use
- Availability of water and changes to river flow regime
- Effects on air and water quality
- Effects on plant and animal habitats
- Effects on rare and endangered species
- Effects on ecosystem resilience, sensitivity, bio-diversity, and carrying capacity
- Viability of local species' population
- **E**ffects on human health and safety

- Potential loss of agricultural lands, forestry, and animal species with current and future commercial values)
- Recreational or aesthetic value
- Demands on public resources such as social service
- Demands on transportation and other infrastructures
- Demographic effects

Environmental Standards

Environmental standards are among the most common means for assessing significance. These are criteria designed to contain certain environmental conditions within specified limits believed to be requisite to achieve social objectives (usually health related). Some examples are, limits on effluent discharge concentrations, clean air standards, water quality standards, etc.

5. METHODS OF IMPACT PREDICTION AND ASSESSMENT OF IMPACT SIGNIFICANCE

5.1 Methods of Impact Prediction

There are several methods available for predicting impacts on environmental resources. No prediction method is perfect, and new or improved methods are constantly being developed. Predictive methods are extrapolative or normative (relating to standards or norms).

Extrapolative methods are those in which the predictions are made on the basis of past and present data and which include trend and scenario analysis, analogies (transferring experience from elsewhere) and intuitive forecasting from specialist group consensus (Delphi Method).

Normative methods examine how the fulfillment of a desired target or standard is achieved. For example, if during construction phase a target set is to employ 50% of the local populace, meeting this target may require changing the project and associated employment policy.

In general, the prediction methods involve use of one of the following types of analysis:

i) Mathematical Models

Mathematical models are based on cause-effect relationships usually expressed in the form of mathematical functions. They may be simple input-output models or of complex dynamic types.

Such models necessarily make several, assumptions in the analysis Comprehensive models that provide a holistic approach to identify impacts of inter-related resources over long-term are rare and infeasible. Some land-use planning models attempt such approaches.

Mathematical models are divided into three types:

- Deterministic model is usually derived through fixed relationships. They are more commonly used in prediction of impact on socio-economic and cultural environment, for example, the economic multiplier in a project where the injection of money into the project area takes place and the impact on the economy of the project area is examined; many models used in hydro project impact predictions are of the deterministic type
- Stochastic model is a probabilistic type in which the impact prediction is based on the degree of probability of occurrence of a number of events in a given area and time; and
- A simple model termed a 'mass balance model' is usually applied for indicating the input from one component (of a project/activity) resulting in an output/change in another. If the inputs were water, food, and chemicals in one component, the outputs would be waste water and effluents flowing out into another component. Mass balance models are primarily useful for predicting impacts from industries or the manufacturing sector and may not be of significant use in assessing impacts of hydropower project except in special cases.

ii) Statistical Model

Statistical techniques such as regression or component analysis are sometimes used to indicate the relationship between the data and the test hypothesis. This technique is used successfully in forecasting river flows, particularly flood flows and low flows.

iii) Geographic Information System (GIS)

Satellite images, physical maps, and aerial photographs provide information on existing resources. Prediction of impacts of the development project may be made by analyzing the effect of project activities on the resources present in the location by using GIS techniques. This technique is useful in assessing effects of hydropower projects on land use, forestry, vegetation, wildlife, and fishery habitat.

iv) Field and Laboratory Experimental Method

Field inventories carried out prior to project implementation provide the baseline information on resources. For example, a fish survey in a river may indicate that a long-distance migratory fish species exists in the river. It could then be determined that the construction of a dam in the upstream part of the river might create an obstacle for the upstream migration of the fish for breeding. Such an impact would lead to the decline of the fish population in the area upstream of the dam unless appropriate mitigation measures are implemented.

Similarly, laboratory tests also provide some insight on the effects of certain activities on the resources and help in design/improvement of mitigation measures. For example, the application of pesticides may inhibit the growth of seedling of crops or proposed mitigation planting. The laboratory simulation tests would determine what doses of pesticides might inhibit the growth and what range of dosages would be safer.

v) Expert Judgment

Expert judgment refers to predicting the occurrence of an impact due to certain activities in a particular location, based on impacts that have already occurred in other locations with similar conditions and due to similar activities.

The experience from one location may often be transferred for application in similar places elsewhere, where detailed environmental data is not available for analysis. For example, experience of effects of infra-structure mitigation measures in one local community may be easily transferred for application at another project site. Decisions on anticipated impacts based on past experience are the result of conceptual models or analogues and are referred to as “expert judgments”.

The Proponent is responsible for ensuring that its environmental team members are adequately qualified and experienced in selecting impact prediction methods for the proposed project. It is necessary to keep in mind that the selected methods should produce acceptable, replicable, and consistent results and be adaptable and meaningful in the local context.

5.2 Uncertainty in impact prediction

When the impact of some activity is predicted, the assessor often gives the impression that it is certain to happen. However, all predictions have some elements of uncertainty. In resolving the question of uncertainty, the issue of probability of occurrence has to be addressed. Some of the predictions may be made with high (say 90%) confidence (e.g. the case of a new, well designed industrial machinery proven to emit a noise level of 65-70 dBA). This means that 10 times out of 100, the predicted noise level may be outside the expected range. However, much of the impact predictions on natural and physical resources as well as on local economy are difficult to predict with high confidence. Hence, there is a need to monitor the actual impacts and provide an opportunity for possible changes in mitigation measures over the life of the project.

5.3 Current practice to predict project impacts

Upon the completion of initial identification of impacts, a typical practice in Nepal is to conduct three well-timed meetings to obtain consensus of stakeholders on the potential impacts, their characteristics, and their significance. These meetings are attended by appropriate technical experts and stakeholders including affected/local communities. The process encourages involvement of all the stakeholders from the early stages of preparation of an EIA (MOWR, 2001a).

5.3.1 Preliminary Meeting (usually conducted as Scoping Exercise)

The Proponent and/or its professional representatives prepare and present the proposed project description and a list of anticipated impacts of the project to the Preliminary Meeting. The meeting(s) should be held preferably near the project site (MOWR, 2001). The Proponent should develop initial information package on the project features, realistic alternatives to be considered, identification of potential impacts, their significance (see Section 5), and preliminary mitigation measures (see Section 6) and distribute the information to identified stakeholders prior to the meeting. All identified stakeholders should be invited to the meeting. The meeting should discuss each potentially significant identified impact characteristics in terms of magnitude, extent, and duration, significance, and the proposed mitigation measures. The discussion should result in refining the prediction of significant impacts including additions or deletion to the list of potentially significant impacts, changes to the perceived significance of any specific impact, and options on mitigation measures. The preliminary meeting would ideally result in the preparation of a formal Framework of Impact Prediction (FIP) document.

5.3.2 Confirmation Meeting

The Proponent and its EIA team refine the potential impacts, their significance, and mitigation measures with additional field investigations and analysis as defined in the TORs and prepare a draft EIA report. This report should be appropriately distributed to the stakeholders prior to the confirmation meeting (which may be the mandatory Public Hearing required under Nepali laws). The FIP and the draft EIA report are discussed during the meeting. Comments, opinions, and recommendations provided by local communities, local authorities, NGOs, and other stakeholders in attendance should be solicited and recorded. Where relevant, such recommendations should be addressed in the final EIA report. To the

extent possible, confirmation meeting should solicit participation from stakeholders at local, regional, and national levels as appropriate.

5.3.3 Final Meeting

The Proponent's EIA team convenes a final meeting of experts to consider comments and recommendations received during the Public Hearing (Confirmation Meeting) and make the necessary modifications to the impact predictions, impact significance, and proposed mitigation measures and prepare the draft final EIA report for submittal to the DOED and onward transmittal to the MOWR and the Ministry of Environment, Science and Technology.

5.3.4 Assessment Framework

Impact assessment of a proposed project involves the comparison of a set of alternatives, relative to a series of decision factors (environmental resources) and is often referred to as multi-criteria decision analysis. In order to provide a simple and reasonably uniform framework for assessment of impact characteristics, the National EIA Guidelines (NPC, 1993) provides an Assessment Framework in the form of numerical scores for impact characteristics (Table 9)

Table 9: Impact Assessment Framework

Magnitude	Score	Extent	Score	Duration	Score
High/major (H)	60	Regional (R)	60	Long-term (LT)	20
Moderate (M)	20	Local (L)	20	Medium-term (MT)	10
Minor (L)	10	Site-Specific (SS)	10	Short-term (ST)	5

Scores for the characteristics of impact on each affected resource for realistic alternatives are summed up and multiplied by either an estimated probability of occurrence of each impact or by the ratio of the impact score to the total score (sum of scores of all impacts) of the alternative to calculate a relative impact score. The highest relative score would indicate a relatively greatest potential for environmental impact on the assumption that all impacts are equally significant. An example of assessment of anticipated adverse and beneficial impact characteristics of a typical hydropower project is shown on Tables 10 and 11 respectively.

Table 10: Example of assessment of characteristics of adverse impacts of a typical hydropower project

Anticipated (adverse) Impacts	Magnitude			Extent			Duration		
	H	M	L	SS	L	R	ST	MT	LT
Displacement of population	H (60)	-	-	-	-	R (60)	-	-	LT (20)
Excessive immigration	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Deterioration of condition of people	-	M (20)	-	-	L (20)	-	ST (05)	-	-
Increased health problem	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Loss of native fish species	-	M (20)	-	-	L (20)	-	-	-	LT (20)
Loss of agriculture and forests	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Loss of wetlands	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Loss of flood plains and habitats	-	M (20)	-	SS (10)	-	-	-	MT (10)	-
Loss of bio-diversity	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Water quality degradation	-	-	L (10)	-	-	R (60)	-	MT (10)	-
Reduced down stream river flow	-	M (20)	-	-	L (20)	-	-	-	LT (20)
Decreased temperature, silt, and nutrients	-	M (20)	L (10)	-	L (20)	-	-	MT (10)	-
Decreased O_2	-	M (20)	L (10)	-	L (20)	-	-	MT (10)	-
Barrier to fish migration	-	-	L (10)	-	-	R (60)	-	MT (10)	-
Loss of historic and cultural values	-	-	L (10)	-	L (20)	-	ST (05)	-	-
Increased seismic potential	-	-	L (10)	-	-	R (60)	-	MT (10)	-

Table 11: Example of assessment of characteristics of beneficial impacts of a typical hydropower project

Anticipated (adverse) Impacts	Magnitude			Extent			Duration		
	H	M	L	SS	L	R	ST	MT	LT
Electricity Generation	H (60)	-	-	-	-	R (60)	-	-	LT (20)
Water Resource storage	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Support to water supply	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Increased fisheries	-	-	L (10)	-	L (20)	-	-	-	LT (20)
Increased welfare of People	-	M (20)	-	-	-	R (60)	-	-	LT (20)
Protection of down stream due to flooding	-	M (20)	-	-	-	R (60)	-	MT (10)	-
Increased fisheries potential	-	M (20)	-	-	L (20)	-	-	MT (10)	-
Storage of water in low flow period	-	-	L (10)	-	L (20)	-	ST (05)	-	-
Navigation possibility	-	M (20)	-	-	-	R (60)	-	MT (10)	-
Sustained agriculture due to irrigation	-	M (20)	-	-	-	R (60)	-	-	LT (20)

5.4 Method of Determining Significance of Impacts

Typical steps used in determining the significance of impacts under current Nepali practice described below. The steps provide a structure for simple and uniform assessment of impact significance and incorporate slight modifications of the Leopold-Thanh approaches.

a) Predicting Anticipated Impacts

Following the National EIA Guidelines and using the three-stage meetings described in Section 5.3, each anticipated impact is characterized in terms of magnitude, extent, and duration. Examples of predictions of the anticipated impacts of a typical hydropower project are illustrated in Tables 10 and 11.

b) Determining Importance Weightage

Importance Weighing is perhaps the most structured approach to impact rating that permits a direct transformation of a sum of impact magnitude, extent, and duration into impact significance. Weightage may be determined by organizing a workshop of the stakeholders or the three-stage meetings discussed in Section 5.3. The following steps provide a workable structure for determining impact significance.

Step 1: Select a group of individuals (stakeholders, experts and local people) knowledgeable of the Weighing concept and the use of ranking and Weightage. Where required, the group members will need to be informed of the concept in order to make useful contribution to the process and to accept the outcomes.

Step 2: Prepare a ‘Determination of Weightage’ (Table 12) with columns corresponding to the range of values that can be assigned as a 'score of importance' to each impact area. The rows in the table correspond to the impact areas being ranked with regard to importance.

Step 3: Each member of the group carries out steps 4 through 9 in sequence until no further changes in the table entries are required by the group.

Step 4: Each member of the group places an 'X' in his/her chosen column for each impact area: e.g. a value of 5 for high weightage against the 'displacement of people', a value of 4 for upper medium weightage against 'loss of agriculture and forest', etc. (as shown on Table 9).

Step 5: The members compare their marked columns to ensure that the impacts are ordered on the proper scale, in their opinion.

Step 6: Each member then totals the scores for each impact.

Step 7: Each member then divides the value assigned for each impact by the total score obtained in step 6, to determine the weighing of individual impact.

Step 8: The moderator then compiles the overall (group) averages for each Weighing.

Step 9: The group results are presented to the individual members for review.

Step 10: Individual members are offered the opportunity to revise the scores based on based on the group finding using steps 4 through 9 until the group agrees on final weightage values.

Table 12 shows an example of importance weighing for a hydropower project.

Table 12: Determination of Weightage (sample calculation)

Anticipated Impacts	**Low**		**Medium**		**High**	**Member weightage**		**Final Group weightage**	
	1	**2**	**3**	**4**	**5**				
						Total	Wtg	total	Wtg
Adverse impacts									
Displacement of population					X	5	0.11	5.0	0.11
Excessive immigration			X			3	0.07	2.8	0.06
Deterioration of condition of people			X			3	0.07	2.4	0.05
Increased health problem		X				2	0.04	2.2	0.05
Loss of native fish species				X		4	0.09	4.0	0.09
Loss of agriculture and forests				X		4	0.09	4.0	0.09
Loss of wetlands			X			3	0.07	2.5	0.06
Loss of flood plains and habitats		X				2	0.04	2.0	0.05
Loss of bio-diversity		X				2	0.04	2.0	0.06
Water quality degradation			X			3	0.07	2.8	0.07
Reduced down stream river flow			X			3	0.07	3.0	0.09
Decreased temperature, silt, and nutrients				X		4	0.09	4.0	0.04
Decreased O_2	X					1	0.02	1.6	0.06
Barrier to fish migration			X			3	0.07	2.5	0.06
Loss of historic and cultural values		X				2	0.04	2.5	0.03
Increased seismic potential	X					1	0.02	1.0	0.02
Total (adverse impacts)						**45**	**1.00**	**43.6**	**1.00**
Beneficial Impacts									
Excessive immigration					X	5	0.15	5.0	0.17
Electricity Generation			X			3	0.09	3.0	0.10
Water Resource storage			X			3	0.09	3.0	0.10
Support to water supply				X		4	0.12	4.0	0.14
Increased fisheries			X			3	0.09	3.2	0.10
Increased welfare of People			X			3	0.09	3.4	0.10
Protection of down stream due to flooding				X		4	0.12	4.0	0.14
Increased fisheries potential									0.07
Storage of water in low flow period		X				2	0.06	1.5	0.03
Navigation possibility	X					1	0.03	1.5	0.03
Sustained agriculture due to irrigation	X					1	0.15	1.0	0.17
Total (beneficial impacts)						**29**	**1.00**	**28.6**	**1.00**

5.4.2 Prioritization of potential impacts for mitigation

Total impact scores (Tables 10, 11) multiplied by importance weightage (Table 12) provide a framework for identifying potentially significant impacts of the project and to identify and prioritize impacts for mitigation. The higher values indicate more detrimental effects of the adverse impacts, and the more beneficial of the positive impacts. The framework provides an

opportunity to improve project design to minimize the adverse impacts while maximizing project benefits.

Tables 12 and 13 provide an example of impact assessment and prioritization of mitigation measures using impact significance analysis. The most significant adverse impacts of this hypothetical project include displacement of population because of the project impoundment, effect on native fishery, reduced downstream flow, and deterioration of water quality. Priority should be given in the implementation of appropriate mitigation measures for these impacts. Other adverse impacts such as barrier to fish migration, decreased temperature, silt and nutrients, increased seismic potentials, etc, should be considered for mitigation commensurate with their significance.

Similarly, the most important beneficial effects of the project include the economic advantages of generation of electricity, preventing downstream flooding, and improved quality of life of affected communities. Effort should be made to maximize such benefits.

For small projects with low impacts, a separate calculation of weightage may not be necessary if all the impacts are minor. In such a case, the impacts are assumed to have equal significance. Prioritization of the impacts is, then, based on the descending order of impact scores. Selection of the preferred alternative is often based on low relative impact scores and may be adequate. It is important to note that such selection requires the consensus of the stakeholders for such action and recorded in the Final Meeting (section 5.3.3).

Table 13: Example of assessment of characteristics of adverse impacts of a typical hydropower project

Impacts	Magnitude			Extent			Duration			Total Score	Importance weighting	Significance impact (Total scores x importance Weighing)	Impact categorization
Anticipated (adverse)	H	M	L	SS	L	R	ST	MT	LT				
Displacement of population	H(60)	-	-	-	-	R (60)	-	-	LT(20)	140	0.11	16.0	I
Excessive immigration	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.06	3.2	VI
Deterioration of condition of people	-	M(20)	-	-	L(20)	-	ST(05)	-	-	45	0.05	2.5	VIII
Increased health problem	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.05	2.5	IX
Loss of native fish species	-	M(20)	-	-	L(20)	-	-	-	LT(20)	60	0.09	5.5	II
Loss of agriculture and forests	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.09	4.6	IV
Loss of wetlands	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.06	2.9	VII
Loss of flood plains and habitats	-	M(20)	-	SS(10)	-	-	-	MT(10)	-	40	0.05	1.8	X
Loss of bio-diversity	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.06	3.2	VI
Water quality degradation	-	-	L(10)	-	-	R (60)	-	MT(10)	-	80	0.07	5.5	III
Reduced down stream river flow	-	M(20)	-	-	L(20)	-	-	-	LT(20)	60	0.09	5.5	II
Decreased temperature, silt, and nutrients	-	M(20)	L(10)	-	L(20)	-	-	MT(10)	-	40	0.04	1.5	XII
Decreased O_2	-	M(20)	L(10)	-	L(20)	-	-	MT(10)	-	50	0.06	2.9	VII
Barrier to fish migration	-	-	L1(10)	-	-	R (60)	-	MT(10)	-	80	0.06	4.6	V
Loss of historic and cultural values	-	-	L(10)	-	L(20)	-	ST(20)	-	-	35	0.03	1.2	XIII
Increased seismic potential	-	-	L(10)	-	-	R (60)	-	MT(10)	-	70	0.02	1.6	XI
Total										950	1.00	65	

Figures in parenthesis indicate the rating of the impact prediction
Each of predicted impacts is categorized into magnitude, extent, and duration. Further, on the basis of extent of severity, impacts are classified as high (H), moderate (M), and low (L).
Under *magnitude*, (H) is irreversible, and (M) and (L) are minor with possible mitigation, and/or are reversible.
Under *extent*, Impacts are classified as site-specific (SS), Local (L), and regional (R).
Under *duration*, Impact is classified as short-term (ST), medium-term (MT) and long-term (LT).
Each of these categories is the translated into numerical terms as given in National EIA guidelines (NPC, 1993)
The total numerical values are summed up (maximum value is being 140 and minimum up to 35).

Table 14: Example of assessment of characteristics of beneficial impacts of a typical hydropower project

Impacts	Magnitude			Extent			Duration			Total Score	Importance weighting	Significance impact (Total scores x importance Weighing)	Impact categorization
Anticipated (adverse)	H	M	L	SS	L	R	ST	MT	LT				
Electricity Generation	H(60)	-	-	-	-	R (60)	-	-	LT(20)	140	0.17	24.5	I
Water Resource storage	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.10	5.2	IV
Support to water supply	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.10	5.2	IV
Increased fisheries	-	-	M1(10)	-	L(20)	-	-	-	LT(20)	50	0.14	7.0	III
Increased welfare of People	-	M(20)	-	-	-	R (60)	-	-	LT(20)	85	0.11	9.5	III
Protection of down stream due to flooding	-	M(20)	-	-	-	R (60)	-	MT(10)	-	90	0.12	10.7	II
Increased fisheries potential	-	M(20)	-	-	L(20)	-	-	MT(10)	-	50	0.00	0.0	-
Storage of water in low flow period	-	-	M1(10)	-	L(20)	-	ST(05)	-	-	35	0.14	4.9	IV
Navigation possibility	-	M(20)	-	-	-	R (60)	-	MT(10)	-	90	0.05	4.7	V
Sustained agriculture due to irrigation	-	M(20)	-	-	-	R (60)	-	-	LT(20)	100	0.05	5.2	IV
TOTAL										740	1.00	77	

Figures in parenthesis indicate the rating of the impact prediction
Each of predicted impacts is categorized into magnitude, extent, and duration. Further, on the basis of extent of severity, impacts are classified as high (H), moderate (M), and low (L).
Under *magnitude*, (H) is irreversible, and (M) and (L) are minor with possible mitigation, and/or are reversible.
Under *extent*, Impacts are classified as site-specific (SS), Local (L), and regional (R).
Under *duration*, Impact is classified as short-term (ST), medium-term (MT) and long-term (LT).
Each of these categories is the translated into numerical terms as given in National EIA guidelines (NPC, 1993)
The total numerical values are summed up (maximum value is being 140 and minimum up to 35).

6. IMPACT MITIGATION

Impact mitigation comprises recommended actions that would minimize, mitigate (offset), or compensate for the potential adverse impact on environmental resources resulting from a proposed project. While avoidance of any impact is a target for every development, the objectives of impact mitigation is to minimize or mitigate (provide offsets) for undesirable impacts while maximize project benefits. Cash compensation may be considered as the mitigation of last resort. In the following sections, the term "mitigation measures" is used to indicate such measures that are used to provide acceptable offsets for potentially significant and unavoidable impacts resulting from the project. Mitigation measures are designed to provide both environmental and economic benefits.

6.1 Consideration of Alternatives

Consideration of alternatives is a key aspect of the EIA process. It involves an examination of alternative means of achieving the objectives of the project. The aim is to arrive at a developmental option that maximizes the benefits while minimizing adverse impacts. Typically, a hydropower project proposal should consider the alternatives of the following aspects:

- Project and reservoir size
- Location, type, alignment, and size of project structures
- Type of building materials; borrow and fill areas
- Project operations
- Construction period and schedule of critical activities
- Technology to minimize fish entrainment, re-aeration of turbine flows

Much of the alternatives analysis is done during project design. Specific alternatives identified during the EIA process to avoid or minimize project impacts should be carefully assessed and incorporated in the design where possible.

6.2 Impact Mitigation

6.2.1 Preventive Measures

While developing mitigation action plans, emphasis should be give to preventive measures which promotes improved environment management techniques and reduce the implementation costs. Preventive measures are the best way of achieving environmental sustainability in a project. Some potential adverse impacts may be reduced or eliminated before occurrence by introducing preventive measures. Examples of preventive measures include:

- Implementation of a health education program
- Development and continued implementation of a public awareness and involvement program
- Avoidance of any activities known to cause adverse effects
- Use of best construction practices such as safe shoring of excavations, building sediment traps to prevent contaminated water flows to the water courses, planting of tree cover etc

- Adhering strictly to codes of practice for construction of dams, roads, pipeline construction, and other earth work which have high potential for erosion and sedimentation,
- Development and implementation, in cooperation with local community, of an approved emergency management plan during project construction and operation
- Adhering to approved methods and procedures to transport, store, utilize, and dispose hazardous substances
- Scheduling construction and maintenance activities appropriately to avoid sensitive periods for fish spawning, flooding, slope erosion etc
- Use of local workforce to the extent possible to avoid burden on the local resources and services

6.2.2 Measures to minimize impacts

Through design, efforts should be made to minimize potential adverse impacts on environmental resources to the extent no mitigation measures are necessary. Following international and local best practices, meeting or exceeding prescribed environmental standards, as well as judicious monitoring of activities and refining practices, where necessary, would facilitate minimizing adverse impacts of the project without significant cost.

6.2.2 Mitigation Measures

Mitigation measures are the actions that are undertaken to provide in-kind offsets and alternatives to reduce the impact of significant and unavoidable impacts of the project. Mitigation measures may also include activities that enhance existing habitat, infra-structure, and services in the affected communities to induce the communities to accept development in the larger local, regional, or national interest. Cash compensations are only considered when in-kind mitigation measures are not realistic or infeasible. Typical mitigation measures used in hydropower project developments include:

- Creation of similar resources or habitats elsewhere to replace the loss in the project area.
- Providing land and other properties elsewhere to the affected community for loss of land, house or other properties in the project area.
- Rehabilitation of displaced settlement and community facilities.
- Maintaining minimum flows to meet riparian and other water rights and during certain sensitive times such as spawning
- Establishment of fish hatchery and stocking of fish in the reservoir and upstream areas
- Construction of recreational facilities
- Providing local employment and building or improving educational, social, and religious facilities to affected communities
- Providing free or low-cost electricity and access to reservoir to local communities

Usually, households losing their properties are required to be appropriately compensated according to prevailing laws and regulations.

In the case of displacement of people to a new settlement, a Rehabilitation Action Plan (RAP) may need to be prepared and implemented in accordance with applicable laws. In the case of deforestation, plan for an in-kind compensatory plantation should be made and implemented with the full participation of the stakeholders.

6.2.3 Corrective Measures

Corrective measures are usually part of international best practices designed to reduce the adverse impacts to acceptable levels and are not generally specified in an EIA as mitigation measures. The following are the examples of the types of corrective measures that may find application in any project:

- Installation of pollution control devices
- Control of air borne dusts
- Erosion control and re-vegetation on slopes
- Installation of an early warning system for floods in the downstream area
- Safe disposal of spoil materials
- Provision of Personal Protection Equipment to the workforce.

6.3 Implementation of Mitigation Measures

Estimated cost for the implementation of the recommended mitigation measures should be included in the EIA report. All proposed mitigation measures should be integrated in the project design so that these measures may automatically form a part of the construction and operational phases of the project.

Mitigation is not limited to one point in the process of assessment, but it follows logically from the prediction and assessment of the relative significance of impacts. The original proposal for a project design may be changed in the light of changes in proposed mitigation measures that occur as a result of consultation with local people and/or local authorities. The consideration of alternatives, the earlier scoping, baseline study, and impact identification may suggest further mitigation measures. At any time during project implementation, new types of impacts can be identified and appropriate mitigation measures should be considered at each time. The development of mitigation measures for the impacts identified is not limited to the project design or feasibility stages, but it may start from the very beginning of the project inception period.

Mitigation measures are proposed for each of the adverse impacts identified. For example, if certain activities in the project pollute the air quality then particular mitigation measures for such impacts should be designed. If road construction activities result in the disturbance of hill slopes, soil erosion and landslides may occur affecting the road itself. In such situations, appropriate slope stabilization measures should be identified and implemented.

There is a clear link between mitigation and monitoring the envisaged outputs and outcomes. Mitigation measures, therefore, should be devised with monitoring in mind. They must be clear enough to allow checking of their effectiveness. The use of a particular measure may also be decided on the basis of previous experiences of its relative effectiveness, which is based on previous monitoring activities in other relevant and comparable cases.

6.4 Examples of Mitigation Measures

The descriptions given above on mitigation measures include the principles and types to be adopted while developing mitigation plans for hydropower projects. However, a few examples of some major areas of concern are also presented here, in order to provide some additional knowledge base for those who will be using his manual. Some concepts and practice of designing mitigation measures are furnished in following sub-chapters. These topics have been chosen because they are often the most technical and difficult to implement. The Proponent must understand them fully in order to implement them effectively.

6.4.1 Physical Environment

(a) Geology

It is not possible to cover here all of the mitigation measures necessary to prevent erosion problems during and after project implementation, but the following general guidelines are of use;

- remove as little vegetation as possible during the construction phase, and re-vegetate bare areas as soon as possible at the final stage of construction and upon project completion,
- where possible, create gentle gradients and avoid steep slopes,
- install suitable drainage systems to direct water away from slopes,
- avoid creating large open expanses of bare soil since these are very susceptible to erosion, and
- if the development is near to a water body, silt traps may need to be installed to trap sediment and prevent damage to the freshwater ecosystems.

The main mitigation method against disaggregating of the soil is to keep each horizon in a separate pile. If the piles are to be stored for any length of time, they may need to be grassed over to prevent erosion. Some fertilizing and seeding of the soil, once it is put back in place, may also be necessary.

There are several possible mitigation measures against compaction both during and after the development, for example;

- use wide tires to spread the weight of vehicles,
- use a single or few tracks to bring vehicles to the working area, and
- till the area after compaction has taken place.

It is important to avoid runoff of liquid pollutants and if this is perceived to be a major problem, procedures for the containment of the pollutants on site must be considered. Airborne pollutants can have serious effects on soil chemistry and methods for the reduction of the emissions known to affect soils should be recommended.

It is most unlikely that a development can take place without having some impact on the soil. In some of these projects, impacts will remain even after suitable mitigation measures have been carried out. For example, it is relatively easy to mitigate against the effects of chemical disaggregating by keeping the soil horizons in separate piles and placing them back in the correct order, but it is much more difficult to protect the soil's natural physical structure.

Monitoring of impacts to test the quality of site restoration after a development is recommended, but is rarely carried out in practice.

6.4.2 Biological Environment

(a) Ecology

Mitigation can avoid, minimize, reverse, or compensate an impact. Care is needed to ensure that a mitigation measure does not generate another significant impact and measures proposed for the other components such as visual impacts, hydrological impacts, or noise should be examined to check that they would not create significant ecological impacts.

Two principles central to EIA policy on the environment are;
a) Preventive action is preferable to remedial measures, and
b) Where possible, environmental damage should be rectified at the source.

On these bases, the best mitigation measures should involve modifications to the project components rather than repair at the receptor sites or compensatory measures such as habitat re-creation. Modifications to the project can include adjustments to sitting area, site design (including boundaries and layout), and procedures employed during the construction phase, operational phase, and decommissioning phase. Early consideration of ecological constraints is highly desirable. A technique that can assist in identifying acceptable areas is mapping in which all ecological features within a selected area are mapped, perhaps with the use of overlays of GIS.

Linear developments such as transmission line and roads can have a relatively large area of ecological impacts. However, all the alternative routes of linear developments are likely to have various impacts and the best that can be hoped for is the selection of the ecologically least damaging option.

The site design may be modified in various ways, including those listed below;

- incorporation of features to minimize air and water pollutions and soil erosion,
- reduction of overall habitat/vegetation destruction,
- modification of the layout to avoid impacts on sensitive and valuable ecosystems, and to retain existing semi-natural vegetation,
- creation of buffer zones around the project, and
- location of the project components where they will have least impact.

Disturbance during the construction phase can be minimized by practices such as;
a) Restricting the extent of access roads, temporary buildings, and material stores,
b) Exercising care in the routing/sitting of these,
c) Using wide tires on vehicles, and
d) Restricting the size of vehicles and plants.

When destruction or serious damage to habitats and vegetation cannot be avoided, it may be possible to;
a) Restore general habitat conditions, or
b) Re-instate or create a vegetation community that bears some resemblance to the one that was lost.

Restoration is an option only in relation to temporary impacts. Reinstatement of the original communities is often difficult, especially if the site has been severely impacted. In practice restoration frequently means simply the reinstatement of vegetation cover. Moreover, the more natural and complex a destroyed or damaged ecosystem is the less chance there is of restoring its original richness.

In some cases, an ecologically valuable community may be established by natural regeneration and simply allowing this to occur may be considered an option. Natural succession to forest can take place quite rapidly, at least, when a soil is present and there are suitable species in the locality. The process can be inhibited by management such as grazing or mowing, or can be accelerated by tree planting, although care is needed to ensure that this does not itself create impacts. All the trees planted should be restricted to native species that are tolerant of local climatic and soil conditions. District forest offices, concerned VDCs, community forest users groups (in case of felling of trees from community forests) should be duly consulted while choosing types of sampling to be planted. It is considered good practice to use stock grown from seeds obtained from a local forest.

If permanent destruction of a valuable ecosystem is unavoidable, several compensatory options are available including;

- funding for the protection or management of local nature conservation or the purchase of new sites,
- enhancement of onsite areas that will not be built on,
- transplanting to onsite or offsite locations on similar soil, and
- habitat creation on sites of low conservation value.

(b) Terrestrial Ecology

The general principles and methods discussed (above) apply to both the flora and fauna of the terrestrial ecosystems, but some aspects of particular relevance to animals may be added. These are listed below;

- where possible, major construction and operation should be avoided during periods when individual species and/or species groups are particularly vulnerable,
- fences should often be erected around construction sites to prevent damage to adjacent wildlife habitats. However, it should be remembered that these involve disturbance and land-take and may act as barriers to animal movements, especially for mammals, reptiles, and amphibians,
- methods to mitigate the habitat severance and morality risk effects of roads include provision of underpasses for large mammals and small tunnels under roads for amphibians,
- disturbance by traffic and on-site activities may be reduced by the creation of buffer zones,
- deliberate re-introduction of species lost from a site is rarely practicable and disrupted communities can rarely be re-created. In relation to wildlife corridors, enhancement of the existing habitat and maintaining the continuity of existing links is more important than establishing new ones. Given the appropriate conditions within a habitat and the presence of nearby populations, most animal species will eventually re-colonize a site, and,

- enhancement measures also include the installation of artificial habitats to encourage the nesting of birds.

(c) Aquatic Ecology

Aquatic water bodies receive wide verities of the pollutants from the surrounding areas through project activities and affect the aquatic fauna and flora. Implementation of environmental mitigation measures includes the minimization of such pollutants entering into the water bodies in order to keep the aquatic system intact. A broad range of mitigation measures used to minimize or prevent the impacts on aquatic ecosystem is given in Table 14.

Table 15: Mitigation measures relating to aquatic ecosystem

Materials responsible for impact	Mitigation measures
Silt/Sand-enters into the aquatic body from construction activities	Install silt trap or desanding basin, or construct siltation pond/lagoons/ and use vegetated buffer zone
Organic matter, nutrients and salts	Minimize the soil disturbances, treat agriculture run-off, Install toilet with proper sanitation facilities
Heavy metals and toxic materials	Treat, recycle and reuse
Oils and lubricants	Install gully trap, construct bund or dyke around fuel and oil storage
Acidification	Control the use of flue gas at the power station, control the extent of forestation and modify the forestry practices
Heat	Cooling should be carried out before it enters into water Body.
Changes in the flow regime of the river	Try to maintain the river flow as natural as it is.
River Engineering	Maintain the river depth, flow, river course bottom sediment, active flood plain and flood regime
Physical loss or other damages	Degradation of semi-natural habitats should be reinstated
Disturbances on wildlife	Maintain and create buffer zone and restrict the working area

6.4.3 Socio-Economic and Cultural Environment

Mitigation measures to avoid / reduce/ mitigate / compensate impacts on socio-economic and cultural environment are complex and involve a wide variety of mitigative initiatives to be implemented to minimize the adverse effects and enhance the benefits, so that the people of project area do not suffer, rather the socio-economic and cultural environment of the existing area would improve substantially.

(a) Land Acquisition and Compensation

The first and foremost consideration has to be made on the matter of land take due to the project construction activity, since the loss of land is the loss of livelihoods of the people in the project area. In the process of project implementation local people will also lose properties including their houses and other infrastructure. Consequently the displacement of

local people may take place. In order to properly compensate and resettle the displaced people, formulation of a compensation plan for a land acquisition and resettlement should be made at the EIA stage. The following points are the basis for developing a plan for land acquisition and resettlement;

- determine how much land is required for placing project facilities,
- determine the number of the houses to be dismantled, the number of trees and orchards to be cleared, and the types of properties to be removed,
- categorize the private and national land resources and determine ownership with the consultation of the local people and cadastral maps available in the District Development Committee office. This will determine the ownership and the actual amount of land and other resources to be taken up by the project,
- classify the affected households in the following categories;
  - (i) household subsistence severely affected through the permanent loss of cultivated land and/or dwelling- Severely Project Affected Family (SPAF),
  - (ii) household subsistence is marginally affected through the permanent loss of agriculture land and/or dwelling- Project Affected Family (PAF), and
  - (iii) household subsistence is temporarily affected – land or dwelling to be taken in lease.

This information in the EIA report provides a basis for developing a compensation package and Resettlement and Rehabilitation Action Plan. The legal framework provided by Land Acquisition Act (1978) and Land Acquisition Guidelines (1993) should be complied with while developing such a plan and providing compensations.

(b) Drinking Water Supply, Sanitation, and Other Facilities

The project should guarantee the continuous supply of clean and safe drinking water to the people of the project area where the existing water supply schemes are likely to be disrupted. In other language, the project must install adequate and safe drinking water supply system to the outside workers. The amount of water available to the outside workers must cover drinking, and other daily household purposes. Similarly, adequate numbers of toilets and waste disposal systems should be established in the workers campsite for the outside workers. In addition to these, the local roads, trails, suspension bridges, irrigation canals, and other facilities that are likely to be affected by project implementation should be replaced, constructed, and repaired. Training of local users to maintain such facilities would assist in further increasing the net social benefits.

(c) Religions, Cultural Practices and Cultural Resources

The following broad category of mitigation measures to minimize the likely impacts on religion, culture practices, and cultural resources are recommended;

- the implementation of projects may disrupt the traditional kinship relations among the local people, therefore, the project has to design and implement some appropriate programs to maintain such harmony within the local communities,
- the disruption of community solidarity manifested through ritual ceremonies and festivals should be minimized by the implementation of appropriate programs,
- improved access to education and income generating opportunities of the local women would enable them participate in decision making in the community, and

- traditional craft practices in the project area may be affected and to maintain such practices in the project area some relevant programs should be launched.

Cultural artifacts may be present in the project area either in buried or in exposed form. These may be of archaeological/ historical value. In the case that such materials are found, the contractor should comply with following archaeological laws and rules;

- notify the relevant department of such findings,
- request a site inspection,
- completely halt the work until inspection results are received, and
- decide whether or not to proceed with further work.

If sacred religious shrines need to be relocated from the project area, the first thing to be determined is whether the shrines are of national or local significance. This has to be confirmed by consulting a national heritage registrar. If it is a national treasure the concerned department, relevant NGOs, and local people should agree whether relocation is possible. However such an intervention should be scientifically sound, locally acceptable, and nationally agreeable. If the shrines to be relocated are only of local significance, the local community members and NGOs should reach a consensus regarding how the relocation activity can be carried out.

Water is vital for many religious ceremonies. In a water diversion project this can become a major issue. Therefore, to minimize the effect of water scarcity for religious purposes and to maintain the quantity and quality of water in the river, the following considerations should be made;

- a minimum release must be adequate to fulfill the religious requirements and the needs of the downstream village communities, and
- a monitoring program must check whether this has taken place.

(d) Local Economy

The following frameworks of mitigation measures should be implemented to minimize the effects on subsistence and the local economy;

i) displaced households should be assisted to re-establish their farming practices as quickly as possible, through appropriate agriculture extension support.

ii) cash compensation for land losses should be subjected to certain conditions. A landowner may receive the remainder of his land entitlement in cash, if he qualifies for more than what is receiving as the land replacement. A landowner may request cash to buy replacement land, and the funds should only be released once the project management is satisfied that the purchase is adequate. Alternatively, a landowner may claim for a cash payment as compensation if he/she has an access to another viable form of income generation such as setting up a small cottage industry,

iii) Land temporarily acquired during the project construction period, should be taken in lease. The reasons for taking land in lease include;

    - most of the land to be acquired will be in good and productive land,
    - replacement land for the owner is not readily available in the project area,
    - leasing land may reduce the possibility of displacement of people from the project area, and

- people have expressed that they are not willing to leave the area.

The standard specifications for leasing of land and other properties will include;

- the form of payment,
- the frequency of payment,
- land protection measures during the lease, and
- land rehabilitation at the end of the leased period.

The market value of crops normally produced minus crop production cost and annual inflation adjustment will be basis for rent calculation per hectare/year.

iv) Persons with income capacity severely affected by the project implementation should be registered in a preferential employment category during project construction. Where required, a qualified local NGO should be appointed to assist such persons in the identification and implementation of other possible income generating activities.

(e) Construction Employment

The following measures should be taken while employing project-affected individuals and local people for project activities;

i) A preferential employment strategy should be established and it should contain procedures and mechanisms to enhance the employment of project affected households in unskilled, skilled, and semi-skilled job categories. The strategy should also specify the following for contractors and sub-contractors;
   - recruitment eligibility,
   - age requirements,
   - selection procedures,
   - education requirements, and
   - skill requirements.

   When local people are employed in different job categories, this should be accompanied by on-the-job training and skills transfer.

ii) Preferential employment guidelines should be incorporated into tender and contract documents. Contractors are required to follow these guidelines assisted by the project Proponent. The project Proponent specifically assists in i) establishment of database for job seekers, ii) the development of transparent job advertising and recruitment procedures, and iii) establishment of a recruitment committee with the representation from the project Proponent, contractors, and local people, and

iii) An information sheet in Nepali language should be distributed to the project and adjoining areas. This information sheet provides i) number of construction jobs available, ii) the selection procedures, iii) time for recruitment, etc.

(f) Minimizing Labor force Impacts

The following measures should be introduced to minimize the adverse workforce induced impacts and enhanced the benefits;

- priority should be for the employment of local people,
- provide international standards for work force accommodation facilities,
- provide standard facilities at the construction camps such as health services, water and sanitation facilities, and recreational facilities, and
- provide health program for construction workers.

6.5 Enhancement Measures

There are a number of other mitigation activities to be implemented during project construction and operation and they fall primarily into the following two general categories;

a) A Community Development Program consisting of the following activities;
   - improvement in water supply, sanitation, and health in downstream villages,
   - rural electrification, transport, and communication facilities,
   - other community development and income generating activities, and
   - specific training, capacity building, and skills transfer programs.

b) An Environmental Improvement Program consisting of;
   - preparation of catchments management plan,
   - identification of appropriate vegetation management strategies,
   - establishment of community forestry and nurseries,
   - fish hatchery and enhancement of fisheries in the area,
   - conservation activities and conservation education, and
   - specific training, capacity development and skills transfer programs.

Based on the type and size of the project to be implemented, the above program should be elaborated in the EIA report and implemented during construction.

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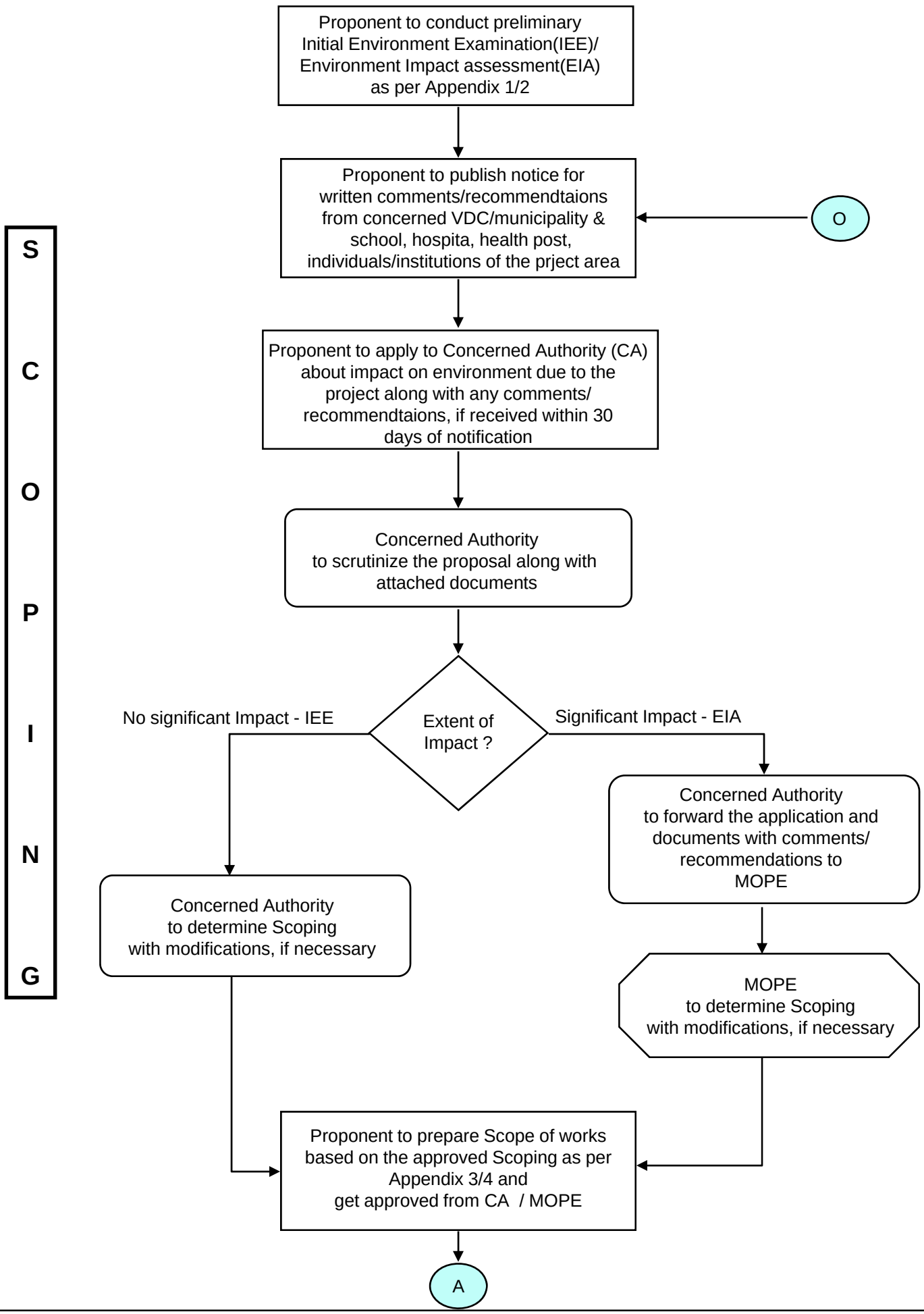
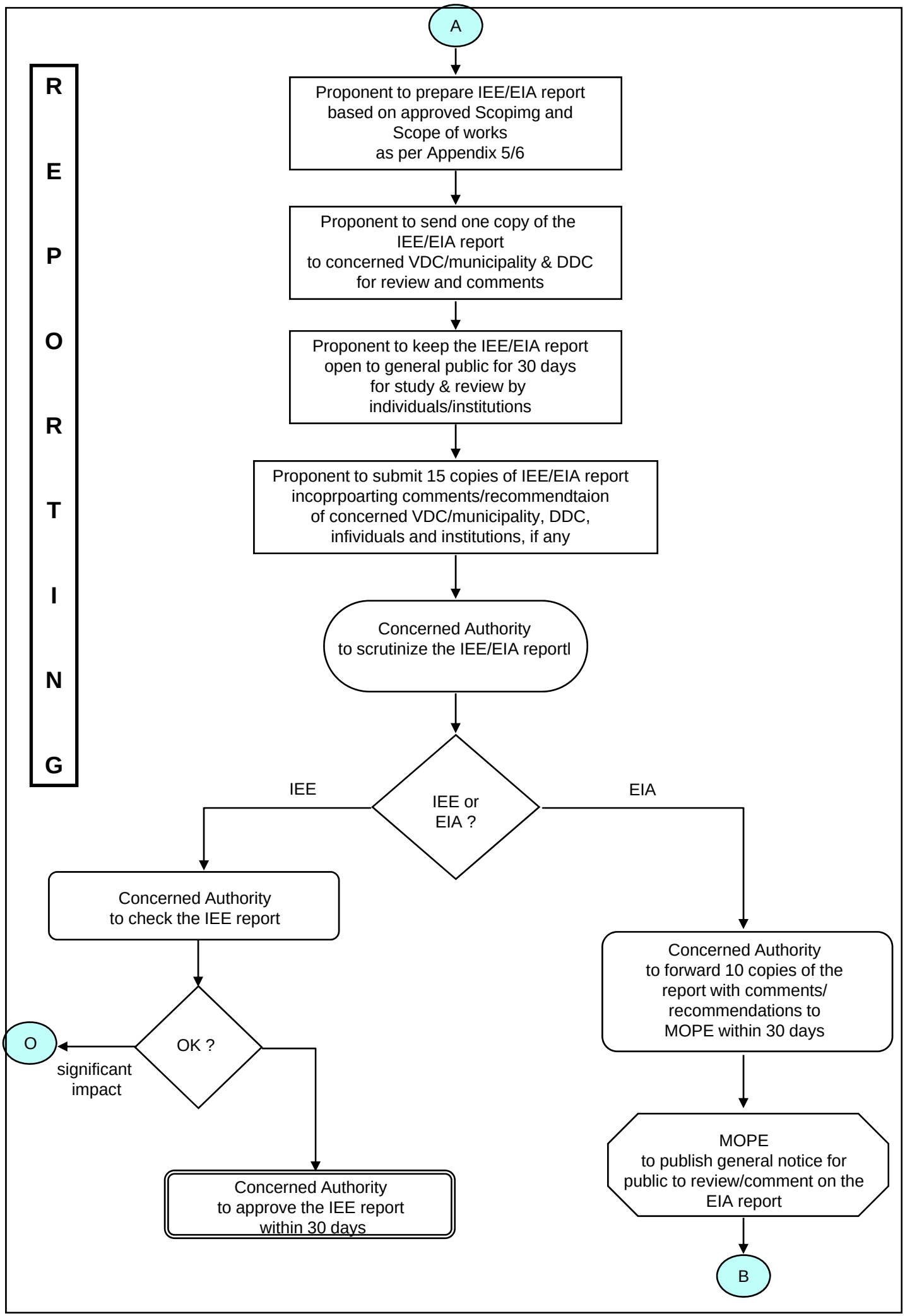
ANNEXES

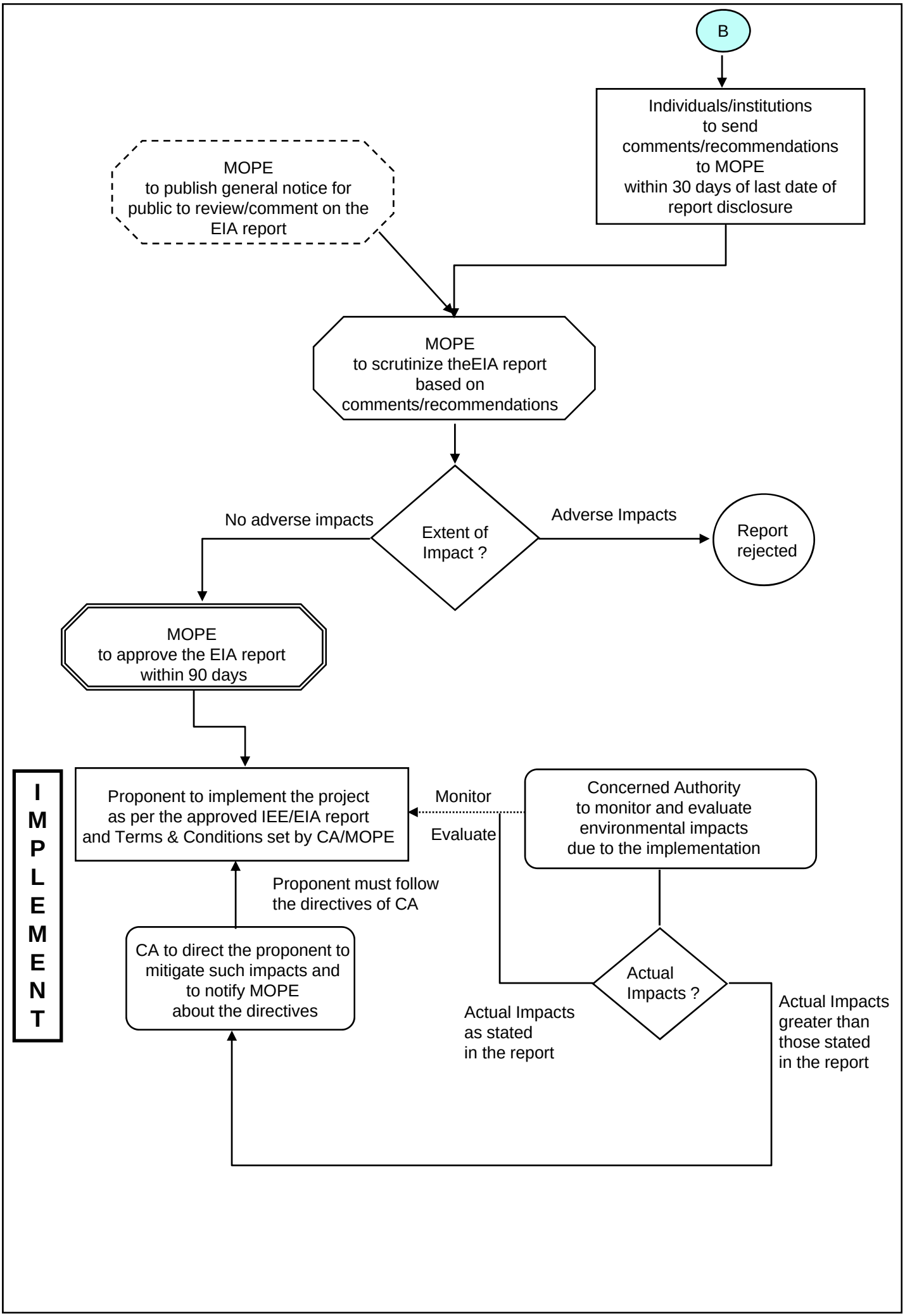
Annex 1

Flow Chart for Initial Environment Examination (IEE) / Environment Impact Assessment (EIA)

FLOW CHART for Initial Environment Examination(IEE)/Environment Impact assessment(EIA)




A
REPORTING
Proponent to prepare IEE/EIA report based on approved Scopimg and Scope of works as per Appendix 5/6
Proponent to send one copy of the IEE/EIA report to concerned VDC/municipality & DDC for review and comments
Proponent to keep the IEE/EIA report open to general public for 30 days for study & review by individuals/institutions
Proponent to submit 15 copies of IEE/EIA report incoprpoarting comments/recommendtaion of concerned VDC/municipality, DDC, infividuals and institutions, if any
Concerned Authority to scrutinize the IEE/EIA reportl
IEE or EIA ?
IEE
EIA
Concerned Authority to check the IEE report
OK ?
O
significant impact
Concerned Authority to approve the IEE report within 30 days
Concerned Authority to forward 10 copies of the report with comments/ recommendations to MOPE within 30 days
MOPE to publish general notice for public to review/comment on the EIA report
B


B
Individuals/institutions to send comments/recommendations to MOPE within 30 days of last date of report disclosure
MOPE to publish general notice for public to review/comment on the EIA report
MOPE to scrutinize theEIA report based on comments/recommendations
Extent of Impact ?
No adverse impacts
Adverse Impacts
Report rejected
MOPE to approve the EIA report within 90 days
IMPLEMENT
Proponent to implement the project as per the approved IEE/EIA report and Terms & Conditions set by CA/MOPE
Monitor
Evaluate
Concerned Authority to monitor and evaluate environmental impacts due to the implementation
Proponent must follow the directives of CA
CA to direct the proponent to mitigate such impacts and to notify MOPE about the directives
Actual Impacts ?
Actual Impacts as stated in the report
Actual Impacts greater than those stated in the report

Annex 2

Vegetation Analysis of Indrawati III Hydropower Project
(Example: size of quadrate is 20m x 50m)

Annex 2:
Vegetation Analysis of Indrawati III Hydropower Project
(Example: size of quadrate is 20m x 50m)

Plot No.	Location	Forest Type	Slope/ Altitude		Density Trees/ha	Total Basal Area (BA) m^2	Basal Area Ration (BAR)	Crown Cover		Wood Volume Estimated Cu.m/ha.
			%	m				Estimated	LRMP	
1	Power house	Forest dominated by *Schima* and *Albizzia*	45-60	549-600	310	4.2612	0.5314	30-50	10-40	199.66
2	Power house	Forest dominated *by Schima Bombax*	30-50	600-650	410	11.4485	1.1255	40-60	10-40	972.5
3	Power house	Forest dominated by *Castanopsis Bomb*ax	40-60	650-700	430	8.5875	0.8443	30-50	10-40	801.2
4	Dam Site (Left east Bank)	Forest dominated by *Engelherdtia Lagerstroemia*	50-60	875-925	470	9.7294	0.9632	30-50	10-40	1178.0
5	Dam Site (Left Bank)	Forest dominated by *Albizzia Castanopsis*	40-60	925-975	550	14.300	1.4299	40-60	10-40	1513.8
6	Dam Site (Left Bank)	Forest dominated by *Gynocardia Macaranga*	40-60	975-1025	530	18.8698	1.8896	40-60	10-40	1061.3
7	Dam Site (Right Bank)	Forest dominated by *Terminalia Albizzia*	45-55	875-925	550	20.3814	2.038	40-60	10-40	1937.9
8	Dam Site (Right Bank)	Forest dominated by *Schima Elaeocarpus*	40-60	925-975	520	16.1482	1.614	40-60	10-40	1044
9	Forest (Adit Area)	Forest dominated by *Schima Bombax*	50-70	1142-1192	500	18.2753	1.8275	40-60	10-40	1164
10	Forest (Adit Area)	Forest dominated by *Castanopsis Quercus*	40-60	1340-1390	510	16.028	1.600	40-60	10-40	1062.8

Source: EIA of Indrawati III Hydropower Project, 2002

Annex 3

Legally Protected Plant species
(Forest Act, 1993)

Annex 3

Legally Protected Plant species (Forest Act, 1993)

SN	Scientific Name	Local Name	Remarks
1	*Rauwolfia serpentina*	Sarpa gandha	Ban on export
2	*Texus wallichiana*	Loth Salla	Ban on export
3	*Nardostachys grandiflora*	Jatamashi	Ban on export
4	*Cinnamomum glaucascens*	Sugandakokila	Ban on export
5	*Abis spectabilis*	Bhoj patra	Ban on export
6	*Valerianna jatamansi*	Sugandabala	Ban on export
7	*Dactylorhyza hatagiera*	Panch ounle	Ban on collection
8	*Juglans regia*	Okhar	Ban on collection
9	*Picrorhiza scrophubriiflora*	Kutki	Ban on collection
10	*Michelia champaka*	Chap	Ban for trade purpose
11	*Michelia kisopa*	Chap	Ban for trade purpose
13	*Acacia catechu*	Khayer	Ban for trade purpose
14	*Shorea robusta*	Sal	Ban for trade purpose
15	*Bombax ceiba*	Simal	Ban for trade purpose
16	*Dalbergia latifolia*	Satisal	Ban for trade purpose
17	*Pterocarpus marsupium*	Bijaya Sal	Ban for trade purpose
18	*Cordyceps sinensis*	Yarsa Gumba	Ban for trade purpose

Annex 4

Protected wildlife under Wildlife Conservation Act 1973

Annex 4:

Protected wildlife under Wildlife Conservation Act 1973

SN	Scientific Name	Common Name	Status		Remark
			IUCN	CITES	
MAMMALS					
1	*Sus salvunius*	Pigmy hog		I	Protected
2	*Ailurus fulgens*	Habre		I	Protected
3	*Antelope cervicarpa*	Krisnasar	V	III	Protected
4	*Bos gurus*	Gaur Bison	V	I	Protected
5	*Bbalus arnee*	water buffalo	E	III	Protected
6	*Canis lupus*	Grey wolf	V	I	Protected
7	*Caprolagus hispidus*	Hispid hare	E	I	Protected
8	*Panthera tigris*	Tiger	E	I	Protected
9	*Ursus arctos*	Brown bear		I	Protected
10	*Rhinicerus unicornis*	Rhinocerus	E	I	Protected
11	*Prionodon pardicolor*	Lingsang		I	Protected
12	*Prionailurus bengalensis*	Leopard cat		II	Protected
13	*Pltanista gangetica*	Gangatic Dolphin	V	I	Protected
14	*Pardofelis nebulosa*	Clouded leopard	V	I	Protected
15	*Pantholopus hodgsoni*	Tibetian Antilope		I	Protected
16	*Panthera unicornis*	Snow Leopard	E	I	Protected
17	*Ovis ammon*	Tbetian sheep	I	I	Protected
18	*Moschus chrysogaster*	Musk deer	E	I	Protected
19	*Manis pentadactyla*	Pangolian		II	Protected
20	*Macaca assamensis*	A. Monkey		II	Protected
21	*Haena haena*	Hyena	E		Protected
22	*Felis lynx*	Lynx	E	II	Protected
23	*Cervus Duvauceli*	Swamp deer	E	I	Protected
	BIRDS				Protected
24	*Burcerous bicornis*	Hornbill		I	Protected
25	*Catreus wallichi*	Cheer	E	I	Protected
26	*Ciconia ciconia*	White stork		II	Protected
27	*Ciconia nigra*	Black stork		II	Protected
28	*Grus grus*	Common crane			Protected
29	*Lophopohrus impeganus*	Pheasant (Danphe)		I	Protected
3O	*Tragopan satyra*	Munal		III	Protected
	REPTILES				Protected
31	*Gavialis gangeticus*	Gharial	E	I	Protected
32	*Python morulus*	Rock Python	V	I	Protected
33	*Varanus flavescens*	Monitor Lizard	I	I	Protected

Annex 5

Nepal's Threatened, Endanger and Rare species of Wildlife listed in IUCN's Red data Book (1994)

Annex 5:

Nepal's Threatened, Endanger and Rare species of Wildlife listed in IUCN's Red data Book (1994)

SN	Scientific Name	Common Name	IUCN's Category
MAMMALS			
1	*Bos gurus*	Gaur Bison	V
2	*Bubalus arnee*	Water buffalo	E
3	*Canis lupus*	Grey wolf	V
4	*Caprolagus hispidus*	Hispid hare	E
5	*Panthera tigris*	Tiger	E
6	*Rhinicerus unicornis*	Rhinocerus	E
7	*Pltanista gangetica*	Gangatic Dolphin	V
8	*Pardofelis nebulosa*	Clouded leopard	V
9	*Panthera unicornis*	Snow Leopard	E
10	*Ovis ammon*	Tbetian sheep	I
11	*Moschus chrysogaster*	Musk deer	E
12	*Haena haena*	Hyena	E
13	*Felis lynx*	Lynx	E
14	*Cervus Duvauceli*	Swamp deer	E
15	*Canis alpinus*	Wild dog	V
16	*Vulpes bengalensis*	Bengal fox	I
17	*Neofelis nebulosa*	Clouded leopard	V
18	*Hemitragus jemlahicus*	Himalayan thar	K
19	*Ochotona nubrica*	Pika	I
20	*Bos mutus*	Wild Yak	E
21	*Bos gaurus*	Gaur	V
22	*Antilope cervicapra*	Blackbuck	V
23	*Elephas maximus*	Elephant	E
24	*Melurus ursinus*	Sloth bear	V
25	*Selenarctos thibetanus*	Asiatc Black Bear	V
	BIRDS		
26	*Catreus wallichi*	Cheer	E
27	*Pelecanus philppensis*	Spot-billed pelican	I
28	*Leptoptilos dubius*	Greater adjutant	E
29	*Falco naumanni*	Lesser kestral	R
30	*Saxicola insignis*	Bush chat	K
31	*Tragopan melanocephalus*	Western tragopan	E
32	*Gallinago nemoricola*	Wood spine	I
33	*Chrysomma altirostre*	Jerdon's babbler	V
34	*Francolinus gularis*	Swamp Fracolin	V
	REPTILES		
35	*Gavialis gangeticus*	Gharial	E
36	*Python morulus*	Rock Python	V
37	*Varanus flavescens*	Monitor Lizard	I
38	*Indotestudo elongate*	Elongated Tortoise	K
39	*Dominia hemiltonii*	Black pond turtle	I
40	*Crocodylus palustris*	Mugger	V
41	*Kachga kachuga*	Red crowned turtle	I

IUCN's Definitions:

Endangered (E); Species that are likely to extinct, if the present level of exploitation continues.

Rare (R); Species, which are at the risk of becoming endangered.

Vulnerable (V) ; Species that are likely to move towards the endangered category in case If the present pattern of exploitation continuous unabatedly.

Intermediate (I); Species may be endangered, vulnerable, or rare, but because of the absence of adequate information, the decision is not yet reached.

Insufficiently Known (K); Species that are suspected but not sure which category that particular species belongs to, or it does not belong to any category. This is because of the lack of information.

Annex 6

Simple Interaction matrix used in EIA Process

Annex 6:

Simple Interaction matrix used in EIA Process

		Project Activity Construction															Project Activity Operation			Remarks
	Parameter	**Land acquisition**	**Delineation**	**Survey**	**Site Clearance**	**Workforce Camp**	**Water Source**	**River Training**	**Excavation**	**Embankment**	**Desanding Basin**	**Pump House**	**Intake**	**Access road**	**Culverts**	**Canal**	**Water Sharing**	**Water users Group**	**Maintenance**	
Physical Environment	Climate																			
	Hydrology																			
	Water Quality/Water Source																			
	Geology/Soil																			
	Topography																			
	Air and Noise																			
Biological Environm	Forest																			
	Wildlife																			
	Aquatic Life																			
	Biodiversity																			
Socio-economic and cultural Environment	Education																			
	Economy																			
	Gender Issues																			
	Institutions																			
	Culture																			
	Population																			
	Health																			
	Land use																			

Source: Khadka *et al*, 1996.

Annex 7

An Example of a Leopold Matrix, showing Magnitude and Significance of Predicted Impacts on a Scale of 1 to 10

Annex 7:

An Example of a Leopold Matrix, showing Magnitude and Significance of Predicted Impacts on a Scale of 1 to 10

(Leopold methods and Methods from Lohani and Thanh)
Lohani and Thanh methods = ∑M x I x Priority Value

M / I

Priority Value	Propose Action / Resources	Immigration of Labor	Dam Construction	Transmi-ssion line	Reservoir Filling	Heavy Metal Discharge	Growth of Aquatic Weeds	Relocation of Inhabitants	Total	
									Leopold Method	Lohani & Thanh
10	Health	5 / 8	4 / 6		5 / 8	4 / 7	6 / 6		24 / 35	1680
8	Biodiversity		3 / 4		3 / 6	3 / 7	5 / 5		14 / 22	608
7	Archeological Artifacts	4 / 6			8 / 8				12 / 14	616
6	Tourism			7 / 6	7 / 6				14 / 12	504
5	Downstream Water Pollution		7 / 7		7 / 8	2 / 4			16 / 19	565
4	Social and Economic Aspects							8 / 7	8 / 7	224
3	Forestry		4 / 2						4 / 2	24
9	Fishery		2 / 5			2 / 5			4 / 10	180
1	Navigation				6 / 5				6 / 5	30
2	Aquatic Plants				6 / 6				6 / 6	72
	Leopold Method	9 / 14	20 / 24	7 / 6	42 / 47	11 / 23	11 / 11	8 / 7		
	Lohani & Thanh	64	103	42	286	67	61	56		

Source: ESCAP-Environment and Development Series 1991

Annex 8

Environmental Impact Summary Matrix of Arun III Hydropower Project Part of Impact Summary Matrix

Annex 8:

Environmental Impact Summary Matrix of Arun III Hydropower Project Part of Impact Summary Matrix

Resources/Project Activity	Impact	Impact Prediction			Mitigation	Responsibility
		Magnitude	Extent	Duration		
Microclimate						
1. Reservoir operation	Changes in temperature humidity	L	L	L	None required (see text),	
2. Vegetation/forest removal	Change in temperature humidity	L	L	S	Protection of vegetation on south-facing slope	HMG
					Avoid or minimize to absolutely necessary extent dump sites in forested area;	JV/Contractor
					Replace adit road with shorter roads;	DOR/SWK; JV/Contractor
					Combine adit and powerhouse construction camps;	DOR/SWK
					Evaluate alternatives to dam site's access road;	JV/Contractor
					Implement ground cover/erosion protection/ revegetation measures.	
Air Quality						
1. Vehicle emissions	Increase of air pollution; possible health hazard	L	L	S	Reduce travel distances by placing construction camps close to work areas;	JV/Contractor
					replace adit road with shorter areas;	DOR/SWK
					Eliminate spoil dumps and associated travel to the extent possible;	JV/Contractor
					Engines to comply with international standards for exhaust gases;	Contractor
					Maintenance of engines and exhaust gas check;	Contractor
					Dust control with water in dry season,	Contractor
2. Road dust	Increase of airborne dust during dry season	L	L	S	Reduce distances between camps and work areas:	JV/Contractor
					Black top heavily used area:	Contractor
					Breathing protection;	Contractor
3. Indirect Impacts	Influx of 2-3,000 job seekers and small entrepreneurs; uncontrolled settlement	M	L	S	Regulation of settlement on public and private land.	HMG
Socio-Economic and Cultural						
1. Project Construction	Loss of arable land	H	L	L	Intensify production on remaining land;	HMG/Project
					Reclaim arable land after construction;	JV/Contractor
	Loss of forest resources	L	L	L	Control deforestation:	HMG
					Forest conservation and development program.	HMG/Project
	Displacement of approx. 144 families; interruption of normal farming activities	H	L	L	Minimize project and requirements;	JV/Contractor
					Compensation and rehabilitation program;	

Resources/Project Activity	Impact	Impact Prediction			Mitigation	Responsibility
					Intensify production on remaining land;	HMG/Project
					Provide skill training for employment on construction.	Contractor
	Requirement of additional food for local people, workforce and immigrants	M	L	S	Encourage production of crops and livestock products for sale to workforce and other outlets;	HMG/Project
					Contractor to provide logistics for his workforce.	JV/Contractor
	Requirement of additional fuel supplies	M	L	S	Contractor to provide kerosene and electricity to workforce, limit use of local fuelwood.	Contractor
					Prohibit unauthorized felling of trees and use of open fire;	JV/Contractor
					Forestry development program	HMG/Project
	Disruption of traditional social and cultural patterns by large-scale immigration	M	L		Training and strengthening of the capacity of VDCs	HMG/Project
					Limited work contracts for non-indigenous labor.	JV/Contractor

Source: EIA of Arun III Hydropower Project, NEA, 1988

Key

Magnitude	**Extent**	**Duration**	
H = High	L = Local	L = Long-term (over 20 years)	JV = Joint Venture Arun III
M = Moderate	R = Regional	M = Medium-term(Over 10 years)	DOR = Department of Road
L = Low	N = National	S = Short-term (Below 10 years)	SWK = Scot Wilson Kirkpatrick (Road Consultant)
	I = International		HMG = His Majesty's Government of Nepal
			NEA = Nepal Electricity Authority