# BANGLADESH FLOOD ACTION PLAN

Ministry of Water Resources
Flood Plan Coordination Organization (FPCO)



Prepared by

**Environmental Study**

**FAP 16**

ISPAN

IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

Sponsored by the U.S. Agency for International Development

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# Manual for Environmental Impact Assessment

April 1995



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## MANUAL FOR ENVIRONMENTAL IMPACT ASSESSMENT

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## ACKNOWLEDGEMENTS

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## GLOSSARY

**Adverse impact** is an environmental impact (q.v.)* that is harmful to human interests over either the short or long term.

**Aman** - rice grown during the *kharif-2* (q.v.) season, with the exception of broadcast *aman*, which is sown in the *kharif-1* season and harvested in the *kharif-2* season.

**Aus** - rice grown during the *kharif-1* (q.v.) season

**Baseline studies** - work done to collect and interpret information on the status and trends of the environment likely to be affected by a development action.

***Baor*** - a lake formed from an abandoned section of river channel (oxbow lake).

***Beel*** - a natural depression, the bottom of which normally remains wet throughout the year.

**Beneficial impact** is an impact that improves resources, the economy and/or the quality of life for a population.

**Biodiversity** (biological diversity) is the variety of species within a given area or region.

**Compensation** is payment in cash or kind to the recipients of unavoidable negative and/or residual impacts (cf. mitigation).

**Biophysical** - q.v. environment.

**Bounding** - a process for determining spatial and temporal boundaries, within which environmental impact assessment will be conducted, based upon physical, chemical, biological, social, economic, jurisdictional and administrative factors.

**Cumulative impacts** are repetitive or multiple environmental impacts to a resource, environmental component or area caused by the same or different factors and which are normally of greater magnitude and significance than simple impacts.

***Boro*** - rice grown during the *rabi* (q.v.) season.

**Broadcast *aman*** - *aman* (q.v.) grown in the *kharif* (q.v.) season in deeply flooded areas.

**Char** - an alluvial island that periodically emerges from the river bed as a result of accretion. Chars may be seasonal or may remain in existence for several decades. They may be attached to the riverbank ("attached chars") or located in midstream ("island chars").

**Coliforms** - a group of bacteria used as an indicator of faecal contamination in water.

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* q.v. = please refer to

**Community** 1. Animals and plants living in the same locality under the influence of similar environmental factors and affecting the existence of each other through their activities. Communities are usually named after their dominant species.
2. A social grouping of people living together (e.g., group of families, a village, etc.)

**Compensation** - replacement of losses by cash, land or other means (cf. mitigation).

**Compensation plan** - the portion of the environmental management plan (q.v.)* that describes the compensation measures that will be undertaken and committed to if a project proceeds.

**Conservation** - preservation of natural resources so as to maintain supplies and qualities at levels sufficient to meet present and anticipated needs.

**Cost-benefit analysis** - technique used to compare costs and benefits of a planned development activity through conversion of losses and gains to monetary units.

**Critical habitat** - areas of land and water required for the survival of a plant or animal population.

**Cropping pattern** - sequence and arrangement of crops (including crop varieties) on a plot of land over an annual cycle (or sometimes more than one year if one crop or a complete cropping cycle occupies the plot for more than one year).

**Cumulative impact** - an environmental impact that results from actions that are added to others of the past, present, and the foreseeable future, caused by multiple human activities and/or natural events that are either repeated or occur in combination.

**Dike** (or dyke) - a natural or man-made structure to impound or curtail the flow of water from one place to another, synonymous with embankment or levee.

**Drainage congestion** is the local abundance of surface water due to sudden high inflow or impeded outflow.

**Ecosystem** (ecological system) is a marine, freshwater or terrestrial linkage of dynamic and interactive components normally divided into two major categories—biotic (living) and abiotic (non-living).

**Embankment** q.v. dike.

**Enhancement** is the improvement of the environmental performance of a project beyond that required for mitigation (see below) where the benefits of such enhancement significantly exceed the costs.

**Environment** is the totality of the natural and human surroundings and includes *biophysical* components of the natural environment of land, water and air, including all layers of the atmosphere, all inorganic and organic matter both living and dead; and *socioeconomic* components of the human environment including social, economic, administrative, cultural, historical, archaeological, land and associated resources, structures, sites, human health, nutrition and safety.

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*q.v. = please refer to

**Environmental impact** is a change in the state or functioning of an environmental resource or component caused by the action(s) of a project. It should be distinguished from the impact to resources or components caused by natural factors, e.g., floods.

**Environmental Impact Assessment** (EIA) is the systematic study, assessment and reporting of the impacts of a proposed program, plan or project, including a plan for dealing with negative impacts.

**Environmental Management Plan** (EMP) is a plan to undertake an array of follow-up activities to provide for the mitigation of adverse environmental impacts and enhancement of beneficial effects.

**Floodplain** - the area of low, flat ground on one or both sides of a stream or river channel subject to flooding.

**Ground truth** - in remote sensing is a process by which remotely sensed data are verified in the field.

**Groundwater** - subsurface water moving under the force of gravity which accumulates in the pores and cracks of rocks and soil.

**Habitat** - division of the environment having a certain combination of physical (e.g., slope, drainage, soil type) and biological (e.g., food) factors necessary for sustained animal, plant or human use and survival.

**Haor** - water body formed in the monsoon season by the inundation of several beels (q.v.)* forming a continuous water body in a large geological depression.

**Hazard** - a type of event that causes damages and/or loss to human life, land use and/or the environment, e.g., floods, erosion, earthquakes, pollution.

**Important Environmental Components** (IECs) are components which by virtue of their importance to ecosystem functioning, production of food and/or maintenance of livelihoods and quality of life are considered essential and worthy of sustaining at existing or enhanced levels under the proposed new project regime.

**Indicator** - an organism or physical feature that by its presence, absence or abundance indicates a particular property of the surrounding environment.

**Initial Environmental Evaluation** (IEE) - environmental assessment undertaken for a regional- or prefeasibility-level study for identifying and assessing possible environmental impacts.

**Interested parties** (also termed "stakeholders") are all persons and groups having a justifiable concern and interest in the project and its impacts. It includes local people, elected representatives and representatives of the government, NGOs and donors.

**Intervention** is the specific action caused by a project that creates an environmental impact, e.g., obstruction of a drainage canal by an embankment.

*Jalmahal* - a leased water body (e.g., for fishing)

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*q.v. = please refer to

*Kharif 1* - early summer (March through June)

*Kharif 2* - late summer and fall (July through October)

**Levee** q.v.* dike.

**Mitigation** is any action taken to reduce unacceptable negative impacts. It includes both design changes to the project and operational strategies (cf. compensation).

**Monsoon** - complex pattern of winds and atmospheric pressure changes which create conditions favorable for rain (usually June to October in Bangladesh)

*Mauza* - smallest administrative revenue unit (a "revenue village")

**Plankton** - microorganisms in water, including plants (phytoplankton) and animals (zooplankton).

*Rabi* - winter season (November through February)

**Residual impacts** are those environmental impacts that remain after application of mitigation measures and that cannot practically be overcome.

**Remote sensing** - collection of spatial information through a system of sensors mounted on an airplane or satellite.

**Return Period** - the number of years interval, on average, between events of the same magnitude and/or type (e.g., damaging floods).

**Risk** - the potential of occurrence of a negative or hazardous event.

**Reversible impact** - an environmental impact that recovers either through natural process or with human assistance.

**Salinity** - content of salts in sea water, soil or brackish water.

**Scoping** is a process whereby the Important Environmental Components, project development issues and concerns of local communities are determined.

**Significant environmental impact** - an adverse environmental impact that is not justified in the circumstances.

**Sustainable development** is development that ensures preservation and enhancement of environmental quality and resource abundance to meet the needs of the present without compromising the ability of future generations to meet their own needs (adapted from the Brundtland Commission, 1987).

**Thana** - main rural administrative unit in Bangladesh, consisting of a group of unions (q.v.) q.v. *upazila*.

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*q.v. = please refer to

**Union** - smallest administrative unit of the local government (usually consisting of 12 to 15 villages).

**Upazila** - old name for *thana* (q.v.)*

**Waterlogged** - condition of soil saturation due to the rise of the groundwater table.

*q.v. = please refer to

## ACRONYMS

| | |
|---|---|
| ADAB | Association of Development Agencies in Bangladesh |
| ADB | Asian Development Bank |
| AEZ | Agroecological Zones |
| AST | Acriculture Sector Team (CIDA) |
| AWB | Asian Wetland Bureau |
| BADC | Bangladesh Agriculture Development Corporation |
| BARC | Bangladesh Agriculture Research Council |
| BARD | Bangladesh Academy for Rural Development |
| BARI | Bangladesh Agriculture Research Institute |
| BAU | Bangladesh Agriculture University |
| BBRI | Bangladesh Rice Research Institute |
| BBS | Bangladesh Bureau of Statistics |
| BIDS | Bangladesh Institute of Development Studies |
| BIWTA | Bangladesh Inland Water Transport Authority |
| BIWTMAS | Bangladesh Inland Water Transport Master Plan |
| BMD | Bangladesh Meterorological Department |
| BOD | Biochemical Oxygen Demand |
| BRAC | Bangladesh Rural Advancement Committee |
| BRDB | Bangladesh Rural Development Board |
| BWDB | Bangladesh Water Development Board |
| CCT | Computer Compatible Tape |
| CI | Cumulative Impacts |
| CIA | Cumulative Impact Assessment |
| CIAM | Cumulative Impact Assessment and Management |
| CIDA | Canadian International Development Agency |
| DAE | Department of Agricultural Extension |
| DANIDA | Danish International Development Agency |
| DEM | Digital Elevation Model |
| DO | Disolved Oxygen |
| DOE | Department of Environment |
| DPHE | Department of Public Health Engineering |
| DSSTW | Deep-set Shallow Tubewell |
| DTW | Deep Tubewell |
| EA | Environmental Assessment |
| EIA | Environmental Impact Assessment |
| EIAR | Environmental Impact Assessment Report |
| EIP | Early Implementation Projects |
| EMP | Envrionmental Management Plan |
| EPP | Environmental Protection Plan |
| FAO | Food and Agriculture Organization |
| FAP | Flood Action Plan |
| FCD/I | Flood Control, Drainage and Irrigation |
| FCD | Flood Control and Drainage |
| FMM | Flood Model Management |

| | |
|---|---|
| FPCO | Flood Plan Co-ordination Organization |
| FS | Feasibility Study |
| GOB | Government of Bangladesh |
| GPA | Guidelines for Project Assessment |
| GPP | Guidelines for People's Participation |
| GWC | Groundwater Circles |
| HD | Hydrodynamic Module |
| HHS | Household Survey |
| HTW | Hand Tubewell |
| HYV | High Yielding Variety (rice) |
| ICDDR,B | International Centre for Diarrhoeal Disease Research, Bangladesh |
| IEC | Important Environmental Component |
| IEE | Initial Environmental Evaluation |
| ISPAN | Irrigation Support Project for Asia and the Near East |
| IUCN | International Union for the Conservation of Nature |
| LAD | Least-Available Depth |
| LGED | Local Government Engineering Department |
| MCA | Multicriteria Analysis |
| MOEF | Ministry of Environment and Forest |
| MOSTI | Manually Operated Shallow Tubewell |
| MP | Member of Parliament |
| MPO | Master Plan Organization |
| NC | North Central |
| NGO | Non-governmental Organization |
| NWP | National Water Plan |
| O&M | Operation and Maintenance |
| PCC | Project Coordination Committee |
| PFS | Pre-feasibility Study |
| PPM | Part Per Million |
| PRA | Participatory Rural Appraisal |
| PWD | Public Works Department |
| PWL | Polder Water Level |
| RRA | Rapid Rural Appraisal |
| RRI | River Research Institute |
| SDC | Swiss Development Cooperation |
| SERM | Southeast Regional Models |
| SES | Socioeconomic Survey |
| SIA | Social Impact Assessment |
| SOB | Survey of Bangladesh |
| SODAPS | Soils Data Processing System |
| SPARRSO | Space Research and Remote Sensing Organisation |
| SRDI | Soil Resources Development Institute |
| ST | Sediment Transport |
| STW | Shallow Tubewell |
| TDS | Total Dissolved Solids |
| SWMC | Surface Water Modelling Center |
| SWSMP | Surface Water Simulation Modelling Program |
| UNCED | United Nations Conference on Environment and Development |

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| | |
|---|---|
| UNDP | United Nations Development Programme |
| USAID | United States Agency for International Development |
| WARPO | Water Resources Planning Organization (formerly MPO) |
| WB | World Bank |
| WO | Without Project Option |

CTO
Mr. Mujibul Huq incorporated all the changes in his copy. But this final version shows only part of it as shown with underline. I still feel the omission I have again inserted should be incorporated. It has a specific purpose considering the present level of capacity in terms of material, man and resources.
Sm. Kamal
24.08.95

## Chapter 1

# INTRODUCTION

### 1.1 Scope of the EIA Manual

This Manual for Environmental Impact Assessment (EIA) is a companion document to the Guidelines for EIA ~~in the Water Sector~~ (FPCO 1992). While the EIA Guidelines outline the steps in the EIA process and describe *what* is required of EIA, the EIA Manual details *how* these steps and procedures are to be achieved. In addition to this EIA Manual and its associated EIA Guidelines, there are many references on environmental impact assessment. In particular, the reader should refer to the most recent versions of the World Bank's Operational Directive and Sourcebook for EIA.

### 1.2 Scope of EIA

The main objectives of EIA are to identify and quantify environmental impacts of proposed plans, programs and projects, thereby:

- providing decision-makers with a basis for making informed decisions on project development and resource allocations;
- providing an environmental management plan to mitigate or avoid negative impacts and enhance positive ones; and
- providing affected communities and concerned interested parties with a basis for providing input on project design, development, operation and maintenance.

EIA is an integral part of *multiple resource development planning*. It provides for:

- planning of resource development in a sustainable manner;
- assessment of the biophysical, social and economic impacts of proposed projects;
- use of environmental data and information to improve project siting design, construction, operation and abandonment. The earlier EIA is integrated with project conceptualization and design, the more effective the assessment is and the more environmentally sound the project becomes.

EIA accomplishes its purpose by providing decision-makers with the best information available regarding:

- intended and unintended consequences of particular investments and alternatives;
- means and costs to mitigate undesirable effects; and
- the consequences of taking no action.

EIA is the systematic study, assessment and reporting of the expected impacts of a proposed program, plan or project. Both the EIA Guidelines and the EIA Manual under reference focus primarily upon the issues raised by development of flood control, drainage, irrigation and various flood protection projects.

## Chapter 2

## INITIATION OF THE EIA

### 2.1 Stages of EIA

EIA is applied at two stages of detail in the planning process: prefeasibility and feasibility (Figure 2.1).

#### 2.1.1 Prefeasibility

Prefeasibility assessment addresses regional planning options for water resource development. The main thrust at this stage is to assess regional resources and the effects of past interventions, examine the likely project-environment linkages and interactions, establish the range and potential magnitude of impacts, identify the key regional environmental issues, compare the environmental consequences of project alternatives, and evaluate broad categories of environmental management actions. The same types of impacts as would be assessed during the feasibility stage are considered but at more general levels of detail and at larger scales of resolution. Prefeasibility-level EIAs are reported in the *Initial Environmental Examination (IEE).*

Following prefeasibility studies, decision-makers may choose to:

- *proceed with feasibility studies* where project impacts are indicated to be acceptable or manageable, in which case a decision will be required as to whether a detailed EIA should be carried out for the selected project; or
- *proceed with feasibility studies of a modified project* to reduce unacceptably high levels of impacts; or
- *reject the project* because the nature and magnitude of the impacts are shown to be technically, environmentally, socially and/or economically unacceptable.

#### 2.1.2 Feasibility

Feasibility-level EIA provides a basis for:

- detailed Impact Assessments of selected project options; and
- detailed Environmental Management Plans (EMPs). The above activities incorporate the following:
  - mitigation planning to reduce biophysical and social impacts;
  - planning of compensation for unavoidable impacts;
  - planning project enhancements;
  - establishing a monitoring program; and
  - ongoing participation by the affected people in project construction, operation and maintenance.

EIA should parallel the engineering studies and economic evaluations in comparative levels of study detail and decision-making (Figure 2.2).

- Environmental and engineering evaluations should be closely linked so that effective project modifications and mitigation approaches can be developed.
- Environmental and economic evaluations should be linked to ensure that the costs of the Environmental Management Plan, are accounted for in the multi-criteria analyses (see Guidelines for Project Assessment (GPA)).

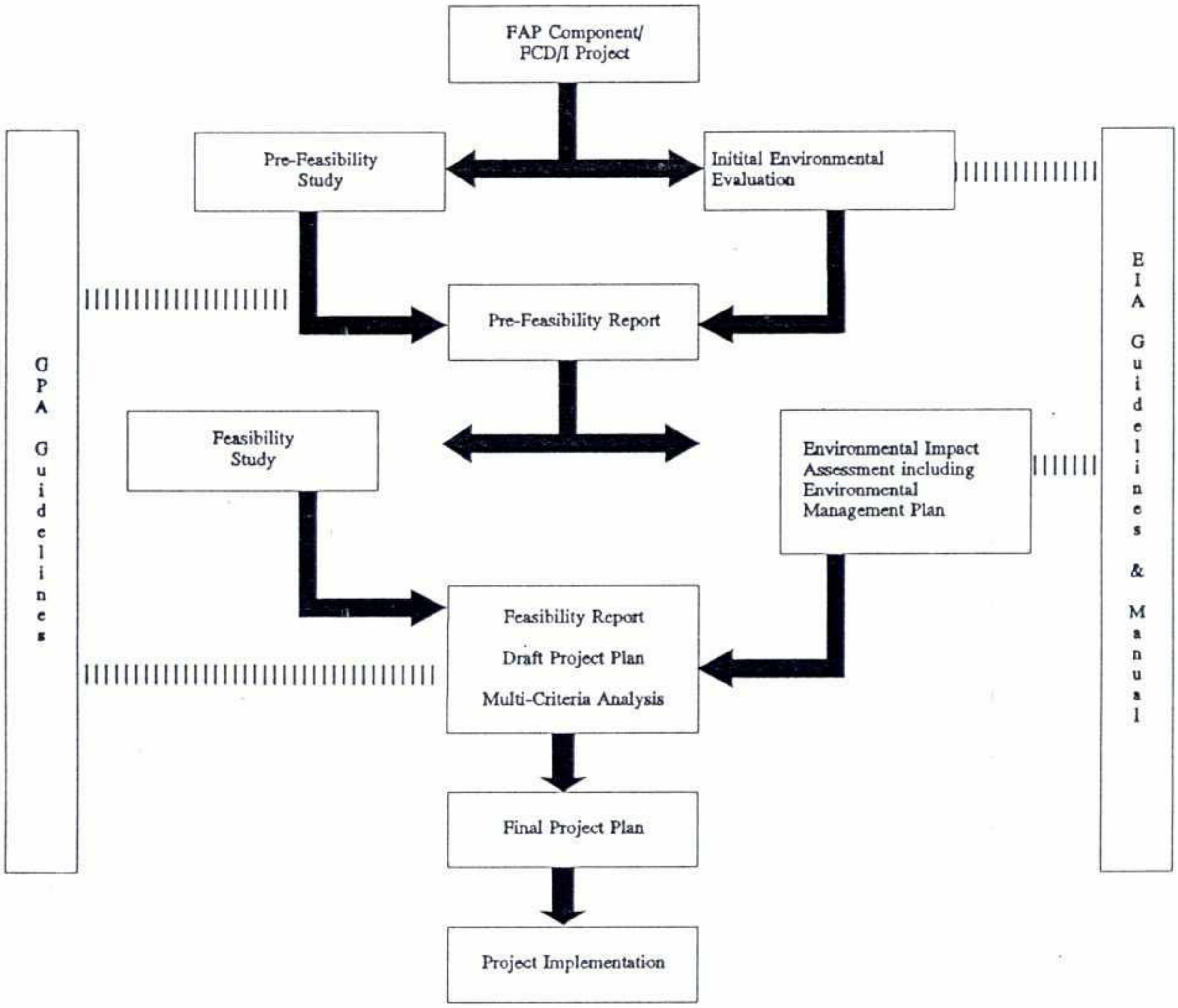


Figure 2.1 Role of EIA Guidelines and EIA Manual in FAP Project Planning Process

(A) Conventional Engineering Approach for Planning, Designing, and Implementing Projects

| A1 | A2 | A3 | A4 | A5 | A6 |
|---|---|---|---|---|---|
| Reconnaissance Survey | Pre-Feasibility Study (PFS) | Feasibility Study (FS) | Final Design (Plans & Specifications) | Construction | Operation & Maintenance |

(B) Corresponding Environmental Planning Activities

| B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|
| Environmental Reconnaissance | Pre-EIA = IEE | EIA | Checking Design | Implementation of Environmental Management Plan for Construction | Implementation of Environmental Management Plan for Operation & Maintenance |

Figure 2.2 Interrelationships of the Project and its Environmental Assessment

## 2.2 Project Screening

The objective of project screening is to determine beforehand the nature and extent of the EIA to be carried out. Screening is a means to match the level of effort in the EIA to the expected extent and severity of the anticipated impacts. Projects are classified into categories based upon type, location, environmental sensitivity, project scale and the nature and magnitude of the potential impacts. Full EIAs are required for some project categories, while only limited investigations are specified for lesser categories. Project screening is often used by multilateral funding institutions, including the World Bank (WB) and the Asian Development Bank (ADB).

Projects requiring full EIAs are considered likely to have significant adverse impacts that may be sensitive or irreversible or whose mitigation effectiveness is not very well known/or understood or are quite difficult to develop. Typical project examples are dams, reservoirs, large-scale irrigation, drainage and flood control, port and harbor developments, resettlement and all projects with potential major impacts on people and special features of the natural environment.

Projects not requiring full EIAs are those with potential impacts unlikely to be significant or as numerous, major or diverse, and for which mitigation measures can be designed. Typical projects include small-scale irrigation and drainage projects, rural water supply and sanitation, and small-scale rehabilitation, maintenance and upgrading. Similar projects normally have been built many times in the past with well-documented effects that are well understood, well anticipated and well managed by available mitigation methods. Institutional structures should be in place and able to deal with such impacts. However, multiple small-scale projects within the same watershed or river basin can result in significant *cumulative* impacts. Thus, even small projects may require a full EIA in order to assess these impacts. Often, a project with potential significant environmental impacts may be justified, if not proceeding with the project, would mean excessive risks to human health, safety and quality of life. Examples include emergency actions such as town protection or cyclone protection plans required to meet possible threat to lives, properties and agriculture from flooding, river erosion and large storms.

Full EIAs should not entail study of irrelevant issues and inefficient expenditure of time, money and resources. Effective scoping (see Section 3.3) of the important environmental components and bounding (see Section 3.4) of the spatial and temporal limits within which impacts will be assessed should determine the appropriate level of effort required to assess a particular project.

## 2.3 EIA Team

It is understood that conducting an environmental assessment is a multidisciplinary/interdisciplinary effort and no single discipline has a monopoly on environmental wisdom. Each regional team (or eventually, those designing and implementing individual projects) must have access to the requisite array of expertise. Each specialist assists in the description of the project (often engineers and social scientists) and/or the environment (physical, chemical, biological and social scientists, archaeologists, economists, etc.). Each discipline needs to choose the IECs (important environmental components) that the assessment will focus upon, determine the impacts upon them, and contribute to the environmental management planning for those impacts. It is critical to the success of the EIAs that there be a great deal of interaction among team members. Each team member should write the sections related to their discipline, including the identification of impacts in their disciplinary area. In addition to the project description, the water resources engineer often writes a substantial section of the EMP (Environmental Management Plan). Who acts as Assessment Leader to collate the various sections and perform the final edit is less important than the integrated participation of all of the team members in the review of the EIA report. Of course, the Team Leader of the prefeasibility and feasibility study teams has final responsibility for the substance and form of the environ-

The best situation would emerge when the EIA Team Leader and the feasibility study Team Leader is the same person and most likely would be a person having science or engineering background.

mental assessment reports and the input of the environmental results into project assessment.

The following *skills* should be available on the study team:

- Water Resources
  - surface and ground water [*hydrologist, geohydrologist*]
  - water quality [*aquatic biologist, limnologist* and/or *health specialist*]
- Land Resources
  - topography/land use [*agronomist, agriculturalist* or *land use planner*]
  - soils and agriculture [*agronomist*]
- Biological Resources
  - fisheries [*fisheries biologist*]
  - vegetation and forestry [*terrestrial ecologist*]
  - wetlands [*terrestrial ecologist* and/or *limnologist*]
  - wildlife [*terrestrial ecologist*]
- Human Resources
  - rural sociology [*sociologist/social anthropologist*]
  - health and nutrition [*sociologist/health specialist*]
  - gender issues [*sociologist/social anthropologist*]
  - people'sparticipation/socialfacilitation [*sociologist/social anthropologist*]
- Economics
  - economics [*natural resources economist*]
- Systems Analysts and Information Specialists [*modelers, geographic information systems analysts*]

The *EIA Team Leader* is responsible for the smooth functioning of the EIA team, quality control of products, on-time production of drafts and reports, and liaison with the rest of the project planning team. The EIA Team Leader may delegate some functions to appropriate team members, but should retain responsibility for production of the Initial Environmental Evaluation (IEE) or EIA Report (EIAR). The EIA Team Leader reports to the Team Leader leading the whole study including engineering, economic and environmental aspects.

The management process can be divided into a sequence of tasks.

- Mobilization: one of the first actions of the EIA Team Leader may be to screen candidates for the team and select the members. Frequently, however, the team has already been formed by the project management group and the EIA Team Leader is expected to work with the personnel thus assembled. In this case, the EIA Team Leader should confer with the Team Leader to ensure that the required skills are represented on the team or available elsewhere in the planning study group.
- Review the background and skills of each team member to ensure that he or she possesses appropriate training and experience for the assigned tasks. The review should include both a résumé check and a personal conference. It should not be deferred on the assumption that shortcomings will be revealed and corrected during the EIA program; there often is not enough time for replacing staff after the EIA has begun.
- Brief each team member on his or her assignment, making sure that the opportunity is provided to ask questions. This one-on-one briefing is important, as some individuals may be embarrassed about asking questions in a group meeting.
- Establish, preferably in writing, procedures for quality control, including information flow, protocol for contracting individuals inside and outside FAP, record keeping and technical review of documents.
- Hold a team meeting to lay out procedures and outline the responsibilities of each individual. At this meeting, procedures for quality control, administrative review and other management matters should be presented to the group.
- Hold periodic meetings to review progress and identify solutions to emerging problems.

- If the team is not trained in records management, special attention may have to be paid to the keeping of files, both written and computerized: what to keep in written form and what electronic; what goes on floppy disks and what on hard drives; what sort of backup is required.

## 2.4 Level of Effort

Levels of effort in terms of human and material resources required for assessment will vary according to:

- whether the study is at the regional (pre-feasibility) or project (feasibility) stage;
- the size of the area being studied;
- the complexity of the area under study;
- the EIA experience of the study team members;
- the amount of study support available from other study components, especially the engineering studies;
- the degree of development within the study area.

For either a feasibility-level EIA of a project of moderate size or a regional planning study, it is likely that 12 months of effort (to capture seasonal variability), depending on the above factors, would be required for adequate study, assessment and reporting. Additional time would be required for the Assessment Leader for coordination, integration, reporting and reviewing. Budgets to perform EIA tasks must also be commensurate with the effort (time) required.

It is desirable that all of the team specialists be knowledgeable about rural Bangladesh and flood conditions, as well as experienced in environmental assessment procedures. In addition to the technical experts on the team, there should be adequate support in the form of drivers, office staff, draftspersons, technicians and field investigators and enumerators. The services of a reliable water quality and/or soil analytical laboratory may also be required.

## 2.5 EIA Study Plan

Prior to beginning the environmental study, the Assessment Leader should develop a definitive plan that will result in an effective EIAR. The plan, and its effectiveness, will be influenced by the stage of the project in the planning process, time/budget restrictions, schedules and the availability of skilled personnel. Despite such limitations, the Assessment Leader should not allow the study program to fall below the level that he or she believes is minimal for an effective environmental study.

Each specialist on the EIA team should contribute appropriate sections to the Study Plan. It is the responsibility of the Assessment Leader to ensure that environmental components are neither under- nor over-scoped, and that the study methods proposed are realistic.

The Environmental Study Plan should address the following topics.

- Environmental components to be studied; the list is the result of the scoping process (see Section 3.3); for each resource the Study Plan should include:
  - parameters to be studied;
  - methods of data gathering (see Annex C of the EIA Guidelines (FPCO 1992) for a summary of information required for assessment) including secondary sources (literature and agency contacts) and field sampling;
  - equipment requirements, logistic support, permits and other factors that may influence the success of the program.
- Personnel: identify by name the specialist(s) who will do the work, technicians required, and manpower allocation.
- Schedule of the task, including start-up, finish, seasonal restrictions.
- Participation required from other staff, especially those engaged on feasibility studies and who overlap with the EIA studies (e.g., hydrologists, agronomists);

the Assessment Leader should discuss this with the individual specialist on the project team or, if they are not available, with the Team Leader:

  - types of information required (e.g., soils, hydrology) and level of detail;
  - level of effort, by staff member;
  - timing of input;
  - include drafting and secretarial assistance, if required.

- Data handling and record keeping (see sections on the individual resources).
- Overall budget, including personnel salaries, non-expendable equipment purchases, field costs, and report preparation costs; to permit easy analysis by reviewers, a breakdown by tasks is desirable.
- Environmental Report Outline.

The Study Plan, having been prepared with the active participation of the Team Leader, should receive quick internal review/approval. A draft should be circulated for comment to the agencies and project proponents (clients) that will have primary review responsibility for the EIAR.

# Chapter 3

## STEPS IN EIA

A set of 10 steps has been recommended as standard EIA procedure in the EIA Guidelines (FPCO 1992a). These are outlined below and detailed in the following sections. All steps are intended to be followed against a background of full and effective people's participation (see Chapter 7).

*Step 1: Project Design and Description*

Description of all components to be constructed and all activities to be undertaken in the various phases of project design and development. The description also includes rationale for the development, details of project alternatives, assumptions and schedule.

*Step 2: Environmental Baseline Description*

An environmental profile of the project or regional planning area based on area reconnaissance and available information addressing area and location, climate, hydrological cycles, physiography, landforms and soils, surface- and groundwater, land use, biological components, urban and rural settlements, infrastructure, major socioeconomic features and natural hazards.

*Step 3: Scoping*

Identification, quantification and prioritization of the Important Environmental Components and the issues most important to various groups of interested parties. This is an important part of People's Participation.

*Step 4: Bounding*

Establishment of the spatial and temporal limits for impact assessment.

*Step 5: Major Field Investigations*

Field studies to obtain and update data, including sample sites and methodologies.

*Step 6: Impact Assessment*

Identification and quantification, where possible, of environmental changes expected with and without the project and alternatives, and with and without mitigation.

*Step 7: Evaluation of Impacts*

Assessment of the physical, chemical, biological, social and economic significance and implications of the predicted impacts. likely to manifest upon project intervention or without project situation.

*Step 8: Environmental Management Plan*

Development of a detailed plan for environmental management of the project to implement if the project proceeds. The EMP also provides a firm commitment of the proponent to proceed in an environmentally-sound way.

*Step 9: Feedback to Improve Project Design*

Utilizing environmental information and impact assessment results to improve project design and operation to minimize negative impacts as early in the planning process as possible. Feedback can occur at any earlier step but should be completed before Step 10.

⇩

*Step 10: EIA Reporting*

Detailed reporting on the EIA for the benefit of local people, reviewers, agencies, donors, decision-makers and other interested parties.

### 3.1 Project Description and Design (Step 1)

Environmental Impact Assessment is carried out at two levels. First, at the pre-feasibility or regional study level, a region is studied and a number of potential projects are identified which might benefit the area. Various alternatives are evaluated and revised with emphasis on economic viability, environmental impacts (especially cumulative impacts), anticipatory environmental planning and sustainability. The project description at this stage consists of alternative project concepts, possible locations and their relationship to other projects and activities and to regional issues. A subset of projects which appear potentially economically and environmentally viable is identified for further study. At the feasibility level, each of these projects undergoes an impact assessment, based on a detailed but generic description of the project location, structures, and activities (at a conceptual level, with numerous assumptions about specific details) and the environment. As the project design is finalized, additional details of the project design become available, and the Environmental Management Plan is completed and approved.

In both phases, the project description is the basis upon which impacts of the project are predicted. The project description should give an overview of the project design, including its location and extent, its components, and their functions. Description should also be given of the technology to be used, local infrastructure required (e.g. roads, utilities, operation and maintenance facilities), inputs of capital, labor (skilled and unskilled) and natural resources (including quantities of fuels and raw materials required, and where and how these will be provided), waste products generated, and how and where these will be delivered, re-used, or disposed of, and the duration of each project phase. A project rationale should also be provided.

Project descriptions should be written by a multidisciplinary team of project planners, engineers, scientists, sociologists, economists and other specialists who have familiarity with the activities, processes, and materials the project will require as well as its human dimensions, and should include sections giving: (1) a text description of the project; (2) a description of the assumptions about the project necessary to assess its environmental impacts; and (3) a description of the project activities.

The description of project activities and operations should be broken down into the different phases of the project, namely: preconstruction, construction, operation including maintenance, and abandonment. For each phase, the magnitude, timing and duration of each activity should be given with overall schedules for each phase. The term "construction phase" is used broadly here to include the implementation of both structural and nonstructural project activities. Parts of most projects will include less technical activities such as flood proofing that may not involve construction *per se*. These activities, however, would be implemented in what would otherwise be considered the construction phase of the project. Thus, the use of the term "construction" is not in any way meant to delimit or constrain the full use and implementation of non-structural activities. If the proposed projects involve few or no construction activities, then this phase should be termed, "implementation phase". Examples of activities which might occur in each phase are given in Table 3.1.

All parts of the project description should proceed in a logical manner, usually in chronological order with activities grouped by project site, and in enough detail to enable the reviewer to understand exactly how the project will proceed. A satisfactory project description is essential to the success of the assessment. Project assumptions are used the most at the earliest levels of the assessment such as the prefeasibility stage, when there are still many unknowns and it is impossible to be specific about some aspects of project design. For the purposes of proceeding with the assessment, however, reasonable assumptions are made to eliminate as much project uncertainty as possible. By stating these assumptions explicitly, the reviewers and interested parties can easily refer to them in their evaluation of the assessment report.

When reasonable assumptions cannot be made or the EIA cannot reach a consensus, then the "worst case condition" must be assumed. This means that without data or knowledge to the contrary, the worst or maximum possible impact will be assumed.

Each phase has associated with it normal or planned activities that are necessary to design, construct and operate the project. Potential accidental or unplanned events may also occur. Accidents may include fuel or chemical spills, fires, vehicle or vessel collisions, structural collapses, dam bursts, floods, surface and groundwater contamination. The potential for accidents during all four project phases should be described. For the assessment, it is usually assumed that accidents will happen regardless of how unlikely they are. This ensures that they are adequately planned for. The likelihood of an accident can be couched in terms of probability. Accidents may have a low probability or a high probability of occurring, depending upon the frequency or duration of the event that could trigger an accident. Project activities should follow the same logical sequence of the project phases with normal (routine) activities listed first and then accidental events for each project phase.

### Rationale

The project rationale explores the need for the proposed project. The description should also state who is advocating the project, who would build it, who would operate and maintain it, who and what may benefit from the project, who and what may suffer from it, and which interested parties may be affected by the project. The rationale also includes a description of the goals and objectives of society that would be served by the project, reasons why the project is needed, and direct benefits expected, including return on investment, employment, production and other benefits. The rationale should also identify criteria for sustainability and how these would be met, or if not met, how this would be justified.

### Alternatives

This section describes possible alternatives which would achieve the same purpose as the project as well as a discussion of the consequences of postponing or abandoning the project. The "no action alternative" or the without (WO) project option should always be included in the set of alternatives. Alternatives may involve different configurations, design technologies, components, processes, or other design options, alternative location(s), and environmental management measures, mitigation measures, compensation, enhancement, and monitoring (see Section 3.8). Depending on the type

## Table 3.1 Normal Activities Associated with ~~Water Sector~~ Projects Having Potential Environmental Effects

1. *Preconstruction (Planning, Exploration and Study) Phase*
   - Land, topographic and benchmark surveys
   - Hydrological and climatic surveys
   - Land use and natural resource inventories
   - Socioeconomic surveys
   - Land acquisition
   - Temporary access roads
   - Geotechnical data collection
   - People's participation
   - Village and infrastructural resettlement and relocation

2. *Construction and Operation & Maintenance Phase*
   - Road access
   - Temporary structures and land occupation:
     - Storage
     - Staff and labor camps
     - Garages and parking sites
     - Canteens and kitchens
     - Waste and garbage disposal sites
     - Water handling and storage facilities
   - Excavation of canals:
     - Drainage
     - Irrigation
     - Navigation
     - Fisheries
   - Embankment construction
     - Labor mobilization
     - Soil taking and borrow pit construction
   - Installation of tube wells and associated electricity and energy supplies
   - Construction of hydraulic structures:
     - Sluice gates
     - Regulators
     - Culverts
     - Fish ladders
     - Navigation lock gates
     - Pump houses
     - Irrigation canals
     - Drainage canals
   - Shoreline construction:
     - Excavation
     - Dredging
     - Shoreline reinforcing
     - Construction of coffer dams and protecting walls
   - People's participation
     - Navigation lock gates
     - Pump houses
     - Embankments
     - Drainage channels
     - Irrigation canals
     - Cyclone and flood shelters
   - Agricultural development:
     - Institutional development
     - Agricultural extension
     - Credit inputs
     - Seed acquisition and distribution
     - Fertilizer storage and application
     - Pesticide storage and application
     - Irrigation
     - Establishment and operation of cooperatives and resource user groups
   - Development of infrastructure and supply services
   - People's participation
     - Community educational programs
     - Project support programs

4. *Abandonment (Post-Project) Phase*
   - Land reclamation
   - Monitoring and evaluation
   - People's participation

and feasibility of each alternative, it may be necessary to carry each throughout the remaining assessment steps treating them as fully as the main project. If alternatives are clearly dysfunctional and non-viable they should be deleted at this step of the assessment. There must, however, be clear justification given when doing this.

### 3.2 Environmental Baseline Description (Step 2)

The purpose of the environmental baseline description in an EIA is to provide a comprehensive but succinct understanding of the area that will receive the proposed project. The baseline description introduces EIA readers and reviewers to the environmental characteristics of the area and provides the basic information used in the scoping and bounding steps which follow (Sections 3.3 and 3.4).

Environmental baseline information is obtained from several sources:

- reviews of available reports on the area from previous studies and regional planning reports;
- government statistics and resource publications (described in more detail in subsequent chapters);
- reconnaissances of the area by the EIA Team, using road and boat travel and, if possible, aerial overflights. There are often severe time and budgetary constraints on EIA teams with the result that field reconnaissances and studies may not be done at appropriate times to detect seasonally significant changes and patterns.

In developing the environmental baseline description, the EIA Team should bear in mind the requirements of the scoping process (see Section 3.3) so that *Important Environmental Components* (IECs) can be identified early in the assessment process.

For ease of presentation and reporting purposes, the environmental baseline is customarily broken down into biophysical and socioeconomic environments. The description should emphasize the *linkages* between various components, the main flows and exchanges of materials and energy, and identify the main *ecological, social and economic constraints* within the area.

The main features of the baseline description are:

- area characteristics—watersheds, area size, location in relation to regions, major rivers and topographic features (e.g., foothills), major infrastructural features (e.g., linking roads, existing embankments);
- main features of the hydrological cycle, including climate, rainfall, flooding patterns (flash floods, seasonal floods), drought patterns;
- major land use patterns and distribution of population (settlement areas) and resources;
- trends in land use, resource availability, urban expansion, wetland conversion; and
- primary conditions that limit biological resources.

Baseline descriptions tend to be based heavily on study team impressions at the time of the initial field reconnaissance and subsequent detailed studies. Practitioners should attempt to distinguish seasonal fluctuations and long-term trends in environmental features of the study area.

- Short-term trends are due to seasonal or periodic fluctuations in biophysical conditions or resource availability and use.
- Long-terms trends are due to changing baseline conditions on a local, regional, national or global scale (Figure 3.1).

The environmental baseline description should end with a review and emphasis on those environmental components most related to the features of the project, e.g., frequency, duration, ecological and socioeconomic features.

### 3.3 Scoping (Step 3)

A scoping process should be used to identify the IECs and key issues associated with the assessment. Scoping is performed in consultation with both government agencies, NGOs, and the public.

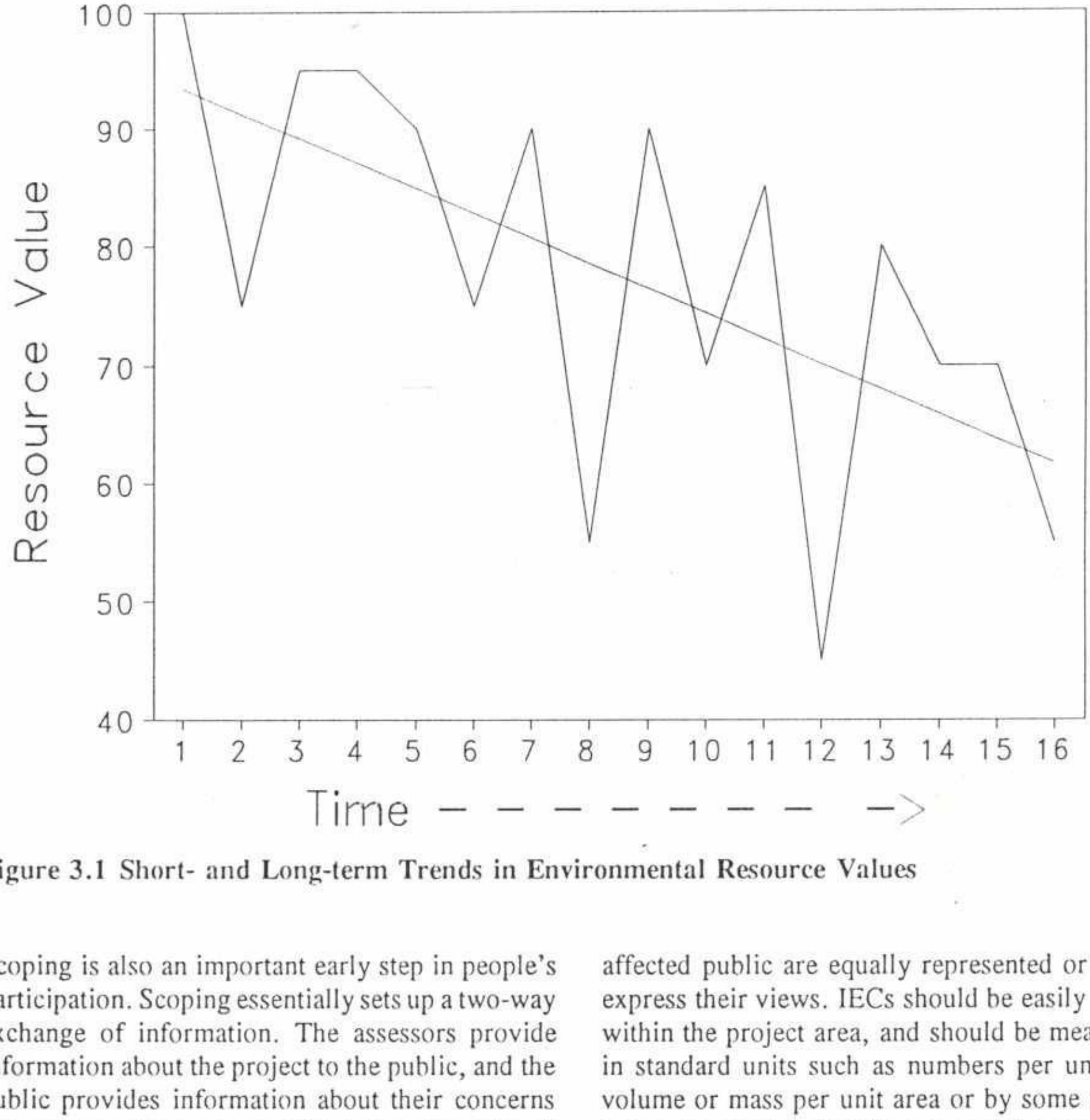


**Figure 3.1 Short- and Long-term Trends in Environmental Resource Values**

Scoping is also an important early step in people's participation. Scoping essentially sets up a two-way exchange of information. The assessors provide information about the project to the public, and the public provides information about their concerns and needs to the assessors. This is beneficial for all parties because the public is now involved in the assessment, and the assessors are more aware of what issues and IECs to focus upon.

IECs are components that, by virtue of their importance to ecosystem functioning, production of food and/or maintenance of livelihoods and quality of life, are considered essential and worthy of sustaining at existing or enhanced levels under the proposed new project regime. Generally, IECs are chosen for their importance to various interested parties; in many cases, however, not all of the affected public are equally represented or able to express their views. IECs should be easily defined within the project area, and should be measurable in standard units such as numbers per unit area, volume or mass per unit area or by some form of index. Examples of IECs selected for projects in Bangladesh could be as follows: surface water quality, salinity, groundwater recharge rate, groundwater quality, wildlife species, special environments such as wetlands, biodiversity, agricultural production, soil fertility, open-water fisheries production, culture fisheries production, navigation, health, and nutritional state, way of life, property ownership, employment, and per capita income.

Care should be taken with the identification and definition of IECs so that they are not confused with impacts and assessments. For example *surface water* may be selected as an IEC and may be separated into sub-components such as *peak flooding levels at selected times* and *mean annual water levels*. *Reduction in peak flooding* levels would not be considered an IEC but rather an impact on the IEC (= peak flooding levels). The purpose of selecting IECs is to reduce the EIA to manageable proportions in terms of data collection and impact assessment by focusing on the most important and most affected components, and eliminating components and resources that are likely to be affected to a very small degree or where the impacts cannot be measured or assessed due to technical and other limitations.

Scoping is best accomplished in a number of stages.

1. *Integrate available knowledge*: knowledge and information available from as many sources as possible, including at least the following, should be summarized and compared:
   - archived information sources including literature and reports on previous projects;
   - expert opinion from technical specialist, national, regional and local government officials, and non-government organizations (NGOs);
   - information gathered during the preliminary field reconnaissance; and
   - knowledge gained from local communities, especially those using local land and water resources.

2. *Integrate available expertise*: scoping by technical specialists is best achieved through technical meetings and workshop sessions where information sharing and simple quantitative analyses can identify the IECs to be considered further and to eliminate those components not requiring further attention.
   - Team meetings, at which each member contributes ideas about potential project impacts in his or her specialty area.
   - Meetings between individual team members and representatives of government agencies responsible for their resources. Records of these meetings should be kept by the EIA Team Leader.
   - Production of scoping papers, which are clearly written and well illustrated documents describing the proposed actions and their foreseeable effects.
   - Organize and conduct scoping meetings. The scoping meetings require considerable planning, both logistical and technical. The former should be assigned to a team member with experience in organizing meetings in Bangladesh, while the EIA Team Leader and staff concentrate on technical matters. Meetings should be held at several levels of government and society (see People's Participation in Chapter 7).

3. *Refine and establish issues and priorities* associated with the IECs by evaluating them in terms of:
   - distribution (within the study area and elsewhere);
   - quantity, quality and seasonality;
   - interaction with other IECs;
   - biophysical and/or socioeconomic importance;
   - availability of substitutes;
   - economic value; and
   - management responsibility and practices.

As a step in environmental assessment, scoping provides cost efficiencies in the conduct of assessment and review by limiting the work required to key components and issues; it enhances public credibility of the process by incorporating their concerns from the outset; reduces the chances of delays further along the process; and makes the results more meaningful and relevant to political decision-makers.

## 3.4 Bounding (Step 4)

The process by which the spatial and temporal dimensions of the EIA are determined is termed *bounding*. Bounding should be a conscious and deliberate procedure on the part of the EIA team and should be specifically documented in the IEE and EIAR. In the absence of a rigorous bounding procedure, practitioners are likely to select limits that reflect the availability of data and information. They may tend to drift into the use of limits that are too wide, thus de-emphasizing the magnitude of localized impacts. Conversely, if bounds are selected too narrowly, localized impacts are overemphasized while possibly neglecting more widespread impacts. Appropriate bounding requires judgment and consideration of all major resources and environmental components likely to be affected by the project activities.

*Spatial boundaries* for the EIA are best determined by selecting the major groups of project activities and interventions, and then considering how they will interact with the major classes of IECs (Section 3.2). Network analysis is a useful technique to trace the cause and effect patterns of environmental components and impacts, which may extend beyond the immediate locality of the project. Usually several sets of spatial bounds are selected to suit the requirements of the project, the IECs and the resources being studied (Figure 3.2). For most plans and projects in the water sector the following are likely considerations:

- physical factors, especially watershed boundaries;
- ecological boundaries that encompass the spatial and seasonal ranges occupied by biological populations being considered in the assessment; and
- social and administrative boundaries, including regions, districts and upazila boundaries.

Watershed boundaries should include areas both up- and downstream of the immediate project site within which project effects are likely to occur. Separate boundaries should include the areas within which off-site and cumulative impacts should also be determined.

A useful criterion to apply when considering study area bounds is to consider how far from the actual project site will effects be measurable. EIA practitioners are usually constrained by limitations of the available methods and techniques of acquiring data, and by the variations and sampling errors inherent in most databases. There is little point in data collection efforts in areas where the amount of project-induced change is unlikely to be detectable against background variation. Qualitative assessments might be made for such cases. The boundaries within which hydrological changes could be measured with standard recording equipment, e.g., level and flow gauging stations, often governs the choice of primary study area.

The level of effort needed for data acquisition, analysis and assessment is not necessarily uniform for all environmental components and resources within all selected study area boundaries. While the most comprehensive effort would usually be directed at the area in the immediate vicinity of the project, less effort might be directed at more specific items of importance in a wider context, e.g., hydrological changes downstream of a project area (See Figure 3.2).

*Temporal boundaries* refer to the timing and duration of the proposed phases. Construction periods are usually relatively brief but induce certain types of impacts of high intensity, e.g., determining water quality (sedimentation effects) or labor influxes. Operational periods are usually longer than construction and induce impacts of longer duration.

## 3.5 Major Field Investigations (Step 5)

Field studies should be conducted to obtain information unavailable from existing sources, and to update and verify existing data. Rapid field assessments are recommended for regional plans and prefeasibility-level studies. For feasibility-level EIA more detailed investigations, entailing data collection and consideration of seasonal cycles, should be undertaken. Chapters 8 to 11 detail the recommended sources of data and methods of analysis and presentation for four main resource sectors. Field data collection should:

- focus on IECs so that time and resources are not spent on measuring irrelevant environmental components;

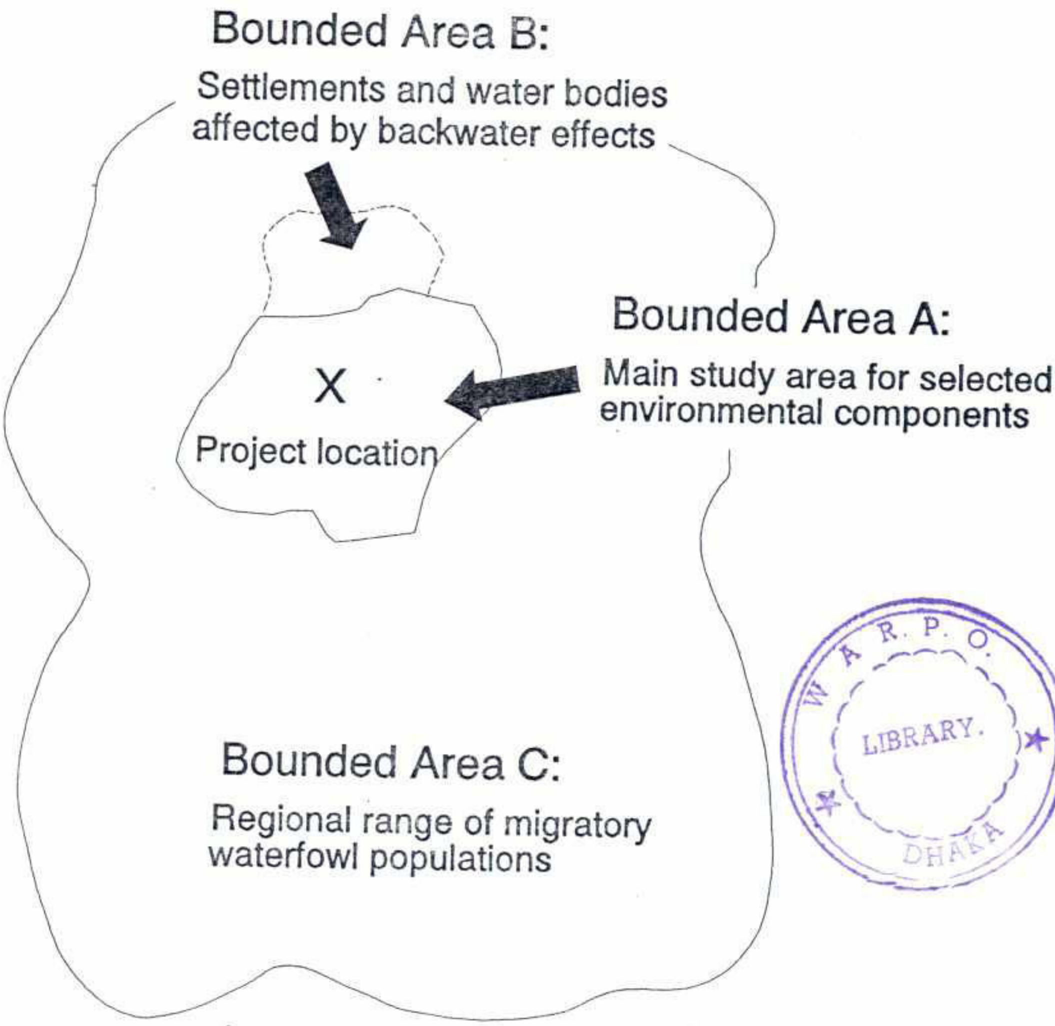




Figure 3.2 Example of Bounding for Specific Study Purposes in EIA

- quantitatively establish the status and trends of existing IECs;
- provide measures of future status in the absence of any project development;
- occur within the project impact areas as defined during the bounding process;
- meet accepted criteria for sampling adequacy and data reliability (practitioners should consult standard statistical texts for background information on sampling procedures);
- encompass the whole range of important conditions prevailing within hydrological cycles (pre-monsoon, post-monsoon, dry season), agricultural cycles (kharif 1, kharif 2, rabi) and ecological cycles (waterfowl and fish migration periods).

All methods used in field sampling should be fully documented, including the provision of maps indicating sampling sites and times.

### 3.6 Impact Assessment (Step 6)

There are essentially four types of impacts and issues to be considered in an assessment: the project-on-environment impacts, environment-on-project impacts, scoping issues, and cumulative effects. Project-on-environment impacts are usually the largest category of project-specific impacts relevant to the assessment and thus form the bulk of the assessment proper. The environment-on-project impacts relate to any environmental factors that might affect the construction and operation of the project that lead to subsequent environmental effects. This type of impact includes such diverse environmental factors as cyclones and other tropical storms, extreme rainfall and flooding, public cuts of embankments, etc. Scoping issues are those issues that arise in the scoping step and constitute major concerns of the interested parties. Most often scoping issues will be included in the first two types of impact assessment, however, occasionally this is not appropriate, and these concerns need to be carried throughout the assessment in a separate category. Cumulative impacts are those that occur over extended space and time dimensions, and thus, represent regional patterns of environmental deterioration. Cumulative effects often arise because of multiple human activities in a region such as farmers undertaking unsustainable agricultural practices that lead to extensive soil erosion. Individual actions need not be large but their combined or cumulative impact can be serious. The IEE level of assessment in the regional plans should particularly focus on cumulative impacts and regional trends of environmental quality and deterioration.

Assessment methods are described in Chapter 4. Details of impact assessment for specific IECs are given in the respective resource sections (Chapters 8 through 11).

Impact assessment consists of predicting the amount and direction of change in an IEC in the future if a specified set of project activities are implemented and the type, timing, direction, duration and significance of the amount of predicted future change. Impact assessment is an iterative process by which impacts are predicted and then the assessment team attempts to determine whether or not the project design could be modified to lessen or alleviate these impacts (Step 9). If this is not possible, then the predicted impacts are analyzed through the preparation of an Environmental Management Plan (EMP).

The EMP includes a variety of measures that are custom-designed to lessen or avoid the predicted impacts and to ensure an environmentally sound and sustainable project. Sometimes it is impossible to mitigate impacts because the technology is not available or the cost is prohibitively high. In these cases, impacts that are expected to occur after the EMP is implemented, are termed residual impacts. It is these remaining impacts that are evaluated in the project assessment process and used to determine whether or not the project should proceed. Thus, significance of impacts refers to residual impacts that constitute the "bottom line" of the assessment.

### 3.7 Impact Evaluation (Step 7)

Evaluation of impacts requires the assignment of a set of values that signify the importance of the impacts. Evaluation begins when impacts are initially identified. The process can only be finished, however, once residual impacts are determined after the EMP is finalized. A system of *multi-criteria analysis* (MCA) has been accepted for project appraisal in the water sector (FPCO 1992b), and environmental impacts should be similarly evaluated so that the full benefit and cost of environmental change and management can be factored into the overall project evaluation. Under the MCA system, residual impacts are evaluated in:

- economic terms (taka or dollars) where valuation is possible and acceptably accurate; or
- numeric terms, where costing is not feasible; or
- descriptive terms where neither of the above is possible.

The terms "valuation" and "evaluation" are often used interchangeably. In this manual, "valuation" is used in specific reference to the assigning of monetary values, while "evaluation" is used in a more general sense of judgement and consideration of significance of residual impacts.

Even where full economic and/or quantified assessment is possible, it is always beneficial for decision-makers and people affected by the project to have the impacts clearly described in descriptive terms, using carefully chosen and objective descriptors as well as numeric and comparative ratings (see Section 3.7.3).

### 3.7.1 Economic Valuation

The assigning of values is undertaken within the economic analysis of a project. The basic data for these values are derived from the EIA, and the EIAR should provide the information in a form that can be readily used and adopted in the economic analysis.

The value of environmental impacts includes costs of impact mitigation measures and other actions detailed in the Environmental Management Plan (see Section 3.8). These have two parts:

- costs directly related to project measures taken to mitigate impacts (e.g., specific control structures, fish passes, access roads, embankment strengthening, maintenance, etc.); and
- costs externally related to the project through the Environmental Management Plan within the project impact area (e.g., agricultural extension, social, women's and educational programs, fisheries enhancement and extension, programs, etc.).

Costs accruing to different project components (*especially flood protection, drainage and irrigation*) and to different projects (*if more than one is being developed contiguously and simultaneously*) should be computed and reported separately to ensure adequate attention is given to mitigation and monitoring. These requirements assume that all reasonable steps will be taken to mitigate negative impacts through development of an effective Environmental Management Plan (EMP).

### 3.7.2 Numeric Evaluation

Evaluation of the impacts in quantified terms such as numbers, densities, percentage changes, etc. without the application of economic evaluation is usually done where the EIA practitioner chooses not to apply costing methods because of doubts or inconsistencies in their validity. This could apply to impacts on resources such as wildlife or habitats that have an undoubted value but the actual economic losses or gains cannot be estimated because of a lack of market-based prices for such resources. The basic quantities are given in the evaluation as gains or losses with no associated economic values.

### 3.7.3 Descriptive Evaluation

Where an impact cannot satisfactorily be quantified in terms of standard units expressing weight, density, quality, etc., attempts should be made to rate them on the basis of their classification. Rating requires a sound level of professional judgement and experience and is therefore best accomplished by an integrated Assessment Team working in collaboration with project planners, engineers and decision-makers. The following are the main characteristics:

- *Sustainability* of the resource or environmental component when impacted; three broad categories may be adequate, i.e., sustainable when impacted, sustainable provided mitigation measures are put into effect, and not sustainable under impact, even with mitigation.
- *Magnitude* of the change expressed in relatively few categories, e.g., "high", "moderate" and "low", where the distinction among the categories is explicitly stated, e.g., 20 percent reduction in resource, 40-60 percent reduction, etc.
- *Duration* of impacts, i.e., usually long-term (e.g., life of the project) and short-term (relative to overall project life).
- *Reversibility* (e.g., cutting off fish migration by an embankment might be reversible at a later stage if a regulator were built, provided conditions on both sides remain favorable to migrations);
- *Cumulative or non-cumulative*: most impacts are cumulative by nature, but the

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key consideration is whether or not there will be impacts extended enough in space and time to cause patterns of regional environmental deterioration;

- *Direction* of the change, expressed quantitatively as an increase or a decrease normally corresponding to the descriptors "positive" or "negative" depending on the direction of the change; and
- *Desirability* of the impact, corresponding to the broad descriptors "beneficial" or "desirable" and their opposites "harmful" or "undesirable."

The smallest numeric rating scale recommended is a seven-point one (1, 2 or 3 for positive or beneficial impacts, 0 for no impact, -1, -2 or -3 for negative or harmful impacts, the numerals corresponding to "high," "moderate" and "low," respectively). A 21-point scale has been suggested for Flood Action Plan projects (FPCO 1992a), for example (1 to 10 for beneficial impacts, 0 for no impact, -1 to -10 for negative impacts). Ratings should be consistently applied to reflect the characteristics given above. Numeric impact indices can be *weighted* to reflect the relative importance of the IECs subjected to the impacts. A range of values reflecting the relative weights (e.g., 1-2-3, or 1 to 5) are selected, the highest value indicating the most important IEC being rated, and multiplied by the base impact rating. Thus, a high cumulative irreversible long-term impact on a resource that is not sustainable under the impact (-10 on the 21-point scale) and that is regarded as most important on a 10-point scale would have a total impact rating of 10 x 10 = -100.

Weighting of impacts is a highly judgmental procedure since assigning importance to an impact and a particular environmental component depends very strongly on the background, experience and viewpoint of the individual conducting the assessment, and it is generally not repeatable from one individual or team to the next, thus leading to inconsistency in approach. Moreover, the plethora of invented numbers produced tends to cloud the description and presentation of impact assessments and renders the decision-maker's task much more difficult. Figure 3.3 outlines one possible set of values for beneficial and negative impacts, based on weighting according to sustainability, impact reversibility and environmental component sensitivity.

### 3.7.4 Alternative Analysis

The scoring and weighting of environmental impacts is a very subjective way to resolve environmental impacts and to make project decisions. Another approach to impact analysis, not based on scoring and weighting IECs, is Alternative Analysis. The purpose of Alternative Analysis is to allow the EIA team to recommend one project action over another based upon the team's conclusions concerning impacts on specific IECs.

An EIA normally addresses two or more project alternatives:

- Preferred Alternative—the scheme presented as the project;
- No Action Alternative—environmental conditions if the project is not built;
- Project Alternative—one alternative (siting, size, operation, etc.) to the preferred alternative; or
- Other Alternatives may be presented by the project proponent or suggested by the EIA team for evaluation.

Each alternative is evaluated as if it were a separate project. The same data set used for the preferred alternative is also used to assess the impacts of all other alternatives. Thus, EIA sections on climate, land, water, biological, and human resources need not be duplicated. However, each alternative requires a separate environmental impact section (including cumulative impacts) that focuses on specific IECs.

The first step in Alternative Analysis is to tabulate the gains and losses predicted for each IEC for each alternative. Tabulation, for the most part, is quantitative; however, qualitative statements for IECs that cannot be numerically described are appropriate.

| Beneficial Impacts | | | Impact Scoring Categories | | |
|---|---|---|---|---|---|
| | | | Sustainable | Sustainable with Mitigation | Not Sustainable |
| Sensitive | Immediate | High Magnitude | +10 | +7 | +4 |
| | | Low Magnitude | +6 | +4 | +2 |
| | Gradual | High Magnitude | +7 | +5 | +3 |
| | | Low Magnitude | +4 | +3 | +2 |
| Less Sensitive | Immediate | High Magnitude | +6 | +4 | +2 |
| | | Low Magnitude | +3 | +2 | +1 |
| | Gradual | High Magnitude | +4 | +3 | +2 |
| | | Low Magnitude | +2 | +2 | +1 |

| Negative Impacts | | | Irreversible | Reversible with Mitigation | Reversible |
|---|---|---|---|---|---|
| Sensitive | Immediate | High Magnitude | -10 | -7 | -4 |
| | | Low Magnitude | -6 | -4 | -2 |
| | Gradual | High Magnitude | -7 | -5 | -3 |
| | | Low Magnitude | -4 | -3 | -2 |
| Less Sensitive | Immediate | High Magnitude | -6 | -4 | -2 |
| | | Low Magnitude | -3 | -2 | -1 |
| | Gradual | High Magnitude | -4 | -3 | -2 |
| | | Low Magnitude | -2 | -2 | -1 |

**Figure 3.3 Assignment of Numeric Rating to Impacts Using a 21-point Scale**

The tabulated IEC impacts are then converted to percent change so that all IECs have a common unit of measure.

$$\text{Percent Change} = \left[\frac{A-B}{B}\right] 100 \ \textit{when } A < B$$

where: A = impacts with project
B = impacts without project

A single table is produced that lists the percent change for all IECs for each alternative (Figure 3.4).

In making their recommendation, the EIA team can establish specific criteria or standards for each IEC that project impacts cannot exceed. Essentially these are thresholds based on scientific literature or the team's conclusions concerning cumulative impacts.

For example, in the scientific literature the U.S. Fish and Wildlife Service uses a threshold or criteria or standard of 20% for fish habitat loss. A project impact cannot result in more than 20% reduction in fish habitat. This threshold is based upon years of sampling in a variety of river types. While such a standard does not have the authority of a law passed by a governing body (like water quality standards), it does have the authority of the scientific community that any degradation below this threshold will result in irretrievable impacts and permanent loss of habitat.

The EIA team can also establish their own thresholds or standards for the IECs based on the cumulative impact assessment presented in the EIA. If it is known that the project under investigation will be followed by more projects of a similar nature in the same area, then, in order to allocate the amount of environmental impacts that must be accommodated in the future, the team can state a threshold for this particular project based on future impacts that will come from future projects. For example, if the planned scheme is an irrigation project and will result in a 25% loss of fish habitat, and it is known that three other projects just

| IEC | Preferred Alternative | No Action Alternative | Project Alternative |
|---|---|---|---|
| Fisheries: | | | |
| catch | -43% | -5% | -23% |
| habitat | -22% | -0% | -15% |
| income | -38% | -7% | -8% |
| Wildlife: | | | |
| species | -40% | -0% | -30% |
| habitat | -10% | -1% | -2% |
| Homesteads | | | |
| garden | +25% | 0% | +45% |
| trees | +10% | 0% | +25% |
| Socioeconomic: | | | |
| wages | +13% | +8% | +13% |
| Quality of Life: | | | |
| nutrition | decrease | no change | decrease |
| space | decrease | no change | decrease |
| health | decrease | no change | decrease |

**Figure 3.4 Example of a Table Listing Percent Change for IECs for each Alternative**

like it will be developed in the near future, it is a simple matter to predict that with all four projects in place there will be a 100% loss in fish habitat. Obviously, this is an irretrievable and unacceptable level or impact. The EIA team can, therefore, set a threshold of no more than 10% loss of fish habitat because when future projects are all in place the total fish habitat will be reduced by no more than 40%. Thus the team can cite strong justification for establishing a standard or threshold for this particular IEC (fish habitat) which will be difficult to argue against.

Of course, the EIA team must be careful that any thresholds used in making their recommendations is verifiable (can be cited in a scientific document), or can be justified with logical arguments based on the facts presented in the EIA, and is applicable to the environment included in the EIA.

The EIA can include a recommendation section where the team puts forward its joint decision on which alternative (including the no-action alternative) is most acceptable. The recommendation should address each alternative separately and state very clearly, using the results and conclusions of the EIA, why the alternative is acceptable or unacceptable in terms of environmental impact.

The recommendations should not be based on comparisons between the project benefits and environmental impacts. That the project will have benefits (more crop land, flood protection, etc.) is a given. The issue to be resolved with an EIA is the cost of those benefits. Since there is no such thing as a free lunch, one must recognize that no project can be built that does not have some environmental impacts. The question is, will the benefits of the project cost too much in terms of environmental degradation.

It follows that when the impact (percent change) on an IEC is identified and becomes a primary element in the decision-making process, mitigation of the impact on the IEC becomes more focused. If the impact on the IEC must be reduced to a more acceptable level (below the established threshold, for example), then mitigation actions that (1) avoid, (2) minimize, or (3) replace become easier to identify because the *mitigation goal* is easily understood. The project proponent, knowing that fish habitat cannot be degraded below 10%, can then reconfigure or redesign specific components of the project to make them less damaging to fish habitat. Thus the final project depends upon feedback from the EIA process to minimize, avoid, or mitigate impacts.

## 3.8 Environmental Management Plan (Step 8)

The Environmental Management Plan (EMP) is the basis for dealing with all major negative impacts of a proposed project during the construction, implementation, maintenance and (if required) abandonment stages. It may also contain specific measures for environmental enhancement to increase the benefits of a project. It is the link from the EIA stage through to the implementation stage of the project, and is the environmental equivalent of the engineering design documents and drawings.

The main components of the EMP are:

- long-term mitigation and enhancement;
- environmental protection measures, largely mitigation during construction as described in the Environmental Protection Plan;
- monitoring;
- contingency planning;
- people's participation;
- institutional arrangements;
- compensation arrangements (if applicable);
- cost estimates (for implementation of the detailed EMP); and
- reporting and accountability.

The level of detail in the EMP will vary according to the stage of project study and development.

- *Prefeasibility*: identification of broad management options and major constraints: the EMP is an integral part of the IEE;
- *Feasibility*: prior to review and decision

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on project development—identification of specific mitigation options and expected residual impacts in the EIAR;

- *Detailed design of selected option* of specific proposed mitigation, cost estimates, implementation schedules, mode of implementation, personnel requirements and training, and institutional arrangements.

For the third step, a detailed EMP report preferably separate from the EIAR is required to provide a working link to detailed engineering designs and contract documents. The EMP draws on the EIAR for its basic information inputs.

Reviews and recommendations on the Environmental Management Plan should be undertaken among the EIA practitioners, the project design and planning engineers, the government ministries/agencies responsible for the project including operation and maintenance, and local community representatives.

Budgeting for the EMP should be included in the project development and operations and maintenance (O&M) budgets to ensure implementation is effective. Budgetary support for mitigation programs may involve:

- one-time financial grants to implementing agencies or bodies;
- continuing financial inputs as part of project management.

The EMP and, in particular, the Environmental Protection Plan which specifies measures to be taken during project construction, should be made an integral part of the tender and contract documents for the project.

## 3.9 Feedback to Improve Project Design (Step 9)

Feedback to improve project design is a step incorporated into the assessment process and used before the EMP is finalized. It anticipates potential environmental problems and helps improve the project description to avoid those problems. This involves decisions made during planning stages of the project with regard to site selection, design alternatives and technologies used. This tool is implemented by the entire assessment team and requires integration of environmental (biophysical and socioeconomic) and engineering components simultaneously.

This is an iterative and integral step in the EIA framework as outlined at the beginning of this chapter. New impacts, identified as a result of project scoping, bounding, or additional studies and analyses, are accounted for by the anticipatory planning feedback loop, which then alters the project design to avoid negative impacts and enhance positive ones as much as possible. This ensures that the project design will entail environmental concerns from its earliest stages. For example, if bounding resulted in the prediction of significant cumulative effects at a proposed site, then alternative sites would be examined and perhaps another site could be selected which would result in fewer impacts. This type of planning is especially important in the prefeasibility phase.

Anticipatory feedback planning is one of the most cost-efficient steps in the assessment process. Its integration in the early design of a project helps to avoid the need for expensive or time-consuming alterations after a project is designed. Most project designs can be altered through changes in siting, design specifications, scheduling, size or operational mode to reduce the expected level of negative impact, and/or to enhance the amount of benefit received. Changes in design are most easily achieved at an early stage in the studies, i.e., preferably after the IEE stage. Changes in project siting usually precede changes in design specifications, e.g., embankment heights, regulator discharge capacities, etc. It eliminates a series of potential impacts and consequently minimizes the need for mitigation and other costly environmental management measures such as retrofitting. This produces a speedier assessment process, a better project and more protected environment. An overall awareness of the environment in the project design is also a direct benefit of anticipatory planning.

A knowledge of the beneficial or negative effects of other project designs already in existence is of considerable benefit in considering and justifying project design changes to achieve effective environmental management.

Effective feedback from the EIA study team to the project design engineers is best done through the use of *integrated* study teams, where information on project design changes and the results of environmental assessment studies is exchanged and discussed frequently. Regular meetings should be held among the Assessment Team, the Team Leader, and the design and planning teams. Individual team members should be encouraged to present their findings with suggestions for how any negative residual impacts could be reduced.

### 3.10 EIA Reporting (Step 10)

Results of environmental assessments are reported at two levels:

- an IEE report for project prefeasibility or for regional planning studies; and
- a detailed EIAR for feasibility studies.

A finalized Environmental Management Plan (EMP) is included in the EIAR when reviews have been completed and a decision has been made to implement the project with all modifications and subsequent incorporations (see Section 3.8).

Standardized approaches to study and reporting procedures on methods and data collection are encouraged to facilitate reviews and to promote efficient implementation of project development and mitigation measures. EIARs are the main medium of information exchange among EIA practitioners, project planners and engineers and decision-makers. They should be detailed and analytical while presenting information, conclusions and recommendations clearly and unambiguously. Main sections of the reports are described in Chapter 6.

# Chapter 4

# IMPACT ASSESSMENT METHODOLOGIES

## 4.1 Simplification

Ecosystems and environmental resource systems are complex, with many components, many types of interactions between and among these components, and many types of potential reactions to project activities. To make comprehensible and useful impact assessments, some form of *simplification* is required. Simplification is a process of breaking down a large complex system with associated complex questions into smaller, more manageable pieces with simpler questions, which are more easily dealt with, and restricting the activity to a few selected questions relating to the most important components and impacts. Two steps in the simplification process are recommended:

- selection and use of IECs (Section 4.3): these are the main focus of the impact assessment process, assessment of impacts is best related to expected changes in the IECs;
- development of a conceptual model describing how the main features of the project relate to the IECs.

## 4.2 Models and Modelling

Models are simplified representations of reality that define the relationship of selected components to one another. Maps, diagrams, flow-charts, small-scale replications, verbal descriptions and mental visualizations are all representations of reality and are thus all useful "models" in describing and assessing environmental impacts. More sophisticated models may be dynamic and describe the rates of transfer of energy and material from one component to another in the form of words, pictures or mathematical equations. Such models have four levels of sophistication:

- conceptualization: description of the components, the inputs and outputs, and how these relate to one another;
- development of mathematical equations that describe the rates of transfer of materials (e.g., water), energy, etc. from one compartment to another;
- parameterization of models by defining numerical values for the various components and transfer rates;
- use of models by entering selected values (e.g., rate of inflows and precipitation) into the set of equations (i.e., the model) and receiving selected values (e.g., water levels at specified points in a river) as output.

Frequently-used dynamic models include hydrological ones (e.g., the MIKE-11 model in common use in the water sector), which mathematically describe the movement and retention of water, sediments and/or chemicals through compartments of an area (e.g., river, canal, floodplain, incoming precipitation) and produce information such as water levels and discharge rates, which are of direct value in understanding and predicting potential environmental changes induced by project activities. Environmental and ecological models can be developed in similar fashion, but have yet to be developed to the same mathematical and operational stage for floodplain systems in Bangladesh. When they are, they will be of considerable for the broad field of environment but different levels of sophistication can be achieved for specific components of environment (i.e. Water as stated above.)

value in predicting and understanding environmental changes brought about by specific interventions. At present, only the *conceptual* stage of modelling has been attained.

Conceptual models provide a description of the main components of the floodplain ecosystem and describe how these relate to one another and to proposed interventions such as embankments and regulators. They provide a valuable basis for impact assessment:

- they provide a method for simplifying the complex environmental system down to a relatively few components for description and prediction;
- they provide a common integrative base for assessments that deal with many components ranging from physical to biological to human; and
- they provide a valuable means of communicating with reviewers and users of the EIAR.

Conceptual models used in EIA generally take into account only the IECs or a component or process related to the IECs.

In the absence of a specifically defined conceptual model of the environmental system and the relationship to the proposed project, practitioners will tend to use their own undefined intuitive models, which usually relate in some way to projects they have seen or worked on in the past and greatly influenced by the level of insight and knowledge of project area environment.

Three types of conceptual models are useful in EIA to define the relationship of environmental components to one another and to the project, and to serve as a basis for describing and, in some cases, for predicting and assessing impacts:

- matrices
- networks
- seasonal models

Each of these are best developed over a series of stages:

- following the field survey of existing environmental conditions and collection of historical data, a preliminary model describing major components and their relationships can be sketched out;
- identification and inclusion of IECs;
- during the description of environmental baseline conditions by subject experts with quantification of the IECs;
- refinement during the impact assessment stage.

Different approaches can be usefully integrated during the course of an EIA. Networks and matrices are often interchangeable because the elements of the matrix frequently represent links in the network. Both networks and matrices can serve as the basis for developing more sophisticated computer simulation models.

### 4.2.1 Matrices

Matrices are useful two-dimensional models for relating two sets of items represented by rows and columns in the matrix. A common use in EIAs is to relate project activities to environmental components. A cross-impact matrix illustrates the project activities (rows) that have an effect on the column-listed IECs. The elements of the matrix represent the individual relationships between each project activity and each IEC (Figure 4.1). The reverse situation would be an environment-on-project matrix, to show the cause-and-effect relationship of environmental factors (e.g., cyclones, erosion, wave action, embankment cuts, flooding frequencies) on project components (e.g., embankment stability).

The main value of a matrix lies in its use in communicating complex information in a simplified and easily assimilated form. Items displayed in a matrix can easily be compared and contrasted. Matrices can also be utilized quantitatively by computing means and ranges of the rows and columns to provide summarized information. Such use should be limited to matrices containing valid numerical data on quantities or rates (e.g., amounts of land lost per year, numbers of people displaced, etc.). EIA practitioners should

| PROJECT COMPONENTS | IMPORTANT ENVIRONMENTAL COMPONENTS (IECs) | | | | | |
|---|---|---|---|---|---|---|
| | Agricultural Land | Agricultural Production | Homestead Land | Homestead Crop Production | Capture Fishery Production | Culture Fishery Production |
| CONSTRUCTION | | | | | | |
| Land Acquisition | | | | | | |
| Embankment | -2 | -2 | -2 | -2 | | |
| Drainage sluices | | | | | | |
| RCB sluices | | | | | | |
| Closures | | | | | -7 | |
| Khal excavation | | | | | -2 | |
| Culverts | | | | | | |
| Footbridge | | | | | | |
| Tubewells | | | | | | |
| Cyclone shelter | | | | | | |
| Maintenance | | | | | | |
| Borrow pit | | | | | | |
| Soil disposal | | -1 | | +2 | | |
| Labor mobilization | | | | | | |
| OPERATION AND MAINTENANCE | | | | | | |
| Embankment | | +7 | | +3 | -7 | +4 |
| Drainage sluices | | +7 | | +3 | -7 | +4 |
| RCB Sluices | | +7 | | +3 | -7 | +4 |
| Closures | | +7 | | +3 | -7 | +4 |
| Re-excavated khals | | +7 | | +2 | +3 | |
| Culverts | | +7 | | | | |
| Footbridge | | | | | | |
| Tubewells | | | | +2 | | |
| Cyclone shelter | | +3 | | +2 | | |
| Borrow pit | | | | | +3 | |

Note: Impact ratings are composites.

**Figure 4.1** Example of a Matrix Showing Environmental Impacts of Each Activity of a Project on Some IECs guard against the temptation to carry out mathematical manipulations and computations on matrices containing pseudo-quantitative data such as scales or ratings, since adding, multiplying or weighting of scales or coefficients seldom increases their intrinsic value and may in fact do harm by obscuring the underlying assumptions concerning the impacts from the EIAR reviewer or decision-maker.

### 4.2.2 Networks

Networks are useful tools in describing and graphically displaying relationships between and within three groups of components:

- IECs;
- environmental driving forces (e.g., floods, climatic factors); and
- project components.

The chief advantage of networks is their usefulness to an integrated team in systematically conceptualizing, considering, and documenting each major project and environmental component, and the sequence of likely events under existing pre-project and future with-project conditions. Networks have the advantage of display capability, and they facilitate communication among EIA team members. Their disadvantages are their inherent complexity if more than a few components are selected for analysis, the time required for preparation, and the limitation to two-dimensional displays. At least two sets of networks are normally required:

- without project situation; and
- with project situation.

Further separation according to IECs, project components and seasons may be necessary. Networks constructed in draft for use by the EIA team may be too complex for presentation in the EIAR, and may have to be simplified or omitted. Figure 4.2 presents a partial network constructed for a project with and without the proposed interventions.

### 4.2.3 Seasonal Models

Seasonal models conceptualize the periodicity and fluctuations in the IECs and display them in relation to the seasonal changes in such main environmental driving forces as flooding and rainfall. They are derived from the well-known two-dimensional crop calendars commonly used in Bangladesh, which display months or seasons along one axis, crops along the other and the planting, fertilizing, harvesting and other activities in the body of the calendar.

Seasonal models display months along one axis and classify these according to seasons of importance to each IEC resource component, critical times of the year for particular resources, and seasons or periods when interventions would bring significant changes to the existing pattern of IEC production, utilization or damage. Along the other axis are displayed the following:

- environmental driving forces, including rainfall, occurrence of major hydrological forces including early, flash and seasonal floods, drainage congestion, siltation, bank erosion, etc.
- IEC abundance, frequency, utilization, etc., e.g.,
  - sowing, harvesting of crops
  - use of agricultural inputs
  - migration of fish from rivers to floodplains
  - breeding periods of fish and wildlife, etc.

Hydrological, biological and social components may differ in abundance or reaction to the interventions according to their position within the area, and separate sub-models may be required (e.g., according to land type). Figure 4.3 illustrates a seasonal model for some environmental driving forces and some IECs within a typical project area. As with networks, more than one seasonal model may be required for comparative purposes (without versus with project).

## 4.3 Impact Prediction

Four approaches to predicting environmental impacts commonly are employed:

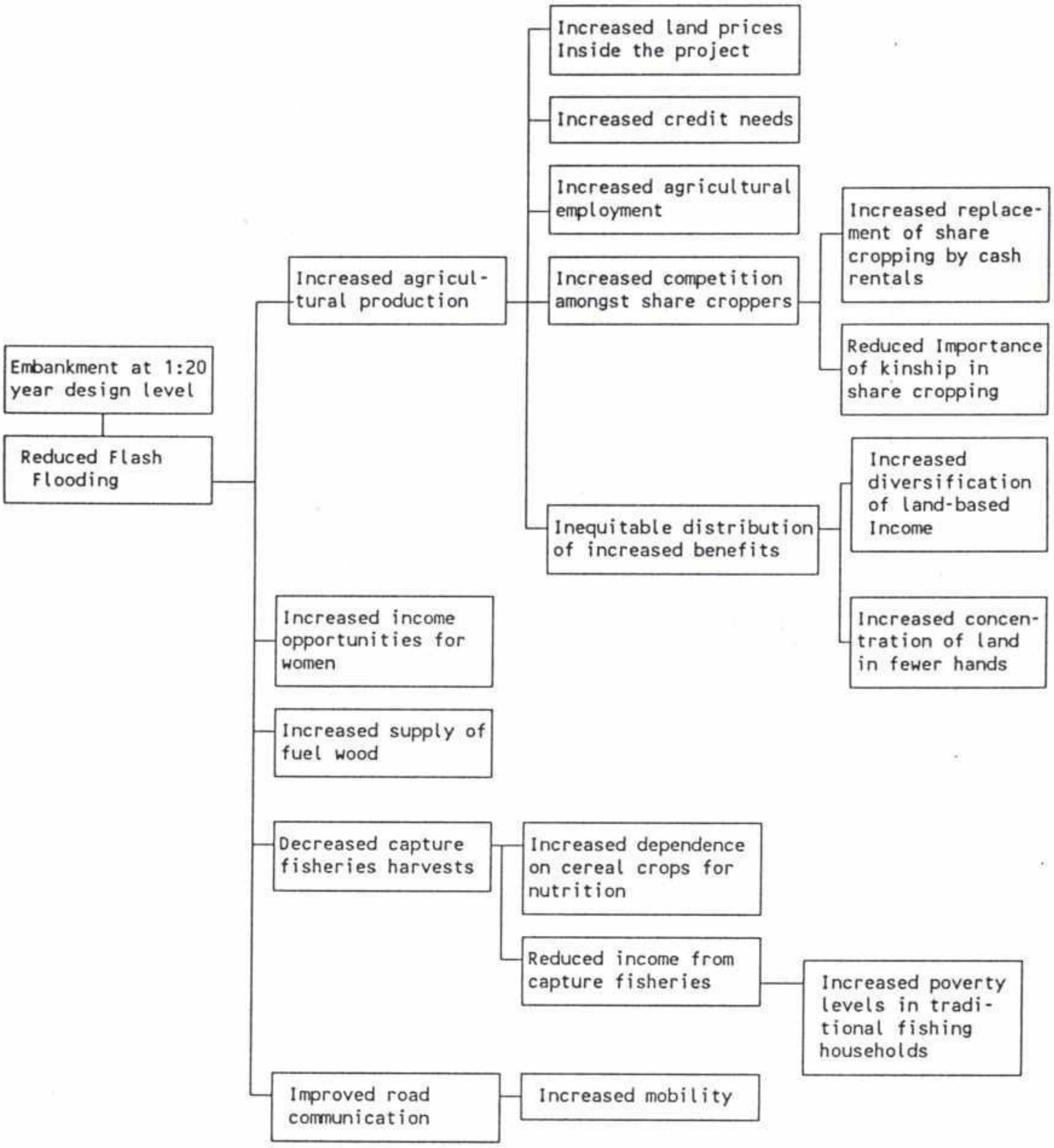


**Figure 4.2** Example of Network Analysis for a Section of a Typical Water Sector Project

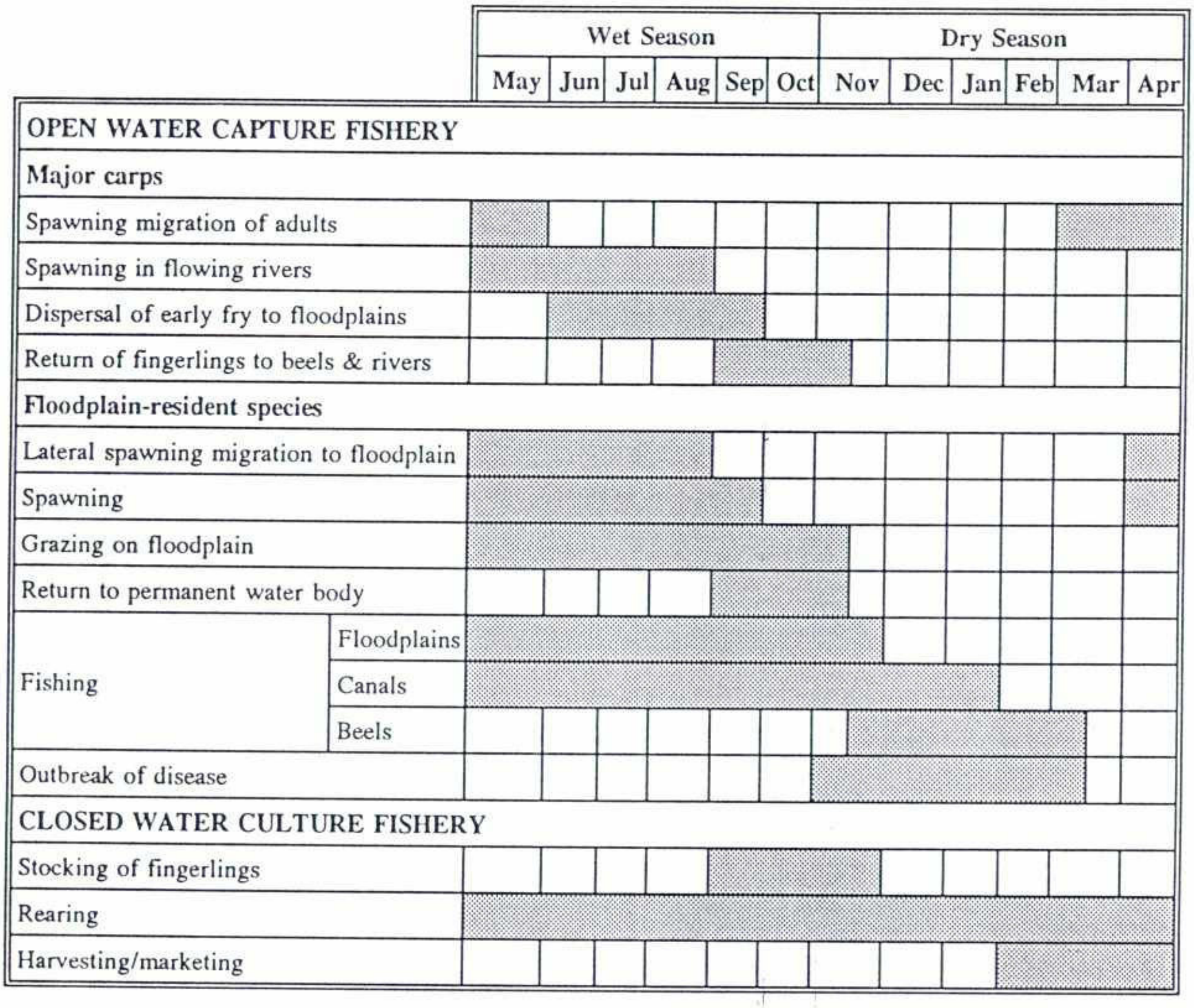


**Figure 4.3** Example of a Seasonal Model for Selected IECs in a Typical Water Sector Project

- modelling;
- correlation with specific key variables;
- trend analysis (thresholds and limits); and
- comparison and projection.

### 4.3.1 Modelling

To date, modelling in Bangladesh has centered on predicting hydrological changes. Since all primary changes in water sector projects stem from hydrological changes, the ability of models to estimate future scenarios is a very valuable tool in impact assessment (Figure 4.4).

### 4.3.2 Correlation with Key Variables

If the abundance or functioning of an IEC can be closely linked to that of a variable whose future can be predicted, then simple correlation can provide a basis for estimating future changes. Some examples follow for water sector-related situations.

- Since the distribution and surface area of land types is related to water levels, then prediction of future water levels (e.g., by the use of hydrological models) can provide a basis for computing land type distributions and areas under future scenarios;

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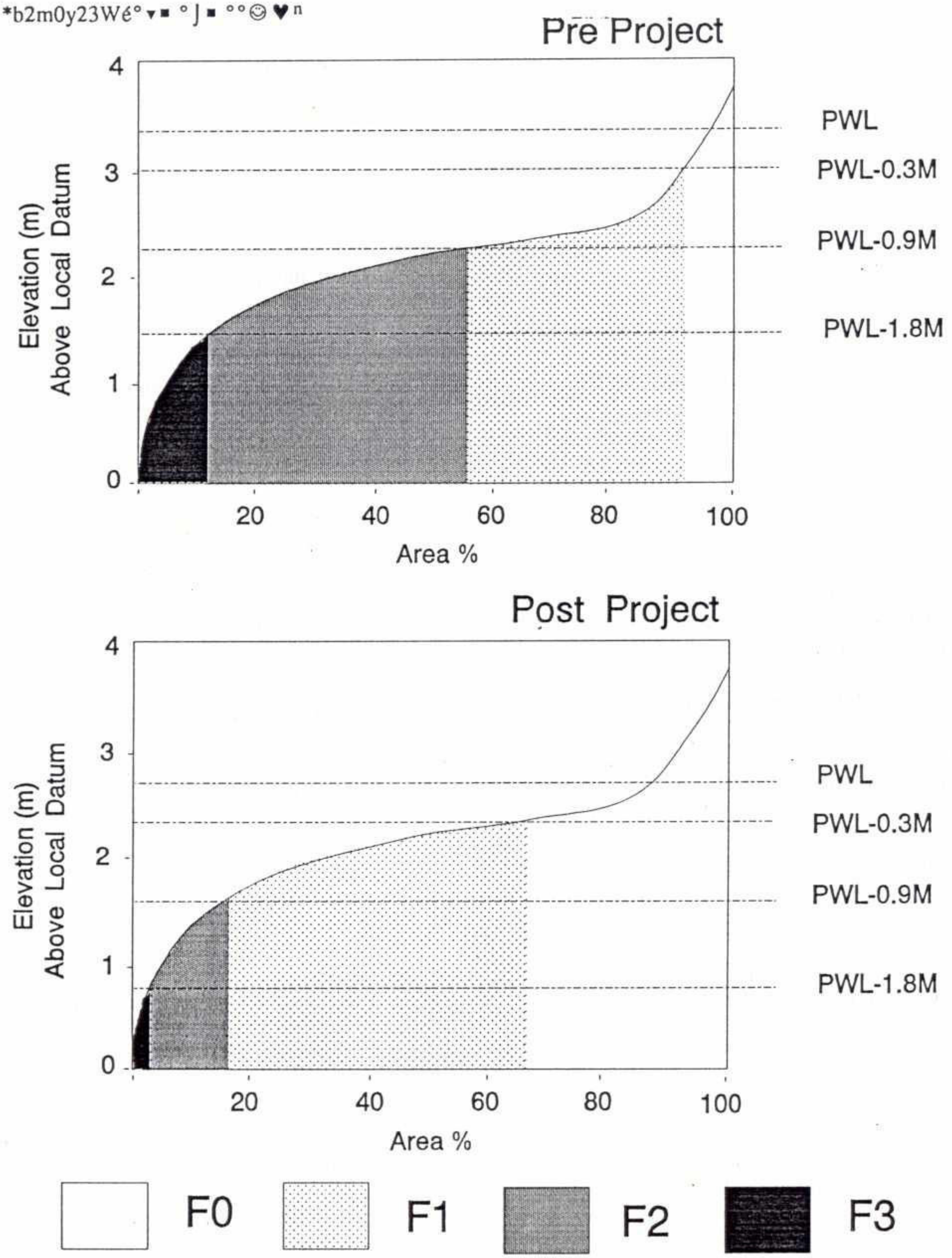


**Figure 4.4** Prediction of Land Types in an Area Based upon Changes in Flooding Levels

- If fish and wildlife habitat can be numerically related to stream flow or floodplain extent, then changes in the latter (e.g., by reduction in flooding or irrigation) can be directly related to change in habitat quantity;
- Many socioeconomic indicators are fixed within fairly narrow ranges to well-known population parameters, e.g., the amount of available transportation (rickshaws, boats, and other vehicles) is proportional to the population of an area, and if the latter changes through in- or out-migration, then the amount of transportation facilities required would likely change accordingly.

Examination of the distribution of an IEC over an area and its relation to other variables often provides a basis for estimating the extent of correlation and a means for projection into the future.

A frequent problem with quantification by the use of correlated variables is the difficulty of isolating the effects of one cause from those of many others. The method works best when data from test and control sites are compared. This separates natural variability from non-induced changes.

#### 4.3.3 Trend Analysis

Environmental conditions are continually changing, and the Bangladesh floodplain is particularly dynamic in terms of hydrological, ecological, and corresponding social shifts. In examining IECs for changes under future with-project conditions, it is important to distinguish such changes from those that would have occurred in the absence of the project due to nonproject-related causes. It is also important to distinguish short-term fluctuations in IECs from long-term trends

Analysis of trends requires quantitative historical data for the IEC in question and also for the factors that determine the abundance and distribution of the IEC. In the absence of the latter, it has to be assumed that the factors are exerting their effects at a constant and proportionate rate and will continue to do so under post-project conditions. These assumptions should be carefully checked. For example, fish populations may have declined over a period due to increasing harvest rates as well as declining habitats. A project may further alter the amount of habitat and change the harvest rates accordingly, but not necessary in proportionate rates.

#### 4.3.4 Comparison and Projection

It is often possible to obtain some estimate of future conditions for a specific area under a specific set of interventions by making comparisons to areas that have already been subjected to similar interventions and where the results have been observed and adequately documented. This method is probably the most common one in use, since most practitioners tend to evaluate conditions based on their experience of previous projects. The approach has several drawbacks, among them:

- impacts are usually the result of complex interactions and not all the dominant factors may be equally active in the existing and proposed projects; and
- post-project conditions such as management, changes in land use patterns and socio-demographic shifts may obscure the primary impacts that occurred in the existing project.

Examination of all major causative factors and adequate quantification of environmental variables will improve the application of the method.

### 4.4 Impact Classification

Impacts are classified according to a number of criteria. These should be examined separately and reported in the EIAR. All impacts should be predicted, described and classified with and without prescribed mitigation measures to provide reviewers and decision-makers with an insight into the practicality of managing the impacts and their relative severity.

- *Role in the ecosystem*: the existing and future role of the IEC should be compared to the amount and direction of change expected. The most significant impacts will be those that:

- provide key links in the economic base of the nation, region, or locality (e.g., water);
- are directly or indirectly linked to human health or survival (e.g., animal protein, increase in vector transmission diseases);
- affect the ability of local key resources (e.g., fuel wood);
- affect the ability of irreplaceable cultural resources (e.g., archaeological sites, historic shrines);
- affect the ability of internationally recognized and/or endangered species (e.g., Royal Bengal tiger);
- affect the ability of special habitats of importance (e.g., wetlands).

- *Magnitude* of the change relative to the amount or stock normally available and the amounts of change in seasonal fluctuations.
- *Frequency*: whether the impact occurs only a few times or repetitively over a long period.
- *Duration*: impacts should be classified as permanent or temporary, and long- or short-term. Short-term impacts are those lasting one or two seasons (e.g., influx of construction laborers), while long-term impacts would typically last for most of the project's life.
- *Reversibility* (e.g., cutting off fish migration by an embankment might be reversible at a later stage if a regulator were built, provided conditions on both sides remain favorable to such migrations).
- *Cumulative or non-cumulative*: most impacts are cumulative by nature; the key consideration is whether the added project impacts will be sufficient to change the scale of existing impacts (e.g., from local to regional).
- *Direct or indirect*: most physical and hydrological impacts are direct, ecological and social impacts are often indirect or secondary in nature, which is why network analysis is useful in impact assessment.
- *Synergistic* with impacts caused separately by other project components (e.g., pollution problems cause by drainage congestion and lack of seasonal flushing) or by nonproject-related factors (e.g., reduction in fish stocks caused by project-induced closure of migration canals plus nonproject-related overfishing).
- *Direction* of the change, expressed quantitatively as an increase or a decrease that normally corresponds to the descriptors "positive" or "beneficial" and "negative" depending on the direction the desirability of the change.
- *Significance* of the change: significance here does not refer to statistical significance, but rather, is a collective term summarizing the magnitude, direction, frequency, duration and reversibility of the predicted impacts. EIA practitioners should always explain the basis for its determination in the EIAR.

## Chapter 5

# ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The central tool for managing impacts once the plans and projects are defined and described is the Environmental Management Plan (EMP), which provides a method for executing the project through the construction, operation maintenance and abandonment phases (if applicable) in an environmentally acceptable manner. The EMP develops measures to avoid, reduce or resolve the impacts associated with the project and provides for follow-up activities such as measures for monitoring the project. It consists of seven main elements:

- long-term mitigation and enhancement;
- the Environmental Protection Plan, which includes plans for mitigation and contingency during construction;
- plans for compensation and adjustment;
- a plan for other needs such as institutional strengthening or training;
- a plan for monitoring;
- a continuing people's participation program; and
- an accountability and reporting framework.

After the EMP is implemented, the impacts remaining from the development are termed residual impacts. It is on the basis of the acceptability of these remaining impacts that the decision of whether to proceed, modify or cancel the project is made. In particular, a determination needs to be made whether these residual impacts are significant or not.

The level of detail in the EMP will vary according to the stage of project study and development.

- Prefeasibility: identification of broad management options and major constraints: the EMP is an integral part of the IEE;
- Feasibility: prior to review and decision on project development—identification of specific mitigation options and expected residual impacts in the EIAR;
- Selected option to be developed—detailed description of specific proposed mitigation, cost estimates, implementation schedules, mode of implementation, personnel requirements and training, and institutional arrangements. The finalized EMP should be a highly practical document that can be amended to project contracts.

### 5.1 Environmental Protection Plan: (EPP)

The Environmental Protection Plan (EPP), comprises a key element of the EMP (Figure 5.1) It goes beyond compliance with regulations and demonstrates a commitment to active environmental protection. The EPP summarizes and builds on existing regulations, standard codes of good engineering practice, and good environmental housekeeping practices by describing site-specific environmental impacts and outlining plans for mitigation. Each medium- to high-level impact identified in the formal assessment and scoping is considered individually. Mitigation and contingency plans describe preventive measures that will be used to lower or avoid the identified impacts. These plans address mitigation of impacts from normal project activities, as well as measures to prevent or reduce effects associated with accidental events.

Site-specific instructions to personnel as to how mitigation and contingency measures will be carried

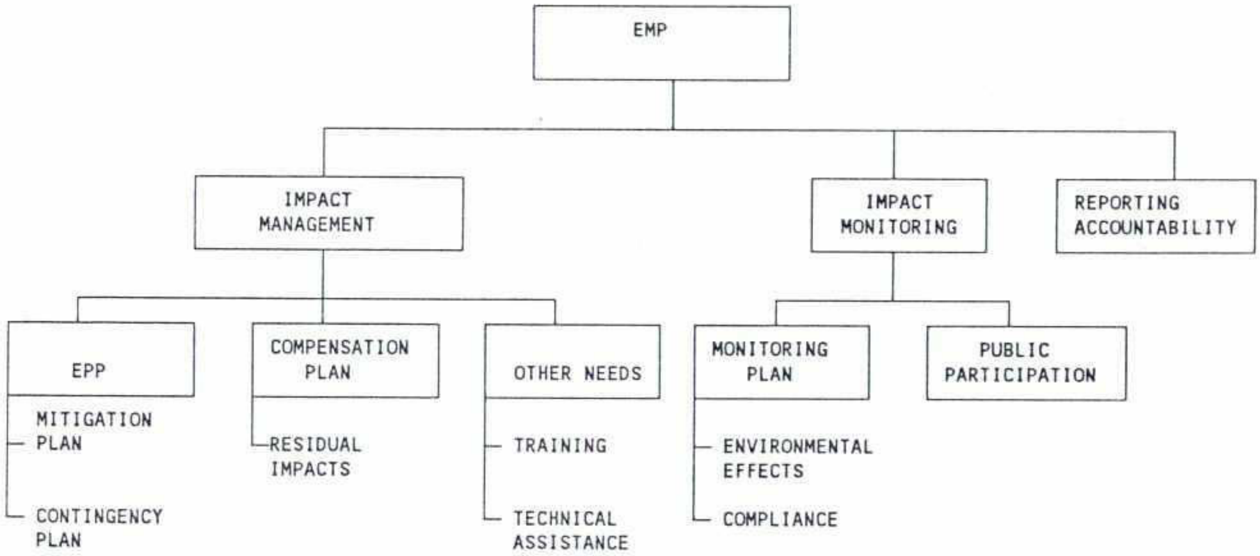


**Figure 5.1 Environmental Management Plan**

out are an integral part of the EPP. These instructions should be very concise and practical so that the personnel targeted by the specific set of instructions will be able to clearly understand the actions that they must take to reduce impacts. For major and common mitigation measures, as well as codes of good practice, it is useful to prepare separate manuals specific to these actions so that personnel are well informed of what is required of them. For example, the person responsible for movement of soil material would receive precise instructions on what actions to take to avoid soil erosion. A useful summary of the Environmental Protection Plan may be presented in a 4-column table, which lists: (1) location of the impact; (2) brief description of the impact; (3) recommendation for management of the impact; and (4) types of monitoring recommended. Contingency planning is necessary for impacts predicted to result from accidental events.

### 5.1.1 Legislation Summary

Government of Bangladesh administrative and jurisdictional regulations that are summarized in the EPP consist of any existing legislation which provides for basic protection of the environment. This includes any environmental requirements set by donor agencies involved in the proposed project. The EPP delineates the individual legislative requirements and describes how the proposed project will comply with existing regulations and guidelines. Additionally, any permits or preconditions necessary for the project to proceed must be described in this section. See also Chapter 13.

### 5.1.2 Mitigation Plan

The mitigation plan develops specific measures that minimize impacts associated with the project. This is the focus of the EPP (Figure 5.2). Management of low impacts is usually accomplished by compliance with legislation, standard codes of practice, guidelines and good environmental housekeeping, whereas potentially significant impacts are managed by specific mitigative measures. Normal activities with significant impacts require mitigative measures, but accidental events have measures developed to prevent their occurrence. In addition, accidental events require detailed contingency plans for emergency response. Site remediation measures may also be necessary.

Types of mitigation measures can be seen in the following example. If a project anticipates the need

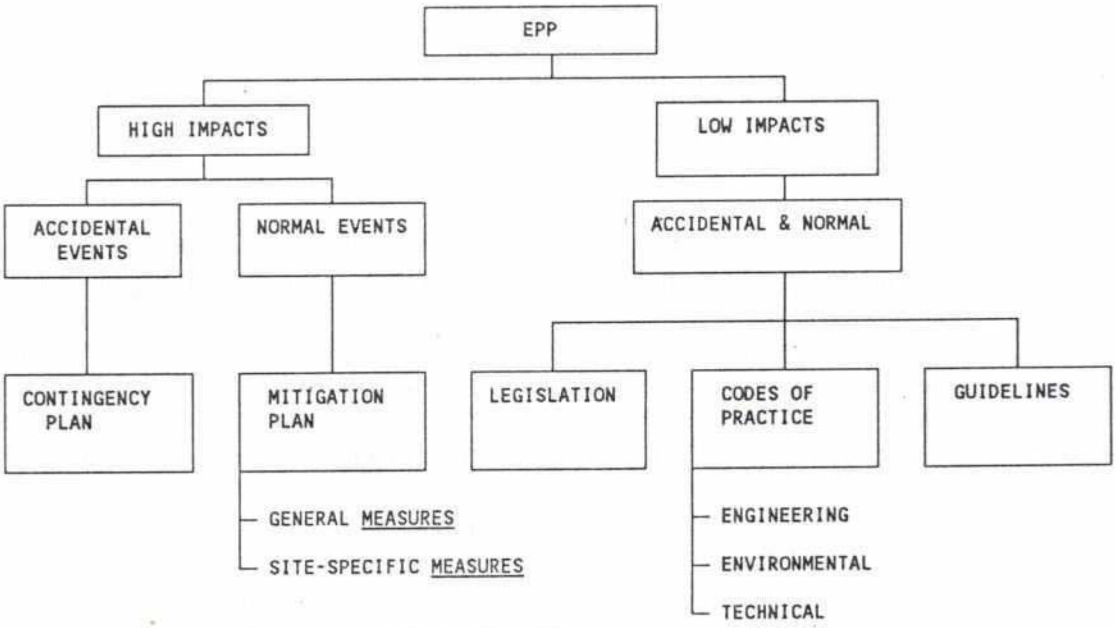


**Figure 5.2 Environmental Protection Plan**

for large numbers of kiln bricks for construction there could be a negative impact on the fuel and natural resources in the project area. Mitigating measures could include ensuring that bricks are not fired by fuel wood and that large pits created by the brick making are returned to economic use. They could perhaps be turned into ponds for fish farming.

Developed mitigation plans should not only be specific to identified impacts, but should also include general mitigation measures to protect the environment. Examples of general measures would be as follows: education of construction and operation personnel about environmental impacts and mitigation measures, definition of the locations of work areas, or establishment of barriers to protect surrounding areas from impacts arising from the work area. Usually an environmental inspector is present at a construction site to ensure that designated mitigation measures are implemented.

Any measures developed should be reviewed carefully by relevant technical experts to ensure their effectiveness. Each mitigative or remedial measure should then be summarized in the summary table of the EPP, and the mitigative measures, as well as their predicted degree of effectiveness, should be documented in greater detail in the accompanying text. All proposed mitigation proposals should be costed and meet economic efficiency requirements [see GPA (FPCO 1989b)].

Potential mitigation considered should include:

- selection of alternatives (elevation, slopes, dimensions, site, size, sources of materials, placement of access roads, connections with existing systems, construction materials, energy, work force, scheduling of construction and/or operation, etc.) that may not be optimal on technical or economic grounds but are environmentally more benign;
- modification of a component to enhance a secondary benefit or reduce an impact;
- change in construction materials, methods, work force, etc.;
- alteration in project operation (volume, flow, timing, etc.) or management;
- supplementary programs to counteract adverse effects (e.g., agricultural extension);
- education or training to reduce risk or to

allow more effective management of a diminished resource (e.g., fisheries training) to avoid some existing poor management practices;
- resettlement—a special case of mitigation of displaced people requiring major social and infrastructural programs.

As the EIA proceeds, mitigation and enhancement measures should be developed to take full advantage of available information and engineering design possibilities. Mitigation measures should be planned and implemented in parallel with project design to reduce environmental damage and to provide for more effective program development. Project modifications should preferably be designed into structures or operating procedures. After-the-fact changes tend to be costly and ineffective.

Table 5.1 indicates examples of mitigation measures proposed for a typical water sector project. (See also the World Bank EIA Sourcebook 1991). Environmental enhancement should be considered where significant gains in production, resource management and environmental protection can be achieved within the project area, through close collaboration with project development and operation and with financial support from the project. Potential enhancements to be considered include:

- replacement or upgrading of affected resources;
- education and/or training to allow more effective management of a diminished resource (e.g., fisheries training to avoid existing poor management practices); and
- introducing community management systems (e.g., water user associations).

### 5.1.3 Contingency Plan

Because any major project increases the potential for accidental events, contingency planning is necessary to prevent or remediate the impacts of these events. Contingency planning is a broad term that includes disaster and hazard management. The types of accidents and emergencies likely to occur vary from project to project and may range from fuel spills to dam bursts or embankment failures to extreme natural disasters.

Prevention of accidental events and the amelioration of emergencies is based on sound engineering, environmental and construction practices, routine maintenance procedures and safety precautions, as well as thorough training and organization of personnel. The organizational structure is outlined, and officers and personnel responsible for programs to lower environmental impacts from accidental events are designated. The contingency plan describes the measures needed for preventing accidents and reducing the impacts of any accidental events that occur.

The contingency plan must include not only particular physical methods for response and cleanup after accidental events, but also plans for organization and education of personnel, site-specific instructions to personnel, provision of lists of agency contacts, provision of manuals on emergency procedures such as flooding, and coordination of communication to the public. A comprehensive contingency plan will then contain certain elements summarized as follows:

- clear identification of key response roles within the management structure, with individuals and reporting relationships, responsibilities and authorities all presented in detail;
- well-defined alert procedures including up-to-date contact list for key individuals both within the project management structure and with relevant outside agencies and organizations;
- a practical means of characterizing the accidents or emergencies as to their nature and severity, and predictive capability for the effects of the events such as flooding through breached embankments given the present environmental conditions; and
- clearly specified countermeasures and identification of support capability (equipment, location, availability).

Table 5.1 Examples of Mitigation Measures in a Typical Water Sector Project. (Some examples were taken from the World Bank Sourcebook, 1991.)

| Potential Negative Impacts | Mitigation Measures |
|---|---|
| Flooding of lesser magnitude, but greater duration flood plain downstream due to dam releases | 1. Adaptation by changes in agricultural practices. |
| Potential for structural failure and floodwaters higher than capacity of control structures/measures, leading to increased risk to life and property because local pre-project adaptations are relaxed or abandoned or increased development on the floodplain has occurred post-project. | 1. Implementation of non-structural measures to prevent increased flood risk, and of a flood warning system. |
| Adverse effects of construction. | 1. Minimization of effects by avoiding impediments to natural drainage, uncontrolled run-off and soil erosion, and air pollution.<br>2. Provision for adequate filling of borrow areas, control of land clearing, and disposal of spoil.<br>3. Limitation of access of vehicles to stream bank. |
| Soil quality degradation due to intensive use. | 1. Use of organic manures.<br>2. Use regulators to flush areas occasionally |
| Increased fertilizer use on agricultural fields to compensate for loss of fertility, leading to water pollution and dependence on imported supplies. | 1. Optimal timing and rate of application.<br>2. Use of nitrogen fixing cover crops.<br>3. Use of organic instead of chemical fertilizers. |
| Deterioration of surface water quality | 1. Provision of groundwater for domestic purposes.<br>2. Health & sanitation programs.<br>3. Extension programs to limit unwise use of pesticides.<br>4. Integrated pest management to reduce use of pesticides. |
| Reduction in livestock carrying capacity due to lack of fodder production | 1. Incorporation of fodder crops into cropping patterns.<br>2. Use of embankments for fodder production. |
| Negative impacts of channelization measures:<br>- disruption of fish habitat by elimination of pools, riffles and channel irregularities.<br>- increased water temperature by removal of vegetation on banks and in stream<br>- increased erosion and sedimentation problems<br>- bed and bank erosion<br>- downstream flooding and sedimentation | 1. Careful selection of engineering options at planning stage.<br>2. Limitation of degree of channel modification or maintenance.<br>3. Mitigating measures after construction phase.<br>4. Minimize reduction of channel length and preserve some meanders.<br>5. Limit excavation and fill.<br>6. Limit destruction of bank- and stream-side vegetation.<br>7. Replant/reseed banks.<br>8. Excavate only one and not both banks, etc. (see Brookes 1988.) |
| Reduction in nutrient inputs to floodplain habitats and cycle of enrichment and groundwater recharge in floodplain soils broken. | 1. Use of regulators to permit inflows to floodplain.<br>2. Excavation and maintenance of khals.<br>3. Where dams are present, partial mitigation of effect by regulation of discharge to imitate natural flooding in a controlled way. |
| Reduction of recession agriculture. | 1. Maintenance of natural flooding regime to extent possible in most productive lands (and intensification of production) by maintaining water courses free of flood control structures or installing structures to enable semi-controlled flooding. |
| Reduction in floodplain fish and wildlife habitat quantity and quality | 1. Use of regulators to permit inflows to floodplain.<br>2. Excavation and maintenance of khals to ensure inflows.<br>3. Extension programs to limit unwise use of pesticides.<br>4. Integrated Pest Management to reduce use of pesticides. |

(continued)

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Table 5.1 **Examples of Mitigation Measures (continued)**

| Potential Negative Impacts | Mitigation Measures |
|---|---|
| Restricted access for fish stocks to floodplain. | 1. Design of regulators which facilitate fish passage.<br>2. Stocking of floodplain habitats (including development of new hatchery facilities).<br>3. Control of fishing effort to reduce impact on young stock.<br>4. Incorporation of fisheries management including hatchery and restocking program. |
| Increased threats to rare and endangered species from habitat loss | 1. Use of regulators to permit inflows to floodplain.<br>2. Excavation and maintenance of khals to ensure inflows to key wetlands.<br>3. Protection of key wetland habitats through conservation programs.<br>4. Where habitats/species are dependent on natural flooding regime, minimize disruption of flow in that area to the extent possible. |
| Flooding problems created downstream | 1. Protection of natural overflow areas downstream.<br>2. Creation of overflow basins. |
| Improved accessibility, development opportunities in floodplain, and sense of security after flood control measures taken, leading to influx of people with associated agricultural development, deforestation, wildlife poaching, infrastructure development, etc. | 1. Limitation of access, if possible.<br>2. Planning for anticipated influx and implementation of companion rural development activities.<br>3. Introduction of non-structural control measures. |
| Resettlement of populations and other negative socioeconomic effects on populations and communities affected by the project. | 1. Identification of at-risk population groups or groups who may be adversely affected by flood control measures.<br>2. Incorporation of their interests and protection into project planning and cost analysis to minimize losses or provide in-kind compensation for losses. |

Socioeconomic considerations should be taken into account through public consultation programs to provide early detection of potential problems. A reporting structure must also be established so that information with regard to accidental events is available. This reporting structure would characterize the type of accident, whether it was expected, how it was handled, how effective the contingency measures were, and reporting to appropriate government officials.

These reports would be primarily for internal use within the executing agency, but a summary of the major accidents or emergencies and their follow-up should be made available to the public.

### 5.1.4 Residual Impacts

At this stage, the EIA impact matrices and cumulative effects analysis will be revised to indicate those impacts for which environmental protection efforts described in the EPP are likely to be effective. Residual impacts predicted to remain after good housekeeping practices, mitigation, and contingency planning have been taken into consideration, constitute the most serious environmental impacts posed by the project. These impacts should be highlighted in a revised impact matrix. It is on the basis of these residual impacts that the project will be judged as environmentally acceptable or not, and if the project proceeds, it is these impacts that will require the most extensive monitoring plans.

Once residual impacts are identified, their significance must be determined. Considerations for residual impact significance include the importance of the IEC affected, perceived need for the project, consistency or conflict with government policies, and any other concerns identified during scoping. Public concern can also be an important gauge of significance.

A list of residual impacts, along with a description of the severity of each impact and the reasons why management efforts are unlikely to reduce their magnitude any further, should be prepared. This list should also include unknown impacts, impacts for which data are insufficient to predict, and objectives for which activities could not be described. Thus, the list should present a final concise reporting of the remaining environmental concerns. This list of residual impacts as well as the cost of the EMP are the main outputs of the EIA to be included in the overall Project Assessment Process.

## 5.2 Compensation Plan

Residual impacts remain when anticipatory planning and mitigation are insufficient to remove the environmental impacts associated with a project. Although no further action will be taken to decrease these impacts, a plan is frequently developed to compensate local residents for both biophysical and socioeconomic impacts. A compensation plan takes the loss or damage associated with the residual impact and attempts to balance the cost to the affected people or ecosystem by providing something else of equivalent value. It is done essentially to address the remaining issues of fairness and equity.

Compensation can take a variety of forms. It may involve offering restoration of damaged resources, establishing new habitats, offering money to the affected people or communities, developing enhancement programs for the affected region, or offering concessions on other issues.

Compensation in kind may involve relocation of an affected animal population to another suitable habitat or resettlement of a human community to another equivalent area. For example, where fish habitat is lost, river beds may be reconstructed to sustain the fish population or to restock its habitat.

Monetary compensation means providing sufficient funds to the affected parties to replace what was lost. If a project required the acquisition of agricultural land, those farmers would have their property evaluated and given the equivalent in money. Similarly, if a project involved the destruction or alteration of shrimp aquaculture habitat, the value of the aquaculture operation would be evaluated and the fishermen would be offered that amount in cash.

Sometimes projects cause loss of employment for certain people. If a bridge were to be built, the person who ran the ferry boat would no longer be needed. In these sorts of cases, compensation takes the form of an adjustment program where retraining is offered and/or relocation assistance is provided. Community enhancement programs are also developed as compensation for project impacts. More of the benefits may be transferred to the affected community such as the right of first refusal for newly created project positions or development in terms of revenue-generating opportunities.

The final type of compensation is essentially a form of negotiation; where certain residual impacts are expected, concessions are made to those people affected on other issues of concern to them. For example, if an industrial plant were to be built on the river which is the water supply source for a village, then perhaps the village would be provided with tubewells or low-lift pumps, which otherwise they would not have received, or they might receive pumped water from upstream of the industrial site.

When replacement in kind is offered as compensation, it must be remembered that it may be offered at the expense of a complete and functioning natural-human environment. Often, even this cannot be offered, however, due to the lack of resources and space. Monetary compensation assumes that (1) whatever is lost or damaged can be evaluated successfully in monetary terms, (2) monetary funds exist for this type of compensation and (3) alternative land or other resources are available for purchase, and (4) no social deprivation and psychological trauma suffered by the evicted persons. Frequently, these are not necessarily true as money does not truly compensate for these impacts.

For example, if money is given to a farmer at the present value of his land for acquisition of that property, consideration is not given to whether there is any land for him to buy elsewhere. If he has to move away, he will suffer deprivation from being severed from his community and cultural heritage. These damages are often not compensated in Bangladesh. Similarly, new job opportunities may not arise as a result of the project or perhaps the market is unable to cope with new business developments. Compensation for cumulative impacts also raises questions for concern because it is difficult to determine responsibility for an impact accrued from a variety of projects or human activities. If a series of projects resulted in the loss of water quality in a river such that it can no longer sustain fish life, then who is responsible for the compensation of the fish killed, their loss of habitat, and loss of protein in the diets of nearby residents?

Most compensation plans only partially alleviate environmental impacts. As a result of the sorts of difficulties listed above, compensation should always be viewed as a poor but essential alternative for impact management and it should never become a substitute for mitigation and anticipatory planning where these alternatives do exist.

### 5.3 Other Needs: Institutional Strengthening, Training, and Technical Assistance

At the present stage of management capability in ~~For~~ Bangladesh, consideration in the EMP must not only be given to the management of effects directly related to the project under consideration, but also to the institutional and structural capabilities within Bangladesh to support these environmental activities. Consequently, a section on "Other Needs" should be incorporated in the EMP. This is consistent with the World Bank's Operational Directive on Environmental Assessment. This section should identify the strengths and weaknesses in Bangladesh concerning the environmental assessment process, and detailed plans for strengthening this process, including all aspects of environmental management.

Five areas should be targeted for evaluation. These areas include: (1) human resources which may require enhancement of management skills or training of qualified personnel; (2) structure or organizations which may need units developed to perform EA functions; (3) environmental policy which includes a commitment to national policies, laws and regulations; (4) information bases which may have gaps in the information required for EIA activities; and (5) resources where there may be insufficient funds for any of the activities required by the EA process. The institutions or persons which should be examined in these areas are as follows: the executing agency, local government agencies, local NGOs, environmental assessment consultants, affected groups, senior advisors, and policy makers.

There are a variety of methods which can be used to ensure that activities required by the proposed project will be completed competently, and to ensure that Bangladesh will be able to sustain these activities whenever they are required. The two ways in which assistance is offered is through training and technical support.

Training is offered by the donor agencies or local expertise where it is available to people undertaking EIA activities. The education can come as a result of seminars, workshops, courses or from on-the-job training. It may be useful to provide some of this training outside of Bangladesh to expose EIA practitioners to a wide variety of EIA methods and procedures. The purpose of this education is to develop an environmental awareness and also the capability for environmentally competent actions of the people concerned. The ultimate goal is to provide Bangladesh with skills which will allow it to carry out EIA independently and effectively.

Technical assistance is the most common temporary type of aid to strengthen the EIA process in recipient countries. It can come in the form of staff such as technical advisors, consultants, or even whole environmental units, and as equipment, and information. The most useful technical assistance that can be provided is the assignment of personnel for a designated period of time to an institution or department in the country. These environmental experts can advise on the development and strengthening of policy or legislation, oversee projects, help to develop sectoral plans



most effective though is on-the-job training under a senior EIA practitioner and policies, set up research programs to fill in information gaps, act as educators or teachers for the training components, participate in field investigations and data analysis, and supervise, monitor and evaluate ongoing projects.

During the development of a project's Environmental Management Plan, Bangladesh institutional strengths and weaknesses must be considered and directed in such a manner that the immediate goal of environmentally-sound projects is achieved and the goal of an effective EIA process in Bangladesh may also be achieved. These two different emphases can best be dealt with in the different project assessment levels. The prefeasibility studies should identify the overall long-term requirements for institutional strengthening, whereas the feasibility study should identify the immediate requirements for implementation and operation of a particular project.

For example, in Bangladesh, legislation to prevent pollution and to protect forests and wildlife are in place, but the institutions responsible for implementation of the legislation are either insufficiently managed and funded or not given enough authority to enforce the legislation. A prefeasibility study may focus on how best the Department of Environment can be strengthened by legislation; how to establish a national research program and base of environmental information, and how to implement a training program for those government staff involved in environmental assessment and management plans. Plans to resolve these problems should be outlined in the prefeasibility study.

The feasibility study would propose solutions which are much more short term in nature to address the identified institutional weaknesses. The same problems might be identified but may be addressed in a different way. For example, plans to strengthen DOE might include provision for immediate EIA review/inspection capability. The lack of environmental information could be dealt with by baseline studies specific to the project area during the environmental assessment; and the lack of training would be addressed through short-term classes only for those people involved with the project and supervised on-the-job training.

The short-term and long-term goals should be considered in this portion of the EMP. It is essential to identify what weaknesses there are so that measures can be developed to deal with those weaknesses. If there is no examination of weaknesses in the institutions nor the development of plans to deal with any identified weaknesses, then despite an extremely comprehensive environmental assessment and well-designed Environmental Management Plan, the practicality of limited institutional capabilities will prevent the successful completion of the environmental requirements for the project, and the effort expended on the environmental assessment will have been wasted.

## 5.4 Monitoring Plan

The Monitoring Plan is a separate plan within the EMP. "Monitoring ..[is] among the methods used to convert environmental impact assessment from a static process to an interactive process characterized by feedback and adjustment" (David and Sadler, 1990). The monitoring itself provides feedback on the predictions and effectiveness of mitigation measures, but flexibility must be incorporated into the monitoring plan to allow for adjustments to be made when unanticipated impacts occur and when protection measures are inadequate. The plan should allow re-evaluation of the project or its impacts if necessary. Monitoring is a continuous activity which has a role at each phase of the project. Definition of the monitoring plans help to focus any baseline data collection required during the environmental assessment. During preconstruction, construction and operation, monitoring ensures compliance and detects unexpected impacts. Finally, during abandonment or after impacts from operation have become firmly established, monitoring provides information to complete an evaluation of the predicted impacts and measures. Figure 5.3 illustrates a conceptual approach to environmental monitoring.

Monitoring has several objectives:

- to detect any environmental impacts (pre-

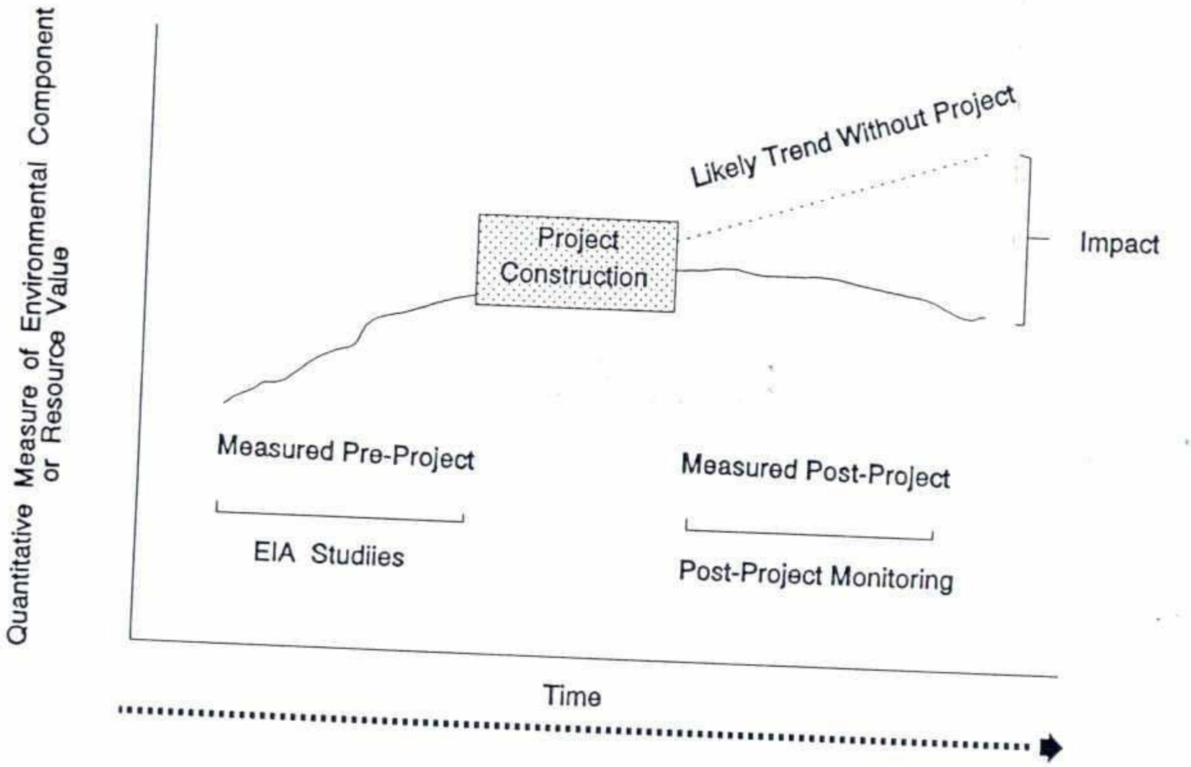


**Figure 5.3 Conceptual Approach to Environmental Monitoring**

dicted and unpredicted) in relation to the project activities (physical, chemical, biological, socioeconomic);

- to ensure compliance with the various requirements set out by the EMP including but not limited to mitigation, contingency, compensation, and institutional strengthening plans; and
- to determine the effectiveness of the measures required by the EMP.

Two monitoring plans should be developed to achieve these objectives. The first plan is an environmental effects monitoring program. It serves to detect the impacts on the environment due to project activities by regular data collection and evaluation. The second checks for compliance with the goals designated in the EMP and determines the effectiveness of these plans. These include all measures for mitigation, contingency, site remediation, compensation and institutional strengthening. The assumptions made with regard to good environmental and engineering practices are verified as well. The compliance monitoring program also determines compliance with specific legislated guidelines and requirements.

- Environmental Effects Monitoring
  - gives early warning of undesirable impacts;
  - improves environmental understanding, especially of cause-and-effect relationships; and
  - checks the effectiveness of impact prediction methods.

- Compliance Monitoring
  - checks compliance with EMP commitments and legislation
  - evaluates whether the assumptions of good environmental and engineering practices are correct;
  - checks the effectiveness of mitigative measures used to avoid, reduce or negate the adverse environmental impacts; and

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- satisfies public and donor concerns.

Each monitoring plan usually involves several environmental components. Primarily, it should identify the variables selected, the methods and techniques used to measure their change, and any assumptions made upon which the monitoring plans are based must be clarified. A rationale should be provided which explains the selection of the variables and monitoring design by using the impacts predicted in the environmental assessment and taking into account the boundaries defined for those impacts. The monitoring plans should include variables specific to predicted impacts; however, some indicator variables which can reflect change elsewhere in the environment should be included as well. The plan needs to be focused on predicted impacts but also flexible enough to detect unanticipated impacts. A project predicted to impact water quality and a fishery may include monitoring variables such as siltation, stock age structure, market value for fish, value of landings and volume of landings.

Special emphasis should be made in all of the monitoring programs for certain situations where: (1) impacts and mitigation measures are not understood, (2) project activities are not identified clearly, are experimental or are subject to change, (3) or potential impacts are controversial. These scenarios all hold a degree of uncertainty and importance, and as such should be monitored closely to prevent undesirable impacts and learn what impacts do result from the project activities.

Socioeconomic factors should not be neglected in the monitoring programs. The fishery impacts example, for instance, includes socioeconomic factors. The EMP requires a people's participation program which includes information distribution. Monitoring produces information which should be incorporated into this program. Consequently, socioeconomic factors should be included in both the environmental effects and compliance monitoring programs. Monitoring plans can also check the effectiveness of the participation program itself.

In Bangladesh, because of its location and geography, many proposed projects will attempt to control flood impacts. The World Bank Sourcebook (Volume II: Sectoral Guidelines) (1991) provides a comprehensive list of factors which may be considered for monitoring programs of flood action projects. They are as follows:

- quantity, intensity, timing and geographical distribution of rainfall and snow melt;
- storm patterns;
- soil moisture conditions at various times of the year;
- stream discharge (including records of annual peak discharge);
- storage, diversion and regulation of stream flows;
- changes in drainage and other factors that affect storm water runoff;
- sediment content of the river water;
- sedimentation problems in downstream areas;
- changes in the river course and river bed;
- demographic changes in the floodplain and watershed areas;
- rural and urban land uses (controlled and uncontrolled land use change on the floodplain and watersheds of the river);
- socioeconomic impacts resulting from the project (including changes to pre-project agricultural, pastoral, fishing practices);
- effects of flood control measures on rivers, estuaries or near-shore marine fisheries;
- effects of flood control measures on floodplain vegetation; and
- effects of flood control measures on wild lands, wildlife habitats and wildlife population.

One of the difficulties associated with monitoring is determining when a variable has changed significantly. Change of a variable does not necessarily imply that an anthropomorphic cause is present. In fact, sometimes lack of change indicates a significant problem. The clue to interpretation of the data collected is in determining change in relation to baseline patterns. It is necessary to know what the normal patterns of variability are in an environment before a change in a variable can be attributed to project effects. A further problem associated with this is determining how much change is required to indicate an impact. In all environmental patterns there are normal deviations, but what constitutes an abnormal deviation?

In order to resolve the issue of the difference between natural variation and project impacts, the monitoring plan must have test and control sampling sites. Control sites are located outside of the project area in environmental conditions similar to the test sites but different only in that the control sites are not affected by a similar project. The test sites are within the project boundaries and thus subject to project impacts. The test sites include variations attributable to natural events plus project events, while the control sites are subject only to natural variation. The test and control sites can be similar in all things (e.g., human activities and population, past development, and level of environmental degradation) because the object is to measure those impacts that occur from the project and are additive to impacts that would occur if the project were not in place.

The development of the monitoring plan is an important step in the environmental assessment process because it will show the accuracy of the predictions, show the effectiveness of the mitigation measures and provide information on any unanticipated changes resulting from the project. Careful planning should be done to ensure that the monitoring plans monitor only the important factors—remembering that time, personnel and money are limited. An ideal monitoring plan uses the fewest possible variables without losing the perspective of the whole environment and the interdependency of its components. Recognition of practical limiting factors in the monitoring agency will prevent overly ambitious programs beyond the scope of that agency. Responsibility given to the organization should not exceed its informational, technical or financial capabilities. If the responsibilities exceed these capabilities, the monitoring objectives will not be achieved unless outside assistance in the form of specific training or technical assistance is available. The practicalities of the situation must always be considered when developing monitoring plans.

## 5.5 People's Participation Program

The people's participation program designed for the EMP is closely tied to the reporting and accountability framework described in Section 3.10. It involves regular notification and consultation with the interested parties during implementation of the project. This is done in order to identify any potential problems arising from the project and to keep the affected public informed about activities and impacts of the project. This program is especially important as socioeconomic factors play a significant role in environmental considerations. Interested parties can help to identify weaknesses in the mitigation or compensation plans which would otherwise go undetected and may even identify impacts not recognized by the monitoring program. The same public participation process should be used in this case as used in the feasibility study.

## 5.6 Reporting and Accountability

The final element required in the Environmental Management Plan is the development of an accountability and reporting framework, which details plans for regular reporting of monitoring results to regulatory agencies. This keeps the decision-makers informed of what is being done with respect to environmental management of the project. It should outline what the reports must include, when the reports should be completed, who is responsible for completing them, and to whom the reports must be submitted.

Reports should be required on a regular basis during all the phases of the project. These reports should include descriptions of any environmental impacts, critical environmental data (for example, violation of environmental quality standards), results of mitigative actions, monitoring program results, results of institutional strengthening programs, unanticipated impacts, any accidents or emergencies, and compliance with requirements and conditions set by donors (must not be below requirements set out by the Government of Bangladesh). Essentially the reports should summarize the current state of all the EMP components with respect to the project and ensure that commitments are honored.

Supervision and verification of these reports could be required if it is deemed appropriate. This may take the form of one or more of the following activities: additional reports completed by the regulatory agency, supervision missions, site visits or permanent environmental inspectors.

Although individuals responsible for reporting activities can belong to the agency or company executing the project, it is preferable that the responsible persons be free from conflicts of interest with regards to the project. These persons could be from the government agency responsible for the EIA process, the donor agency with appropriate GOB concurrence, a consultant company hired to carry out monitoring and supervision, or local qualified interest groups or individuals who can monitor and report on the project's progress. The reports may be submitted to donor agency (if so agreed between the donor and GOB) and/or to an agency designated by the Government of Bangladesh.

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Chapter 6

# ENVIRONMENTAL IMPACT ASSESSMENT REPORT (IEE/EIAR) AND REVIEW PROCESS

## 6.1 Reports: Format and Content

The environmental planning, environmental assessment and EMP described in Chapters 3 and 4, and their related activities (including additional studies and modelling and people's participation programs), lead directly to the preparation of the environmental assessment report. At the prefeasibility level of assessment, a regional study is conducted and an Initial Environmental Evaluation (IEE) prepared. At the feasibility level of assessment, an EIA Report (EIAR) is prepared. Depending on how much the project description has changed between the two assessment levels, the revisions may be minor to major. The IEE focuses on early planning whereas the EIA Report centers on more detailed prediction of impacts and their management. Most of the following components should be included in the reports at both levels of assessment. This guide should be taken in a reasonable, not slavish, manner. The circumstances may more or less dictate the detail of treatment for a particular topic.

Adequate documentation procedures should be undertaken throughout the assessment. A sample Table of Contents for a report is given in Table 6.1.

**Table 6.1 Suggested Table of Contents for Environment Assessment Report (IEE or EIAR).**

List of Tables
List of Figures

1.0 Executive Summary
2.0 Project Setting
- 2.1 Background
- 2.2 Rationale and Objectives for the Project/Regional Plan
- 2.3 Methodology for Environmental Assessment/Review Process for FAP
- 2.4 EIA Team
- 2.5 EIA Budget and Level of Effort
- 2.6 Limitations
- 2.7 Relationship to Project Feasibility Study
- 2.8 Scope and Format of Report
- 2.9 Acknowledgements

3.0 Project/Regional Plan Alternatives
- 3.1 No Project/Plan
- 3.2 Alternatives
- 3.3 Selection of Alternative(s)

4.0 Project Description (or Regional Plan)
- 4.1 Project/Plan Overview (Structural/Non-structural Components)
  - 4.1.1 General Introduction
  - 4.1.2 Type
  - 4.1.3 Location
  - 4.1.4 Layout
- 4.2 Preconstruction Phase
  - 4.2.1 Status of the Project During EIA Study
  - 4.2.2 Preconstruction Activities
- 4.3 Construction Phase
  - 4.3.1 Construction Activities
  - 4.3.2 Hazards
  - 4.3.3 Schedule of Works and Logistics.
- 4.4 Operation and Maintenance Phase
  - 4.4.1 Operation Activities
  - 4.4.2 Hazards
  - 4.4.3 O&M Schedule
- 4.5 Overall Project Schedule and Logistics

5.0 Description of the Existing Environment.
- 5.1 Natural Physical Environment
  - 5.1.1 Atmospheric Environment and Climate
  - 5.1.2 Aquatic Resources (Surface & Ground Water)
  - 5.1.3 Terrestrial Resources
- 5.2 Natural Biological Environment
  - 5.2.1 Terrestrial Environment
    - 5.2.1.1 Types of Terrestrial Habitats
    - 5.2.1.2 Terrestrial Flora

The following are comments on specific sections of the report:

**Executive Summary:** Most assessment reports have an executive summary that is printed both as part of the main document and under separate cover for broader distribution than the report itself. The executive summary is written particularly for the interested parties. The language is purposely non-technical and therefore accessible to a lay person who is literate. Special provision may be needed for reaching illiterate interested parties.

**Project Setting:** The information for the project setting is largely derived from material supplied by the proponent, especially the rationale for the project.

**Project and Site Alternatives:** Depending on how the assessment proceeds, this could comprise a major part of the assessment report and require more than one section in the document. Each of the main components of the project is detailed here with regard to alternatives.

**Project Description:** Each alternative must be treated completely through all of the remaining sections of the assessment report. Regardless of the number of alternatives used, the project description should proceed by project phase to preserve the logical, chronological sequence of events that will unfold in the course of project design, construction, operation and abandonment.

**Existing Environment:** In this section, the environment is described without the proposed development, following the general sequence of atmosphere, terrestrial, freshwater (groundwater and surface water), tidal-marine and socioeconomic portions of the receiving environment. This is sometimes called the without project (or no action) option. This section constitutes the baseline environmental conditions upon which impacts are predicted.

**Environmental Impact Assessment:** This section explains the methodology and presents the impacts that are the prime focus of the assessment, namely, the project-on-environment impacts. It also gives background information to help interested parties understand how environmental assessments work. The choice of the important environmental components and bounding is detailed in this section.

This section also describes how the environment might affect the project and special concerns that must be addressed by the project design.

**Cumulative Impacts (Methodology and Results):** This section explains the cumulative impacts resulting from interactions of project activities with non-project activities, as well as impacts resulting from multiple project activities on the same environmental components.

**Project Scoping and the Public Consultation Process:** This section explains how consultation has been carried out and summarizes the main issues identified by interested parties. Because the interested parties will be especially concerned about this section, it is desirable to be clear on how each of the issues is included in the report and how each is being addressed.

**Environmental Management Plan (EMP):** This section describes the total Environmental Management Plan with the Environmental Protection Plan constituting the major portion of the EMP section. Again, the same logical format is maintained whereby each of the major project components and the management of their respective impacts are described by project phase. Accidental activities are dealt with by contingency plans specific to the predicted accidents or hazards for the project. Monitoring plans for environmental effects and compliance with the recommended management plans are described in detail. Compensation and environmental enhancement plans are detailed in this section as well. A final section on impacts should be included to detail the residual risks associated with the project. Also important in this section is how the consultation process will proceed. This section should contain the ongoing operation and maintenance (O&M) requirements and commitments over the life of the project. The final two sections of the EMP are the costing of the EMP, which facilitates the analysis of the economic viability of the project, and linking the environmental assessment with the project assessment process, which clearly identifies how the assessment report can be used to facilitate overall decision-making with regard to the project.

**Recommendations:** The last section of the EIAR or IEER must be the recommendations of the Assessment Team for going forward with the project, implementing an alternative, or taking no action (i.e., no project development). The team must reach a consensus on the recommendations and this section must be supported and justified with the data and facts presented in the EIA. Recommendations can be modified with the provision that the project can proceed if redesign of high-impact components result in mitigation to an acceptable level below critical thresholds (see the discussion on Alternative Analysis).

### 6.2 Review Process

Environmental assessment reports, both Initial Environmental Evaluations (IEEs) and EIA Reports have a special status in that they need to undergo an additional review process. A draft EIAR should be circulated to a select group of reviewers for initial comments and suggestions. Based on review comments, a final EIAR is produced and distributed to a wider audience. Several groups of interested parties will need to be identified for inclusion in such review depending on the level of environmental assessment. In the prefeasibility level, when the regional study report is being submitted, it is inappropriate to involve every group of local people in reviewing every project alternative because many project alternatives will later be discarded. It is necessary, however, to involve at a minimum:

- a group of regulatory government reviewers from ministries outside of the water sector and its ministry;
- a group of selected NGOs and academic representatives that have either the requisite expertise to review the reports critically, or a particular interest in the area or projects, or both; and
- one or more groups of residents with a range of backgrounds from the study area who can comment orally or in writing on the assessment report.

Translation and other special facilities may need to be available to accommodate residents so that their input is maximally utilized.

At the feasibility and design levels of assessment, when locations of projects and associated detailed descriptions of project activities are known, then the above group 3 should be expanded to include the local residents in the project area and other areas where impacts may occur.

All comments need to be summarized and characterized as to type of concern, positive or negative. It is expected that the comments from Groups 1 and 2 would be in writing, whereas the Group 3 comments will probably have a more diverse array of formats. If people's participation has been initiated early and has continued throughout the assessment process, it is likely that there will be fewer comments to respond to at the time the final assessment report is prepared and reviewed.

### 6.3 Response Document

In projects of national and regional importance, a response document needs to be appended to the final EIA Report. It is important because it takes all of the comments received on earlier drafts of the report and earlier stages of the assessment as applicable, deletes identifying remarks as to source other than major groups 1-3, and gives a response to each comment. In this way, the authors demonstrate that they have surveyed the opinions of the interested parties on the project and have successfully dealt with each of their concerns. Concerns always cover a range of viewpoints and levels of significance. There can be the most trivial to the most significant concerns; however, each concern is real to the person who expressed it, and he or she has a right to receive attention.

The overall quality of reply in the Response Document and the comprehensive and appropriate solutions for concerns are also to be considered in the project assessment process. Furthermore, the assessment report with its accompanying Response Document proves to the Government of Bangladesh, the donors, and all other interested parties that their concerns have been addressed, and that designers and proponents of the project or plan have been responsible and accountable in addressing concerns of interested parties. The Response Document does not constitute a guarantee that all concerns will be addressed to each reviewer's satisfaction. It should, however, demonstrate a genuine accountability to be responsible for all concerns and to attempt, insofar as possible, to resolve them.

The format of the Response Document should include a Table of Contents for the reader to easily identify the type of comments from each of the

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major review groups; a numbering system for the comments that enables them to be easily identified and retrieved; and use of two kinds of types or normal/boldface printing that clearly delineates the comment from the response. The document should also contain an appendix that would list the review groups and their members. Under no circumstances, however, should a particular individual or organization be associated with a particular comment. This minimal anonymity ensures that frank comments are submitted unless the questioner expressly wishes to be identified.

and every endeavour should be made to achieve all those are expected following all the methods and procedure mentioned in so far as available man and material resources permit. It is recognized that it will take years before full potential of public participation as enumerated here could be achieved. It is to be endeavoured none the less as the

Chapter 7

# PEOPLE'S PARTICIPATION

The following section is extremely important and a major element of a credible EIA at project level. The key to achieving long-term sustainability of water management projects is the active participation of affected groups in all phases of project design and implementation. This is based on two fundamental realities:

- extensive experience in Bangladesh has shown that projects lacking local support rarely achieve the success predicted for them by planners; and
- if local people are to support a particular project or program, they must be involved in project planning from the earliest phases (FPCO 1993).

A water sector project involves several key considerations:

- appropriate design (completed after consultation with the affected people uncovers local preferences and national concerns);
- local commitment to maintenance and local participation in management, operation and/or maintenance;
- strict avoidance of unnecessary and unacceptable harm to natural land and water resources, and the livelihoods that depend on them;
- wherever practicable, alternative siting, design changes, and other mitigation should be pursued to reduce damage to natural land and water resources; and
- full compensation should be given to individuals and groups that unavoidably suffer losses in a project, including (at a minimum) aid with the quick restoration of livelihood.

The EIA Manual user should refer to the Ministry of Water Resources guideline for people's participation.

## 7.1 Objectives of People's Participation

Public consultation and participation in EIAs aim to achieve the following objectives:

- to enhance the sustainability of projects by ensuring that water sector interventions are relevant to the people of the area;
- to learn from the various social groups living in a project area how they perceive the existing situation, recent trends, existing problems, and potential solutions; this includes collecting local knowledge, information, and ideas about the technical implications and impacts of project design;
- to identify the Important Environmental Components (IECs) for the environmental assessment, in particular, the scoping step;
- to determine potential social, economic, and cultural impacts not always foreseen in survey-based socioeconomic studies;
- to provide local communities and socioeconomic interest groups with the foundation for a role in post-feasibility project interventions; this means participation in project planning and a role in project implementation, operation, and maintenance.

Ideally, when properly associated with project interventions, "empowered" local groups help stabilize project impacts, provide social channels through which benefits can be provided and mitigation can be managed, and ultimately, result in more sustainable projects. Local interest and resource user groups, of course, will not always agree on project concepts, designs, and implementation strategies. But the selective empowerment of local groups, whether intentional or not, may disturb the local social-political balance and result in additional conflict. Participation plans, therefore, need to include strategies for negotiation and conflict resolution.

## 7.2 Stages in People's Participation

For most water development projects, people's participation will be required at four stages: prefeasibility, feasibility, detailed design, and construction, operation and maintenance.

### 7.2.1 Prefeasibility

The purpose of seeking people's participation in a prefeasibility EIA is to ensure that local knowledge and priorities become part of the information used by experts to identify the key project/regional environmental issues, determine the important environmental components (IEC) examine the likely project-environmental linkages and interactions, determine cumulative impact trends, screen options, and identify alternative sites. This is called scoping. The Rapid Rural Appraisal (RRA) is also conducted at this project stage to generate socio-economic database.

### 7.2.2 Feasibility

The feasibility stage is a complex one involving engineering and design studies, a comprehensive EIA, and a program to develop local community participation. Ideally, there should be considerable interaction among these three tracks throughout the feasibility study as project designers seek to arrive at a program that meets the needs of the local people and has both their participation and support. Generally, the feasibility study activities should align approximately as shown in Figure 7.1. Scoping is continued and enlarged at this stage.

People's participation should intensify as the EIA team undertakes the detailed impact assessment of the project. Local social groups gain a large stake during feasibility stage studies, as these provide the basis for who will benefit, who will not, and environmental management measures that will be needed. People's participation and Social Impact Assessment (SIA) are integral to a successful EIA. They are separated here for convenience. Social impacts are a sub-component of environmental impacts.

During the feasibility EIA, people's participation should proceed in two ways. First, a Project Coordination Committee (PCC) should be established in the project area and, through it, a structured planning process, involving representatives of affected social groups, should be initiated. Second, once the impact assessment is finalized, informational sessions should be held to inform the public about the program. For smaller projects, these should be conducted at the union parishad, thana, and district levels. For larger projects, those of a multi-district or regional scope, a public session should be planned for Dhaka, to which senior government officials, donor representatives, NGO representatives, the press, and other interested parties such as groups at grass root level should be invited.

### 7.2.3 Detailed Design

The involvement of the PCC should be extended to address specific project design requirements such as land acquisition, relocation sites, site-specific locations of project design components, and similar matters.

### 7.2.4 Construction, Operation and Maintenance

The PCC should design and conduct a review of the monitoring program and other environmental management measures to ensure that design stan-

| Step | Environmental Impact Assessment (EIA) | Project Engineering and Design (E&D) | People's Participation (EIA/SIA) |
|---|---|---|---|
| 1 | | | Local demand/Local needs assessment |
| 2 | Summarize project description | Review design principles & standards, complete project design | Scoping sessions planned |
| 3 | Environmental baseline description | Identify design alternatives | Community organizers fielded |
| 4 | Scoping | Evaluate design and/or site alternatives | Village scoping sessions |
| 5 | Bounding | | |
| 6 | Major field investigations | | |
| 7 | Assess impacts | Consider design modifications | Organize Project Coordination Committee (PCC) |
| 8 | Quantify and value impacts | Finalize design modifications | Brief PCC. Consult PCC |
| 9 | Environmental management planning | Recommend construction plan estimate and schedule, assist in mitigation planning | PCC discusses/finalizes compensation package |
| 10 | Feedback | Feedback for design revisions | PCC negotiates adjustments in the Compensation Plan |
| 11 | EIA reporting | Finalize design | PCC informs people of final project configuration and contingency plan |
| | Valuation of EMP and Residual Impacts | Preliminary cost estimate | |

**Figure 7.1 Sequence and Synchronization of Events in EIA, Engineering Design and People's Participation at the Feasibility Stage of a Project**

dards are maintained during project construction. Formal and informal communications with local people should be maintained and should be as open as possible. The details of the monitoring should be included in the EMP (see Section 3.8). From the perspective of effective people's participation, the objectives are to:

- measure the extent of expected or poorly quantified impacts;
- ensure early detection of unexpected impacts;
- determine the efficacy of implemented mitigation measures in reducing impacts;
- provide for periodic review and adjustment of mitigation programs;
- determine if the impacts of the project are exceeding any amounts or levels prohibited by existing laws and policies.

Local people should be provided opportunities to voice their opinions on the efficiency of the project operation and to make suggestions for modifications and improvements to avoid any untoward impacts.

## 7.3 Local Participation

### 7.3.1 Role of the EIA Team

The inter EIA team must be capable of eliciting and recording the views of local people about their development needs and priorities. In most cases, the social scientist and/or women-in-development specialist would ensure that all affected communities and social groups have an opportunity to record their views fully. Social scientists qualified for social impact analysis (SIA) work should be able to organize people's participation in the process.

In medium-to-large projects, social organizers (also called village or community organizers) may also be associated with the EIA team. The purpose of including social organizers (male and female) in the prefeasibility rapid rural appraisal. The RRA team should ensure that the poorest and least-represented social groups in the project area are brought into the prefeasibility process of consultation from the beginning. The objective of the social organizers is to help the unprivileged groups to articulate their views on the proposed project, and to select leaders who can represent them during the RRA and the PCC during the feasibility study.

### 7.3.2 Developing an Effective Participatory RRA

A successful participatory RRA depends on the same elements and attitudes that make for success in the prefeasibility SIA. Although all aspects of the SIA are relevant to people's participation, it is particularly important to:

1. Take time to prepare.
2. Recognize and offset biases in approach and attitude.
3. Involve the local population in major project design scoping.
4. Identify and consult leaders and groups in four social-political arenas.
5. Consider convening a post-RRA public meeting.
6. Report participation in the prefeasibility EIA report.

#### 7.3.2.1 Study Preparation

RRA teams that go into a project area must have an overall picture of the region, a framework within which to interpret the information they gather. NGOs can be an important source of essential background information. In many parts of Bangladesh there are NGOs that have worked in an area for years and are trusted by the local people. These organizations often have valuable information about environmental effects, the presence of disadvantaged social groups, and the effectiveness of local leaders. They also may have devised appropriate participation strategies that could serve as study models.

It is also important to take time to analyze different participation strategies and to orient the EIA team to participatory field work. The Participatory Rural Appraisal (PRA) methodologies developed by MYRADA in South India (Mascarenhas *et al.* 1991) as a starting point for training and orienting the EIA team (including the social organizers).

#### 7.3.2.2 Recognizing and Offsetting Biases

Biases in approach and attitude can be avoided by covering all parts of the project area, identifying and consulting with all the resource user groups in the area, including the poorest, landless women, fisherfolk, etc. While doing so, it is essential to listen and learn. Recognize that rural people have much valid knowledge about their environment and the resources they use. This is knowledge that outsiders do not have. It is also important to ask local social groups who their real leaders and spokespersons are, who they respect and trust, and how they want to be represented.

Once all of the preceding has been done, local social groups and their leaders should then be asked to identify their needs and interests and the ways in which they can be helped. They should also be asked to describe informally the current conditions in the project area, including their perception f recent trends, major problems, and potential solutions. Their opinions should also be solicited on how they would do the project or program at hand. Find ways in their own language to identify, screen and prioritize various alternatives in light of their own definition of their interests. Lastly, the leaders should be given an opportunity to express how they want their views to be presented in the RRA report.

Throughout the process, take careful notes on all activities and significant conversations. Keep a field diary. Record those participation strategies work and those that do not. Using PRA methods, develop simple scales (0-5) to quantify people's responses. Simple scales to describe degrees of impact can provide a measure of quantification that is easily understood by local people.

#### 7.3.2.3 Involving the People in Design and Scoping

Given the requirements of the prefeasibility report, the data and information collected in the RRA should enable the EIA team to relate the views of the people to the appropriate planning requirements of the prefeasibility EIA.

Use public consultation and participation during profiling to identify needs and resources in the potential project area.

During the bounding portion of the planning process, use public consultation to help define and locate remote populations and groups that depend on fragile resources or heritage rights. The social organizers should focus their efforts on identifying these groups.

When defining environmental management objectives, people's participation can be used to help identify indirect or direct effects outside the project area, as well as potential future effects. Public knowledge can also be used to help approximate the impact of project effects on land and water resources and on the livelihoods of the human communities that depend on them.

People's perceptions can be valuable in appraising the level of local public support the project will get and what strategies might work to give local people a participatory role and a sense of ownership of the project. Their knowledge of the area can be helpful in evaluating structural and non-structural options, including various mitigation, compensation, and enhancement strategies.

Public views should be taken into account in identifying and appraising preferred options. The views of all affected social groups should be presented in a separate section on participation in the body of the report, and be fully documented in an Appendix.

#### 7.3.2.4 The Four Main Social-Political Groups

The least powerful of the four groups consists of the landless, poor fisherfolk, and destitute women. Others that depend on scarce or fragile common resources should be identified and consulted. Consulting with these groups means understanding the dynamics of their basic survival strategies. It may be difficult to elicit "views" on the proposed project from these groups at this stage. The best chance probably will be in face-to-face meetings with the leaders these groups have identified as their own or in separate small meetings with members of each of these subgroups. Under no circumstances should these subgroups or leaders be asked for their views in meetings where they may feel intimidated by powerful patron-client leaders, large landholders, contractors, or local officials.

The next tier consists of subgroups that own land, have secure access to other resources (e.g., rights to common resources, fishing leases, rights to waterways), have needed skills (artisans), or operate shops and traditional businesses that might be affected by project impacts. This group constitutes a broad spectrum of social subgroups in rural Bangladesh. The prefeasibility stage does not require that this group be consulted in a highly organized approach (although a special effort should be made to elicit the views of women during this phase). EIA team members should make sure, however, that they consult with members of this group during the RRA. To the extent that EIA team members feel it necessary, small group meetings, or meetings with *gushti* (patrilineal kinship group) heads, can be held. No request for consultation coming from any social group should be rejected.

The third group is made up of the natural leaders of the people. For the potential project area, this would include members of the *samaj* (mosque-based religio-social group), village Imams and school teachers, union parishad members and chairman, and the thana council chairman. These members should be consulted for the views and perspectives they bring and to enable the EIA team to lay the groundwork for more intensive consultation and enlarged participation in the next project phase.

Government officials and specialists at the thana level make up the fourth arena. Many of these officers have a good understanding of social and economic conditions in their thana, some may have a role in future project mitigation, while others have responsibilities—such as road building—that could directly or indirectly affect project infrastructures.

#### 7.3.2.5 The Post-RRA Meeting

Taking this step is recommended if team members believe such a meeting would be used, not to demonstrate the authority of local power holders, but to discuss program options in a larger setting and to point the way to the organization of a formal Project Coordination Committee in the feasibility phase.

#### 7.3.2.6 Prefeasibility Reporting

The prefeasibility EIA report should have a section that describes the effort undertaken in the RRA to consult with the local population in and around the program area. This section should include the following information and documentation.

1. A list of all the social groups found in the area. This must include small groups that live in confined or remote areas, those that depend on fragile resources or heritage rights, and those that are a religious or ethnic minority. For all groups, the number of households should be approximated, group organizations and major leaders should be noted, and a rating should be assigned to the group's local influence (0-5 scale).
2. A list of specific groups and leaders that were consulted during the RRA. Requests for anonymity by leaders or very small groups during RRA interviews must be honored.
3. Based on RRA field discussions about how each group wants its views stated, record how each group views the following:

- The water management problems and trends in the area.
- The needs cited and solutions proposed.
- How its use of local land and water resources would be affected by the technical implications of the proposed program.
- How its use of resources would be affected by the environmental implications of the proposed program.
- How its use of resources would be affected by the social implications of the proposed program,
- The adequacy of proposed alternatives.
- The adequacy of possible mitigation and enhancements.
- What constitutes adequate compensation.
- What is the preferred solution (can be a package of programs, mitigation, compensation, and enhancements).

All of the above should be recorded as closely as possible to the original statements. Any effort at quantification of effects by local people should be included. For those groups and leaders who want their views identified, it is highly desirable that those views be recorded and checked in the field. Any statements, petitions, or other documentation submitted to the RRA team should be appended to the report, together with a translation if the originals are in Bangla. If the documents are too numerous a summary in English may be annexed. For those groups or leaders that request anonymity, the RRA team should devise a way to have their views recorded. This can be done by general references to the needs and interests of these groups as developed in RRA field investigation, particularly if use is made of PRA methods. The role of the social organizers will be key to the success of this effort. It is very important that the RRA team avoid an interpretive presentation of people's views in this section of the EIA report. Where the RRA team believes a term needs translation or a local measure quantified in standard terms, it may add a clearly identified "Team Note" in parentheses.

4. Provision of a representative institutional mechanism through which the local people, principally those who would be affected by the project, have the opportunity to decide whether or not the project should proceed. This can be accomplished through the PCC.

### 7.3.3 Preparing and Organizing Affected Social Groups

The EIA team social organizers should go into the field and begin this step as soon as possible after the decision is taken to move from a prefeasibility to a feasibility study. The number of social organizers will depend on the size of the program area, but the minimal coverage probably should not be less than one two-person team (one male and one female organizer) for a reasonable representative coverage (although this can be adjusted with experience, the socioeconomic complexity of the program area and the projected effects of the project).

The primary purpose of the social organizers is to help the poorest and most powerless communities—landless cultivators, marginal fisherfolk, destitute women, tribal and religious minorities, groups dependent on gathering scarce or fragile resources, etc.—work out the implications of program interventions for them, articulate their needs and interests, choose their leaders, and frame their position on the variety of program packages (alternatives, mitigation, compensations, enhancements).

Using the innovative—and effective—local organizational approaches pioneered by BRAC and other NGOs in Bangladesh, the social organizers should facilitate the formation of an informal committee to act as a sounding board for each social group and the selection of a community leader or leaders to represent the specific community on the PCC. Each social group should decide who its leader/spokesperson should be and how he or she should be chosen.

Organizing the poor takes a major effort and considerable time, hence the use of social organizers very early in the project cycle. This is a necessary part of people's participation, however, and project executing authorities must ensure that adequate time and resources are devoted to this effort.

Although the lowest echelons of rural society should be their first and primary focus, the social organizers should begin the process of stimulating more privileged groups—landholders, women who have some assets, local merchants, leasehold fishermen, transport and ferryboat owners—to take an interest in the proposed program and organize to choose their spokespersons. All affected groups in an area, including women, have the right to be heard and to have representation on the PCC. Indeed, as ample experience in Bangladesh shows, any attempt to exclude the more privileged groups will only create more obstacles to a successful program. The more privileged groups, however, will take less time to produce spokespersons, as they are already represented in *gushtis*, *samajes*, farmers clubs, *wakf* committees, and other dominant social groups.

It is essential that all EIA team members work quickly to gain a detailed knowledge of the project area and the people that will be affected. Much of the information required for the socioeconomic analysis of the project area is also required for enabling public consultation and participation at the local level. Setting up a people's participation process includes the following information gathering steps already cited in the SIA section as far as it is found relevant for the project under consideration.

1. Development of a profile of the people who will be affected by the project.
2. A clear identification should be made of groups that depend on scarce or fragile resources for their livelihoods.
3. A thorough analysis of how the most underprivileged section of the community, particularly women, function in all production systems.
4. An identification of sites that are important for cultural, archaeological, historic or religious reasons.
5. The identification of informal or customary rights to land use or to fishing sites, and to those social groups that depend on them for all or part of their livelihood. Some of these rights can be seen as heritage rights, such as the past assignment of land or beels to customary religious endowments (*wakfs*) to support mosques, schools, or shrines.
6. An understanding of local social organization in the project area. In order to assess the degree to which formal leaders represent the population, it may be necessary to know how people define their community (*para*, *mauza*, or market networks) and identify their primary and secondary group loyalties. Are such loyalties located in *gushtis*, castes (*jati* among Hindus), various kinds of *samaj* organizations, charitable trusts (*auqaf*), local credit groups, co-operatives, market or commodity organizations. Part of the effort here should be to understand local social hierarchy and how social status is interpreted.
7. An understanding of how authority, leadership and mediation (*salish*) are exercised within and among local social groups. How do groups connect with the wider worlds of governmental (administrative/ political) authority and regional commerce? It is useful to make a database of local groups and their leaders, e.g. *murubbis*, *jotdars*, *matabars*, as well as local government leaders, the ward members and the chairman of the union parishad. Such a database should also include locally influential people: school teachers, Imams, and others to whom local people look for guidance.
8. An understanding of which groups or leaders, or government bodies have responsibility/control over access/management of natural resources (e.g., water rights, fishing rights, grazing rights, rights to forage, etc.). This should include an understanding of how such responsibility or control is exercised—both formally and informally. Information here can also be held in a database.
9. An identification of local groups aware of the proposed project, of local levels of literacy, access to media sources (newspapers, radio, TV), and preferred sources of information.
10. A listing of the grassroots organizations in the project area, e.g., women's groups, formal or informal credit groups, labor organizations, and an examination of their track records and capabilities. This should also be done for NGOs already in direct contact with the affected population.
11. A listing of government officials, ministries, and programs in the project region, including officials responsible for health, agriculture, fisheries, forestry, credit, industrial development, and local government.

## 7.4 Establishing the PCC

All water sector projects that initiate feasibility-level EIAs should provide for the structured involvement of local people in determining the environmental and social effects of programs, in planning mitigation and enhancements, in negotiating compensation, in deciding whether the project should or should not go ahead, and in planning post-feasibility phases of the project.

EIA teams should keep in mind that participatory strategies that adapt traditional consensual and mediation approaches probably are more likely to work in Bangladesh than imported models. The *samaj*, the *salish* court, the *wakf*, even the contractual element in the patron-client system, are all deeply embedded rural institutions that could be drawn upon when enabling local participation in EIA work. Granted, some of these institutions in parts of the country have been taken over by local power holders. Where this is occurring or has occurred, EIA teams should avoid the corrupted informal local body and work through leaders who have the real support of the people. Despite the abuses of some, everywhere in Bangladesh one can find respected elders or committed younger leaders who will put the interests of the community before their own.

The PCC should be organized at the project or program level, but in large and medium projects sub-PCCs should be organized at that level where the EIA study team determines that technically rational water management decisions should be made as part of the larger program (e.g., around branch streams in a larger watershed, local catchment areas in a larger polder, or at the compartment level). The decision about where to place the PCC, and sub-PCCs where necessary, should keep in mind the expectation that the PCC will continue to have a role in the post-feasibility phase of the project, including construction, operation, and implementation of the environmental management plan. The lower down the PCC is placed in a hydraulic system or subsystem, the greater will be the capacity of the affected resource user groups to be involved in the planning, implementation, operation, and maintenance of the program. Clearly, experience in establishing the PCC will provide a body of on-going experience about how to do this better.

The hierarchy of program levels could look as follows.

1. Small water management (net area to 4,000 ha) would normally have a PCC at the thana level or below, depending on the size of the program area. PCCs at the thana level should be organized and chaired by the chairman of the thana parishad or whoever occupies the position in the reformed future equivalent structure. PCCs at the union or village level, for very small projects, should be chaired and organized by the union parishad member. The number of people's representatives on the PCC at this level should be around 15-20. Larger committees would become unwieldy. PCCs at the thana, union, and village level, and sub-PCCs at these levels, would have representatives of the resource user groups to be affected by the project or program as voting members of the council. These affected groups would be identified by the EIA team and the social organizers would be responsible for facilitating the selection of group representatives, particularly from among the poor and powerless. Proof of election/selection as group representative should be presented in the form of a petition with the signatures/thumb prints of all household heads in the social group, including women where households are headed by women.
2. Medium projects (net area in the range of 4,000 to 10,000 ha) would normally have a PCC at the zila level, with sub-PCCs at lower levels organized around technically rational water management areas or structures. Here the PCC should be organized by the local MP, or if the area covers more than one constituency of the Jatiya Sangsad (Parliament), by the senior MP. Districts might also convene PCCs for small projects that overlap thana boundaries within districts. In this case, the local MP could appoint one of the thana chairmen to organize and chair the PCC. Rep-

resentation at this level of PCC should still be that of the affected resource user groups, elected upward from the sub-PCCs.

3. Large projects (net area above 10,000 hectares, or dealing with major rivers, etc.) would normally have a PCC convened by the BWDB. The PCC at this level should be chaired by a senior MP from the region, and should have representatives from sub-PCCs created around local water management areas by elected district and/or thana leaders. For programs of national scope, the BWDB and/or Ministry of Environment and Forests would be responsible for convening a national-level PCC, with individuals from universities, think tanks, interest group organizations, NGOs, advocacy groups, etc., who would represent the major socioeconomic interest groups affected by the program.

It is up to the EIA team (including social organizers) to identify all the resource user groups in a program area. There will be cases where the EIA team will have to decide what is and what is not a resource user group in a particular area. One way to approach this issue would be through PRA methods—ask the local people how they classify social groups. Have them make a social map of their village/*para*. Follow this by having them make a resource map of their village and other areas they use (water bodies, embankments, *khas* areas, etc.). Clearly, experience will help to refine these problems as EIA teams work through such issues in their area and report how they classified local resource user groups.

Once these are identified and their leaders selected, it remains to translate resource user group interest into representation on the PCC. This can be done in one of four ways.

1. In proportion to the number of households in each resource user group. For example, if 20 percent of the households in a program area are mostly F-2 land farmers, this group would get 20 percent of the representative seats on the PCC. The advantage of this is that it is a "democratic" approach that relates households and (roughly) household livelihoods (local productivity of resource divided by number of households) to resources. The disadvantage is that it may exclude or give weak representation to small, fragile, but nevertheless environmentally important resource user groups. If this approach is chosen, the latter groups should be given weighted representation—that is, at least one seat on the PCC, regardless of their numbers.

2. In proportion to the surface area that each resource user group utilizes in the program area. For example, if open bodies of water where capture fishing households operate constitute 15 percent of a program area, then these households would have 15 percent of the representative seats on the PCC. The advantage here is that the approach is keyed to the magnitude of resources so that, in effect, "resources" vote on the PCC. The disadvantage is that many resource areas are used by more than one group—land is used by cultivators, grazers, and, after flooding of the lowlands, by fishing households; permanent water bodies are used both by fisherfolk and boatmen.

3. By dividing the project area into one-adult-one-vote PCC constituencies. This would be a fair way to proceed provided the constituencies were drawn in a way to maintain the integrity of resource areas. It would be easy, for example, to put a constituency boundary through an open water body and attach each half to a cultivated area with a larger population. This might end up giving the households living on and around the water body no seat at all, when a fair drawing of constituency lines would have given them one. It would also leave out small, but environmentally important user groups.

4. By giving each resource user group one seat on the PCC. This approach would highlight resources and ensure that even the smallest resource user groups would be represented, but might be resisted by larger populations who believe the weight of their interests is not being given due representation.

No approach is absolutely fair, and the experience developed by FAP 20 and the regional study EIA teams should provide valuable information for future studies. In any case, if EIA teams have developed the kind of relationship with social groups suggested in this manual, the issue of how to choose people's representatives can be worked out in discussions with those who would be affected by the program. The single most important criteria is to ensure that every resource user group in the project area is represented fairly.

Organizing the PCC is the responsibility of the senior elected official at the appropriate level, who should be assisted to the degree necessary by the EIA team, including the social organizers. Until and unless the Government of Bangladesh legislates the devolution of decision-making on local water issues to Local Project Committees, and provides a statutory basis for bylaws for such committees, each PCC should set its own procedure, which can be codified in a simple set of bylaws. These should cover membership, meeting procedures, decision-making procedures, define a quorum, define the function, duties and powers of officers, etc. The EIA team can offer information on local organization, or bring in advice from local NGOs, BRAC, or the Grameen Bank if needed.

As regards the role of *ex officio* members and advisory groups, PCCs below the thana level can decide whether to associate various specialists as nonvoting ex officio/advisory members. These include thana-level specialists in the government departments and local NGO staffers. As a practical matter, the project/EIA team would function as an advisory panel to all PCCs.

The PCCs also can decide whether to associate local NGO staffers, officials of advocacy groups, nationally known specialists from universities and institutes, etc. as advisory members.

The PCC should perform the following functions during the EIA feasibility study.

1. Provide a statement of program area needs and conditions to the project/EIA team.
2. Provide a list of proposed program interventions to the team.
3. Review engineering and design proposed program interventions, including design standards and specific program parameters; suggest modifications or alternatives, or cancellation if desired.
4. Consult with project/EIA team on proposed mitigation, compensation, and enhancements; review mitigation, compensation, and enhancement plans; suggest modifications or alternatives, if desired (The mitigation/enhancement package should include agreements about local participation in construction, operation and management, thus setting the stage for an on-going institutional role for the PCC).
5. Review the feasibility and EIA reports.
6. Review the final program plan package.
7. Organize informational scoping sessions in the program area.
8. Organize a local referendum on the project.
9. Decide to approve or disapprove the program package, or send it back for changes.

There is an underlying assumption here that local representatives on the PCC will engage in considerable negotiation about how the program package will look. Clearly, resource user groups that will lose out in a program can choose either to mobilize local opinion against the program or work out a mitigation/compensation/enhancement package through which they can maintain and improve their livelihood. In cases where there is a sharp disagreement over the program on the PCC, or in local communities, or where a natural resource will undergo substantial material degradation, the local PCC should organize a local referendum on the program.

### 7.5 Consulting the Wider Community and Nation

For projects or programs that have a regional or national scope—such as river training or very long embankments—groups at the national level should also be informed and consulted. These include government ministries with environmental, resource management, and social service responsibilities, as well as NGOs—national and international—interested in environmental effects. In addition, international donors and international environmental groups may be informed and consulted about major national programs that could have massive environmental impacts.

Informing the wider community of government ministries, international and national NGOs, international and national environmental groups, and other interested parties is an important part of the public consultation process. This process is in addition to the process of consultation in affected communities and should be founded on three assumptions.

1. A major objective of this process is to gain agreement on the issues and alternatives in a specific project design that will be examined in detail and, simultaneously, those that will receive less time and attention.
2. Public meetings should be designed to lay a firm foundation of openness, agreement and trust for all the deliberations that follow. The meetings are crucial to building public confidence in a fair EIA and, ultimately, in a fair decision-making process.
3. All parties in the consultation process should have access to all the basic information about the project.

#### 7.5.1 Timing

Apart from the initial meeting (see below), consultation at the national level should begin once the feasibility-level EIA report has been completed; only then will data be available on which informed decisions can be made. Representatives of government ministries and agencies, NGOs, union parishad members and representatives of affected communities should be invited to an initial interagency meeting, preferably located near the affected community. The initial meeting should tentatively schedule subsequent meetings. There can be four general public meetings over a year-long EIA process. Later meetings can be arranged for Dhaka and the district headquarters town or towns.

#### 7.5.2 The Initial Public Meeting on Large Projects

The goal of the initial meeting should be to ensure that there will be a thorough EIA for the project. The purpose of the meeting is not to resolve issues, but to enable major issues to surface early so that they can be addressed in the EIA. This scoping meeting should therefore help identify important environmental components (IECs), issues, types of information and analysis required, sources of relevant expertise, responsibilities and schedule for the EIA, and additional governmental or nongovernmental agencies that should be invited to participate in the EIA consultative process.

Meeting organization should be guided by the rules for any good meeting: for example, creating an open atmosphere and encouraging constructive dialogue. The first part of an initial meeting should be devoted to the distribution of a meeting agenda and small information packet, a discussion of the project in general, covering its purpose, funding, proposed location and any other aspects that can be presented orally with the aid of maps and other visual aids to help illiterate people understand what is going on. A question-and-answer period should follow, after which the meeting can break up into small discussion groups. These can be organized by topic, e.g., hydrological effects, public health, agriculture, fisheries, etc.

Discussion can start with homogenous groups followed by heterogeneous groups including one or more government official, NGO member, and affected community representative.

The task of the small groups is to prepare an initial list of what people think are the significant environmental issues. Each group should choose its own discussion leader or rapporteur and the issues discussed should be recorded on a large pad or blackboard or flipcharts during the meeting and in a subsequent report. EIA team members should join a discussion group.

After the meeting, the EIA team must evaluate comments made during the meeting, or other memoranda and working papers presented by interested groups, including impact reports from meeting with the affected communities. The EIA team should decide which issues to pursue further. It should be kept in mind that all issues named as a priority matter during general meetings or in community meetings must be addressed in the EIA. This can be either by in-depth analysis, or by a supportable justification of why the issue was considered but not explored further.

The style of subsequent meetings can be adjusted with experience. In general, the consultation process should remain open throughout the project cycle. It should include continued feedback to those consulted, with particular attention given to sharing the conclusions of various EIA analytical efforts. Generally, the objective of providing feedback is best accomplished by distributing the latest draft EIA to those groups and agencies participating in the process of public consultation. Project design may include mechanisms for ongoing consultation, for example, a standing review committee that includes NGOs and representatives of affected communities.

### 7.5.3 The Facilitator: Conflict and Compromise

A facilitator should be chosen to handle meetings involving the wider community. The literature on consultation stresses the need for facilitator skills to run a successful public consultation. The facilitator should be chosen for skills such as the capacity to marshall consensual forms of decision-making. He or she may be a university professor or senior government servant, or an NGO worker trained in such matters, but should not be from the project agency. Nor should he or she be from the immediate area or have any stake in the outcome of the project.

The facilitator should be prepared to handle the conflicts which always will usually be present to some degree. Conflict often revolves around power: who has it, who wants it, and who needs even a little of it in order to participate in an EIA process with those who already have it. People will naturally have different views about their own interests and what they perceive to be the interests of their community. In Bangladesh, where so many live in fragile, subsistence conditions, strong reactions can be expected when rural livelihoods are threatened. Conflict arises when one group believes that the net benefit of a project comes at its expense while another gains. In Bangladesh, where the notion that change always comes as a zero sum game is widely accepted, some will see themselves as "losers," and others as "winners." It is part of the task of the EIA process to show that there are situations in which all can be losers, and other situations in which, hopefully, all can be winners.

It is the task of the meeting facilitator not to avoid, cover up, or minimize conflict, but rather to articulate clearly the varying positions and interests—to bring them out into the open. A useful function of conflict is to be a safety valve where the interests of different groups are in opposition. It is usually mismanaged or manipulated conflict that becomes a destructive force. Behind every violent protest is a group that feels that its views are being suppressed and ignored. A main purpose of the EIA consultative process is to ensure that everybody has a chance to express his or her views.

A helpful reference for the EIA consultative process is Fisher and Ury (1983). The authors make useful distinctions between "positions" and "interests." Positions are people's or a group's prepared answers; interests are the reasons people take particular positions. Frequently, during conflict, many people express their differences with positions that are mutually exclusive. Fisher and Ury, and now others in the field, urge the facilitator/negotiator to focus on interests, to keep asking the question "Why?"

During the discussion phase, differences in perception, feelings of frustration and anger, and difficulties in communication can be acknowledged and addressed. Each side should come to understand the interests of the other. Both can then generate options that are mutually advantageous and can begin to seek object standards for resolving opposed interests. If EIA leaders clearly understand the interests (as distinct from the positions) of the opposing sides, they can enlist the advice of technical experts, project designers, and others to propose approaches that address the differences and possibly resolve them through design alterations, mitigation, compensation, or even project enhancements.

## Chapter 8

## WATER RESOURCES

### 8.1 Climate

#### 8.1.1 Baseline Studies

The purpose of the climate section of an EIA is to familiarize reader with the general climatic regime of the project area. It also provides EIA practitioners with the meteorological data on which to base the impact assessment of the proposed project.

The information required includes:

- a general description of the project area climate;
- rainfall data; and
- temperature and relative humidity data.

The data provide engineering planners with the means to derive design storms, irrigation/drainage system design capacities, reservoir/storage tank operation parameters, and parameters for water balance computations. Agronomists and soil scientists use the information to assess crop suitability, compute soil moisture balances and crop water requirements, and set project crop calendars. Environmental scientists use the information to help interpret the results of their baseline studies and to aid in the prediction of impacts.

#### 8.1.2 Existing Data Sources

An EIA for a typical water sector project uses existing long-term data collected, tabulated, and wholly or partially analyzed by others. It is seldom necessary to initiate climatic data collection specifically for project EIAs. Data analysis should be performed or updated by the EIA staff only if absolutely necessary, as dictated by exceptional circumstances.

If data requiring analysis are to be collected, then effort should be made to gather it in a form suitable for computer processing. The Water Resources Planning Organization (WARPO) maintains a large database of basic climatological data. Statistical analysis of these data are available from WARPO upon request, and the organization will provide computer files of the raw data. The Bangladesh Agricultural Research Council (BARC) also can provide data obtained from the Bangladesh Meteorological Department (BMD) on MS-DOS disks.

##### 8.1.2.1 Climatological Description

The general description of the climatological regime of the project area should use standard indicators developed for Bangladesh. Examples of such may be found in the various volumes of the United Nations Development Program/Food and Agriculture Organization (UNDP/FAO) publications on the agroecological zones (AEZ) and climatic regions of Bangladesh (FAO/UNDP 1988). The description of the climate should be consistent with the terminology used in the project feasibility or design reports produced by the project planning team.

##### 8.1.2.2 Rainfall

Information for characterizing the precipitation regime of the project area includes:

1. Isohyetal map(s) of mean annual rainfall and other relevant seasonal or extreme rainfall totals.

Table 8.1 Sources of Rainfall Data

| Agency | Format | Output Medium | |
|---|---|---|---|
| | | Hard Copy | Disk File |
| Bangladesh Meteorological Department | Daily/Hourly | Yes | Yes* |
| Bangladesh Water Development Board | Daily | Yes | Yes |
| Bangladesh Rice Research Institute | Daily | Yes | No |
| Bangladesh Agricultural Research Institute | Daily | Yes | No |
| Bangladesh Agricultural Research Council | Daily/Hourly | Yes | Yes† |
| Master Planning Organization | Daily | Yes | Yes |

*Database is in 8" Tandy TRS-80 format. May be converted to MS-DOS at the Bangladesh University for Engineering and Technology (BUET).
†The database, although obtained from BMD, is in MS-DOS format.

2. Table(s) of monthly rainfall statistics that show(s):

- monthly mean rainfall totals
- maximum recorded monthly rainfall totals
- minimum recorded monthly rainfall totals
- monthly rainfall total equalled or exceeded 80 percent of the time
- monthly rainfall total equalled or exceeded 90 percent of the time.

3. Table of relevant extreme rainfall events (monsoons and dry season), with their associated return periods (or exceedance probabilities) used in design of water management facilities.

4. Table(s) of seasonal rainfall, if available, using 10-day totals (or other appropriate periods), illustrating the rainfall patterns of the study area for the cropping calendars of critical crops. Provide 10-day totals equalled or exceeded 80 percent and 90 percent of the time.

Many of the rainfall data listed above are essential components of agricultural and engineering design of typical water sector projects, and may be obtained from the sources shown in Table 8.1. On request, WARPO can perform extreme value (log Pearson) rainfall frequency analyses on daily rainfall records, and will provide the results on a computer disk file.

Display the locations of the adopted rainfall stations on a map and comment on the length and reliability of the records.

#### 8.1.2.3 Temperature and Relative Humidity

Temperature and humidity data provide information on a large range of processes, including the rate of response of the various biological and chemical processes to external perturbations, and the rate of evapotranspiration in the project area.

Locate the project area within the generalized UNDP/FAO AEZ thermal regimes. Identify and explain the AEZ thermal classifications that apply to the project area. Use temperature data (degrees Celsius) measured at stations in or around the project site and provide table(s) of:

- monthly mean temperatures
- maximum of the monthly mean temperatures
- minimum of the monthly mean temperatures
- maximum recorded daily temperature for the month
- minimum recorded daily temperature for the month
- monthly mean relative humidity
- maximum monthly mean relative humidity
- minimum monthly mean relative humidity

Table 8.2 Sources of Temperature and Relative Humidity Data

| Agency | Format | Output Medium | |
|---|---|---|---|
| | | Hard copy | Disk file |
| Bangladesh Meteorological Department | Daily/3-hr | Yes | Yes* |
| Bangladesh Water Development Board | Daily | Yes | Yes |
| Bangladesh Rice Research Institute | Daily | Yes | No |
| Bangladesh Agricultural Research Institute | Daily | Yes | No† |
| Bangladesh Agricultural Research Council | Daily/3-hr | Yes | Yes‡ |
| Master Planning Organization | Daily | Yes | Yes |

*Database is in 8" Tandy TRS-80 format. May be converted to MS-DOS at the Bangladesh University for Engineering and Technology (BUET).
†Does not record relative humidity measurements.
‡Database, although obtained from BMD, is available in MS-DOS format.

If available, 10-day mean, maximum and minimum temperatures during the crop calendar of critical crops may be presented in tabular form to support the agronomists. This information is available in regional form in the UNDP/FAO AEZ reports.

Sources of such data are listed in Table 8.2. Display the temperature measurement locations on a map accompanying the report, and comment on the length and reliability of the temperature records.

#### 8.1.2.4 Units of Measurement

Many of the older agrometeorological data that are available in Bangladesh are recorded in English units. Such data should be converted to their metric equivalents before being presented in the data tables. The aim is to present data to EIA practitioners and readers in a familiar, consistent, and practical format that minimizes further unit conversions. Table 8.3 lists the suggested units for climatological data in EIA documents.

### 8.1.3 Primary Data Collection

There is no need to collect primary climatological data for the EIA. The climate chapter of the EIA report presents statistical summaries and highlights of existing long-term records of various climatological data. These can be obtained from a variety of sources, some of which are listed in Tables 8.1 and 8.2.

### 8.1.4 Maps and Diagrams

Prepare a map showing the locations of the climatological data observation stations from which the data originated. The map should be of sufficient scale that the project area and most of the observation stations can be shown in a standard report page (A4 or 8.5" x 11" size). More distant stations can be shown on a large-scale map inset in the main location map.

Some regional information (such as AEZ thermal zones, project area isohyetal map and wind roses) are more effectively presented in the report as charts and diagrams. Other time series information may be accompanied by graphs if they serve to accentuate an important fact or trend. The type of graphical aids required to illustrate some aspects of the local climate depends to a large extent on the requirements of the other specialists of the EIA team.

### 8.1.5 Data Analysis

This section provides a general description of some methods commonly used in compiling the data specified in Section 8.1.2.

#### 8.1.5.1 Rainfall

The table of monthly mean, maximum, and minimum rainfall provides a measure of the average rainfall

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Table 8.3 Units of Measurement for Climatological Data

| Parameter | Unit | Symbol |
|---|---|---|
| Rainfall | millimeters | mm |
| Rainfall intensity | millimeters per day | mm/d |
| | millimeters per hour | mm/h |
| Temperature | degrees Celsius | °C |
| Relative Humidity | percent | % |

expected in any given month, and the range of values of the observed monthly totals. For each month, the average of all recorded monthly rainfall totals is computed. Also noted is the highest and lowest recorded total for each month.

Before performing many of the analyses, hydrologists and climatologists typically check the reliability and consistency of the rainfall data. An inspection of the station records may reveal details of the reliability of the records. Standard methods such as double mass analyses and more sophisticated statistical procedures may provide clues to the consistency of the data from one station. This information contributes to the decision use, reject, or adjust the data from selected rainfall stations.

A key design parameter in many cropping studies is the amount of rainfall that would be available ("equalled or exceeded") during the crop season four out of every five years. In probablistic terms, the desired rainfall amount is that which has an exceedance probability of 80 percent (a cumulative probability of 20 percent) during the period in question.

Rainfall totals are typically assumed to be random variables that follow a normal or log-normal distribution. The series of observed rainfall totals for each month is ranked and a normal or log-normal distribution is fitted to the points. This is accomplished analytically using parameters computed from the observed rainfall totals, or graphically by plotting the ranked points on normal or log-normal graph paper.

For the monthly rainfall tabulation, a distribution is fitted to each of the 12 series of observed monthly rainfall totals, and the 80 percent exceedance values are either computed or read from the plots. If daily rainfall data are available, this procedure can be repeated for 10-day rainfall totals, usually involving three 10-day periods per month. Statistics on 10-day rainfall totals allow agronomists to perform more detailed analyses of rainfall and crop water deficits during specific growing seasons.

Another type of rainfall data analysis is often performed by engineers for the design of internal drainage facilities in water projects, road, and other infrastructure facilities. These analyses seek to derive the rainfall quantities (occurring over specific time durations) associated with rare events that may occur once every 5, 10, 50, or 100 years or longer.

In these analyses, a design storm duration is selected. The duration chosen is typically related to the length of time storm runoff from all parts of the catchment takes to reach the drainage channel or structure being designed. For each year of record, the maximum rainfall amount for the selected duration is extracted from the record. These values (annual maxima) are assumed to be random variables that are distributed according one of the "extreme value distributions." Commonly used distributions include the log Pearson and the Extreme Value Type I (Gumbel) distributions.

As in the case of normally distributed rainfall totals, the extreme values are either processed analytically or plotted graphically (usually both), and the desired extreme storm depths for the given storm duration are computed. These rainfall totals are then distributed over time by using design storm patterns unique to the study area and to the duration under consideration.

Graphical aids to presenting rainfall data, such as isohyetal maps, use rainfall data from a number of regional rain gauges to show spatial variations of rainfall over a given area.

In analyses requiring processing of daily and monthly rainfall data, the analyst is frequently confronted with missing precipitation data. The analyst could exclude the data set containing periods of missing information, or may choose instead to fill these periods with estimated rainfall amounts. A variety of techniques are available for estimating missing data, all using concurrent, long-term data from nearby rainfall stations and a considerable amount of judgement.

#### 8.1.5.2 Temperature and Relative Humidity

Data analysis requirements for temperature and relative humidity are minimal. Climatological stations using manually read temperature gauges typically report maximum and minimum temperatures for each day, and the average daily temperature is computed as the average of the maximum and minimum values for the day. These stations typically report mean monthly temperature values, as well as the maxima and minima of the mean monthly temperatures.

Stations with recording temperature gauges may report mean daily temperatures by integrating the entire day's record and computing a mean temperature. This more accurate method yields values slightly different from those computed by taking the average of the maximum and minimum reading for the day.

Relative humidity values are typically derived using data from dry- and wet-bulb thermometers at temperature measuring stations. Tabulations of monthly mean relative humidity values are usually available together with temperature statistics.

The UNDP/FAO AEZ reports show the regional thermal regimes of Bangladesh, as they relate to the growing seasons of the major cropping systems. If daily mean temperatures for the temperature station(s) are readily available, project budget and time constraints permitting, a table of 10-day mean, maximum, and minimum temperatures that match the 10-day rainfall totals may be useful for the EIA.

## 8.2 Surface Water

### 8.2.1 Baseline Studies

EIA baseline data and/or studies on surface water should provide the following information.

- The general pattern of surface water distribution systems and a description of the rivers, small waterways and static water bodies. This information should indicate the extent of interconnections, seasonal changes in drainage, sources of water for these bodies, and seasonal changes in water levels.
- A quantitative description of the hydrological cycle within the study area watershed and within its component systems including: streamflow, water levels, groundwater levels, rainfall, erosion and sedimentation patterns.
- A quantitative description of historic hydrological problems including: flooding, flash floods, inadequate drainage, drainage congestion, flooding risks.

The level of the study determines the level of data required for analyses. For example, monthly hydrologic data will suffice for regional and prefeasibility studies, whereas daily data are often needed for feasibility studies and detailed design. Baseline data are needed by planners to assess pre-project conditions and devise a project plan. They are also needed to analyze the post-project conditions and potential impacts.

As in the case of climatological data, the EIA uses existing long-term surface water data collected, tabulated, and wholly or partially analyzed by

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others. Data analysis should be performed or updated only if absolutely necessary, or if a different data format is required for a particular model, etc.

The surface water section of the EIA should provide a quantitative description of baseline information that characterizes the present physical setting in the study area, including its resources and problem areas. The text should be clear and concise. Liberal use should be made of tables and graphic figures and maps to present the hydrologic regime over the full period of the hydrologic cycle (wet and dry seasons).

A project map is required to show the general pattern of important surface water distribution systems within various water bodies, including rivers, *khals* (canals), *beels*, *haors*, etc. The report should provide a general description of the interconnection between waterways, seasonal variability, sources of water, and seasonal changes in water levels. Locations of the systems should already be shown on the project map, but should be verified in the field. Descriptive information may be obtained from existing records and/or field surveys.

Graphic presentations are particularly effective in showing the cyclical pattern of the surface water regime and for making comparisons, e.g., a graph showing a comparison of monthly mean, maximum and minimum discharges over a full year.

Finally, the surface water section of the report should contain a quantitative description of hydrological problems. The historical nature and timing of flooding (flash floods, seasonal), drainage, flood risks, erosion and sedimentation problems, all need to be presented. Descriptions should include the source, nature and areal extent of the problems. Where possible, the extent of the problems should be quantified. For example, the flooded or water-congested area should be given in hectares together with frequency of occurrence, or the number of kilometers of embankment subject to river erosion, etc. As far as possible, the report should include a map locating the types, distribution and extent of such problems.

### 8.2.2 Existing Data Sources

Table 8.4 lists the major water resource data that are collected in Bangladesh as well as the primary collecting agencies. Secondary sources for data are some of the major data users: BARC, Bangladesh Rice Research Institute (BRRI), WARPO (MPO) and organizations conducting project studies. In particular, WARPO has a large water resource planning database consisting of all the precipitation, streamflow, water level and groundwater data collected from BWDB and other organizations during the conduct of NWP I & II. One of WARPO's mandated functions is to continually update that database and make it accessible to all agencies.

Data can normally be obtained from an agency by submitting a formal written request stating the purpose for the request and the type of data wanted. The agency will charge a fee for providing data in any type of format.

#### 8.2.2.1 Streamflow

Streamflow or river discharge measurements are needed to assess the quantity and dependability of surface water supplies for irrigation development and other purposes. River discharge measurements are also needed for flood analysis.

The Bangladesh Water Development Board (BWDB) is the only agency collecting streamflow data. Measurements have been made at a total of 164 stations since 1964, when the national network was started, but many stations have been abandoned as others were added. A total of 79 stations were operating in 1990. The streamflow data are collected weekly and fortnightly. The data are then entered into the BWDB computer and the mean daily flow calculated. The data are supplied on disks or in hard copy as requested.

There is also a list of the BWDB streamflow gauging stations, accompanied by maps showing the location of the stations and examples of station records. The station listing also indicates the period of record for each station as well as the frequency and units of measurement.

**Table 8.4 Type and Source of Water Resources and Related Data**

| Type of Data | Data Collecting Agency* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | BWDB | BADC | BMD | DPHE | WASA | SOB | SPARRSO | DOE | SRDI | BIWTA | Port |
| 1. Precipitation | ✓ | | ✓ | | | | | | | | |
| 2. Streamflow | ✓ | | | | | | | | | | |
| 3. River WL | ✓ | | | | | | | | | ✓ | |
| 4. GW Table | ✓ | ✓ | | ✓ | ✓ | | | | | | |
| 5. Aquifer Test | ✓ | | | ✓ | | | | | | | |
| 6. Drilling Test | ✓ | ✓ | | ✓ | ✓ | | | | | | |
| 7. Sediment Load | ✓ | | | | | | | | | | ✓ |
| 8. Salinity Level | ✓ | | | | | | | ✓ | ✓ | | |
| 9. River X Section | ✓ | | | | | | | | | ✓ | ✓ |
| 10. Water Use | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | | |
| 11. Land Elevation | | | | | | ✓ | | | | | |
| 12. SW Quality | | | | ✓ | ✓ | | | ✓ | | | |
| 13. GW Quality | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | |
| 14. Evaporation | ✓ | | ✓ | | | | | | | | |
| 15. Climatic Data | ✓ | | ✓ | | | | | | | | |
| 16. Satellite Photo | | | | | | | ✓ | | | | |
| 17. Maps (Topo) | | | | | | ✓ | | | | | |
| 18. Soils Data | | | | | | | | | ✓ | | |
| 19. Cloud Picture | | | | | | | ✓ | | | | |
| 20. Morphological Change | ✓ | | | | | | | | | ✓ | |
| 21. Flooded Area | ✓ | | | | | | ✓ | | | | |

Source: Interagency Committee Report on Data Improvement (1991)
*Acronyms explained in glossary

### 8.2.2.2 Static Water Resources

Static water bodies are topographic depressions which contain water. In monsoon season, these depressions, locally called *beels*, *haors* or *baors*, are connected to rivers and *khals*, but as the floods recede, the *beels* and *haors* become disconnected and form isolated water bodies. During the driest part of the year, many of these static water bodies are completely dried up. Some, however, retain water that is used not only for irrigation but also as fish habitat and for fish culture. These water bodies therefore, although small, may be significant sources of water in the dry season.

Data on the surface areas of standing water bodies is sparse, but SPARRSO (1985), with MPO's guidance and support, has estimated the areas under dry season conditions. MPO used the SPARRSO data for the NWP Phase I and II studies (1983-1991). The data and the SPARRSO report should be obtainable from MPO's files and library. MPO's use of the data is discussed in MPO (1987).

In the SPARRSO studies, topographical maps of 1:50,000 scale were used to identify static water bodies and estimate their surface areas by planimetering individual static water bodies. The 1:50,000 scale maps, obtained from the Survey of Bangladesh (SOB), were updated based on satellite imagery and infrared aerial photographs. Man-made static water bodies, including Kaptai Lake, ponds and tanks, were not included in the SPARRSO studies.

The total surface area of static water in Bangladesh was estimated to be about 1,230 km$^2$, of which more than 60 percent is concentrated in the Northeast Region. The SPARRSO studies were limited to estimating only the area of static surface water. In order to estimate static water volume, determination of static water depth is needed. At this time, no data on static water depths are known to exist. Project studies should include a determination of areas and depths as part of the project baseline studies.

#### 8.2.2.3 Water Levels

River discharges and water levels are the two measurements most commonly used for flood analyses. In Bangladesh the discharge measurement network is not sufficient for a complete flood analysis. Consequently, water level measurements and precipitation data are the primary data used for flood analyses and modelling studies.

The BWDB is primarily responsible for water level data collection. In 1990, it reportedly operated 315 water level stations compared with 299 in 1988. Approximately 28 stations are equipped with automatic recorders; the rest have staff gauges. The staff gauges are read five times daily for non-tidal streams and five times plus the maximum and minimum for tidal streams. The gauges are referenced to the Public Works Department (PWD) datum. The collected data are edited and entered into computers. Information is supplied to water data users on request.

The Bangladesh Inland Water Transport Authority (BIWTA) has a network of water level stations, chiefly in the tidal-affected zone of riverain Bangladesh. The agency also periodically surveys the inland navigable routes to produce navigational charts. The BIWTA maintains 10 water level stations, all equipped with water level recorders. The BIWTA also records and publishes tide water levels. They maintain a list of the data available from BWDB and BIWTA accompanied by maps showing the locations of data stations and examples of station records. The listing of each agency's stations indicates the period of record and the frequency and units of measurement.

Maintenance of station history is especially important to water level data because of the continuously shifting nature of the rivers. Dates and results of zero gauge surveys must be maintained, especially those following damage or relocation of staff gauges. The station history for water level data must also include construction dates of hydraulic structures upstream or downstream of water level stations.

#### 8.2.2.4 Sediment

Sediment data are used for morphological studies of the project. It is used when determining the navigability of streams and priorities for dredging, design of flood control embankments and other river structures, and accuracy of water level and water discharge measurements. Generally speaking, the existing measured sediment data in Bangladesh are inadequate for any significant project study.

Sediment sampling was initiated in 1957 at about 15 locations by the Irrigation Department. At present, sediment data are available at the Hydrology Directorate of BWDB and the River Research Institute (RRI). There have been as many as 51 sediment sampling stations in the past, but in 1989 only 25 were operating. The data are collected weekly, fortnightly or monthly concurrent with discharge measurements. The data are available only in hard copy. Appendix 1 lists the location of data stations and contains an example of station data.

### 8.2.3 Primary Data Collection

Primary data collection for surface water analyses should be done as part of the baseline studies for the feasibility study. The length of the feasibility and EIA studies will determine how much and what type of primary data can be collected.

Primary data collection probably would be limited to conducting field surveys to supplement existing information. Topographic, river section and structure survey data would be the most important. These are needed to support hydraulic studies and hydraulic modelling used to simulate both present conditions and future scenarios, for the purpose of both design, benefit assessment and development of operational rules. Field surveys may also be needed to define the extent and volume of static water resources. The surveys may consist of topographic surveys, or at a minimum, a rapid rural appraisal (RRA).

RRA's will probably be needed to define the pattern of the surface water distribution systems in the study area, particularly the extent of interconnections, seasonal variability, sources of water and seasonal changes in water level. RRA's will also be useful in determining the location and extent of areas that historically have such hydrologic problems as drainage congestion, waterlogging, erosion and sedimentation.

Obtaining additional information on streamflow, water levels and sediment would depend on the length of the study. The data collection would need to extend over a full monsoon period and/or a full dry season to be of any value. Data would be collected from an existing or rehabilitated gauging station, or if necessary, a new gauge could be established at a key point in the project area.

### 8.2.4 Maps and Mapping

The EIA report will require maps to show locations of surface water data stations and to illustrate results of hydraulic analyses. Map sizes should be standardized. Most information can be presented on a map of a scale such that the project area can be shown on a standard report page (A4 or 8.5" x 11" size) or a foldout (A3 or 11" x 17" size). If possible, a project base map should be prepared and placed in the computer for use with computer graphics. Data to be displayed can be entered onto the base map as desired. The information shown on the base map may include:

- surface water system;
- location and extent of static water bodies;
- location of stream gauging stations:
- location of water level stations;
- location of sediment measuring stations;
- location of flooded or other problem areas; and
- flood depths.

Charts, diagrams and tables will also be required for presenting such data as:

- streamflow discharge and frequency analyses;
- flood discharge, flood water levels, and frequency analyses;
- cross section of waterways;
- comparison of pre- and post-project water levels, etc.

As far as possible, report presentation should make use of computerized graphics. Linkages should be established to use the GIS database to interpret and display outputs from model studies, such as flood depth maps.

### 8.2.5 Data Analysis

#### 8.2.5.1 Hydrologic/Hydraulic Modelling

A number of mathematical models have been or are being developed under the FAP and other studies to assist planners and designers in the analysis of Bangladesh's complex hydrologic/hydraulic regime. Among these are the models developed by the Surface Water Modelling Center, the Flood Management Model being developed under FAP 25, and models developed by WARPO (MPO) for national water planning.

Geographic Information System (GIS) studies, being developed under FAP 19, are examining the scope of interfacing with the flood models. Of particular use will be development of the capability to make a spatial representation of model results.

### Surface Water Modelling Center (SWMC)

The Surface Water Modelling Center of the Water Resources Planning Organization (WARPO), formerly MPO, conducts the ongoing activities of the Surface Water Simulation Modelling Program (SWSMP). The SWSMP was established to develop mathematical models of the river system that could be used in an integrated approach to planning and design. The first phase of SWSMP, started in 1986, was financed by United Nations Development Program (UNDP) and executed by the World Bank. The ongoing second phase (SWSMP-II) is running from December 1989 through November 1993 and is financed by DANIDA. The Danish Hydraulic Institute has been the consultant since the project started.

The SWSMP is using the generalized MIKE 11 software package to develop a suite of mathematical river models in two scales. The models include a general model, embracing almost the whole of Bangladesh, and six detailed regional models. The models will be used in flood control design, as well as for compartmental models. The boundary conditions are hierarchical; conditions for each submodel are provided from the higher-level model in which the submodel is embedded.

Model inputs are rainfall and evaporation, flows from across borders, terrain and river channel geometries, and land factors. Outputs are water levels and flows in river channels and flooded areas on a daily basis throughout the year. In addition, groundwater levels are predicted and estimates of sediment movement and salinity intrusion can be made.

The model development is taking place in three stages: pilot, full model and verified stage (Table 8.5). These are applicable in broad terms to planning and prefeasibility studies; feasibility studies and outline design; and detailed design, respectively. At present, the general and Southeast Regional (SERM) models are fully developed and verified. The remaining models are at various stages of development, as shown in Table 8.5. The plan of operation for SWSMP-II calls for all models to be developed and fully verified by May 1993.

The SWMC models are essentially planning tools; they are being verified on existing conditions and are then used to evaluate the effects of engineering work. The output from the models gives the variation of water levels and flows throughout the model area with time, considering also the storage characteristics of the floodplains. The models do not indicate directly detailed areas and depths of inundation. Also, one of

**Table 8.5 Surface Water Simulation Modelling Program Development Schedule.**

| Model | Pilot | Full | Verified |
|---|---|---|---|
| General | | Jul '90 | Mar '91 |
| Northwest (NWRM) | Mar '91 | Jan '92 | Apr '92 |
| North Central (NCRM) | Mar '92 | Jan '93 | Apr '93 |
| Northeast (NERM) | Mar '92 | Jan '93 | Apr '93 |
| Southwest (SWRM) | Mar '91 | Jan '92 | Apr '93 |
| South Central (SCRM) | Mar '92 | Jan '93 | Apr '93 |
| Southeast (SERM) | | May '90 | Mar '91 |

Source: SWMC 1990, pers. comm.

the central elements in the FAP is "compartmentalization" allowing controlled flooding and drainage within and between compartments through the operation of structures on the rim of the compartment(s). Identification of overall water management strategies for compartments and development of simple operational rules are essential for successful operation of compartments on a large scale.

**Flood Management Model (FMM)**

The Flood Model Management (FMM) Study is addressing the need for more detailed information on floodplain inundation, as well as the need for developing operational guidelines for flood control structures and schemes in general and for compartment(s) in particular. The FMM includes the following features:

- linkage of the MIKE 11 SWMC models to a digital elevation model (DEM) to facilitate rapid interpretation of water levels in terms of flooded areas and depths;
- more versatile representation of flood control structures;
- enhanced graphics and more user friendly "front-end"; and
- the capability to be used off-line to determine flood management strategies and on-line to assist flood forecasting.

Users of FMM outputs are expected to include planners and designers of water sector schemes and other infrastructure developments that have an impact on flooding and drainage conditions; operators of such schemes in general and of compartments in particular; flood forecasting authorities; and universities.

The FMM includes modifications to the basic capabilities of MIKE 11 software and has software to link MIKE 11 to digital elevation modeling. The FAP 25 FMM study is scheduled to run between June 1992 and June 1994. During this period, in addition to the general modification of MIKE 11 and linkage to DEM, the FMM will be developed for priority projects, including the development and use of a detailed FMM at compartment level (Tangail); development of a detailed FMM at regional level (NC region); and development of a simple FMM at national level (GM) for flood forecasting.

**GIS Interfacing**

Geographic Information System (GIS, FAP 19) is conducting a pilot study to develop methods of interfacing with the hydrologic/hydraulic models. The primary collaborators on the GIS pilot study are FAP 25 (Flood Modelling) and FAP 10 (Flood Forecasting). Regional studies and FAP 20 (Compartmentalization Pilot Project) are also collaborators. These projects, under the coordination of FAP 25, are working with the SWSMP to develop MIKE 11 applications for the FAP.

GIS can assist modelling efforts in two general areas: new or more detailed data for estimating model input parameters, and spatial representation of model results. The latter will be of the most use to planners and during the conduct of an EIA. The output of models are volume and water elevations at river cross sections and flooded areas. However, there is an immediate need to convert these data into a water level surface that could represent the extent of flood in a map form. The GIS pilot study on digital elevation models (DEM) and spatial interfacing with output from the SWMC models will develop this capability.

Initially, FAP 19 will produce a pilot DEM for the Tangail, NC region and General Model, which will be used in the FMM study described above. Later, DEMs should be produced for all regions. Other important uses of GIS as a mapping and analytical tool for EIA studies should also be developed. For example, the possible linkage/superimposing of MIKE 11 inundation maps with GIS comprising different overlays with information on cropping pattern, cropping values, infrastructure, etc.

**WARPO (MPO)**

During the NWP Phases I and II, WARPO, formerly MPO, developed a number of models to assist macro planning efforts. WARPO's computer

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modelling capability is described in a supporting document (MPO 1991) to the 1991 National Water Plan Report (MPO 1991). Of interest to surface water studies is MPO's capability to analyze surface water availability using its Water Balance Model, particularly for dry season flows.

A Water Balance Model was produced as a major component of the Water Balance Studies (UNDP) undertaken in the early 1980s. Originally covering only the north of the country, it was extended to cover the southwest under NWP Phase I. During NWP Phase II, it was upgraded by transferring it onto a fast microcomputer, making it menu-driven and user-friendly, and upgrading the database to 1989. The production runs performed by the model are now 25 years. The Water Balance Model covers four regions and comprises the catchment that is common to the entire country and a river network model specific to each region, although structured in the same way.

The principle inputs to the model are rainfall, potential evapotranspiration, cropping and water use. Observed groundwater levels are used in the first phase calibration process, as there are seldom adequate streamflow records to define locally generated runoff for individual catchments. The overall model is applied regionally and there is no interdependence between regions since they are effectively separated by the international rivers that form the model boundaries. The production run model, which is the planning tool, produces information on individual catchment water balances, simulated catchment groundwater levels and simulated streamflows throughout the modelled network.

WARPO's Water Balance Model, and the information generated from the model for the updated 1990 National Water Plan, may be of particular use in project analysis of surface water available for development. This would be particularly true where existing data is sparse or nonexistent. MPO used the Water Balance Model to assess the availability of surface water for irrigation development in each of the NWP planning areas.

#### 8.2.5.2 Streamflow

Measured streamflow or river discharge records are the primary source of data for analyzing historical streamflow patterns. The location of all gauging stations in and around the project area should be identified and the records collected for analysis. Stations with a long period of record are the most desirable. Data from stations with less than 10 years of records are normally discarded from further analysis. Before using the records of the retained stations the data should be subjected to testing, using standard methods, to determine their reliability and consistency. Attempts also should be made to make station records complete by filling in missing data with estimates using accepted hydrologic techniques. This requires the use of concurrent, long-term data from nearby stations and a considerable amount of judgement.

Generally speaking, the network of gauging stations in Bangladesh (79 in 1990) is adequate for determining available streamflows for macroscale studies (national and regional plans) but is inadequate for microscale studies, including feasibility studies. Where data are inadequate, hydrologists have to resort to estimating streamflow using rainfall-runoff relationships derived for the area. Parameters used to estimate streamflow include: precipitation, periodic measured discharge, groundwater levels, land elevations, water use, etc. The relationship between these parameters can be complex and often requires a mathematical model to simulate. Examples are the SWMC models and WARPO's Water Balance Model discussed in the previous sections. Project studies may make use of these models, where possible, to estimate streamflows.

Streamflow estimates, over the period of record, are analyzed to determine maximum, minimum and mean discharges. They are also subjected to frequency analysis to determine probability of occurrence. For example, the 80-percent dependable flow (equaled or exceeded in four out of five years), which is used to determine the size of an area that can be irrigated, is calculated this way.

The analyses are made on monthly or daily records. Generally, monthly streamflow data are adequate for planning studies while daily records are needed for more detailed design analyses. Results of all analyses undertaken should be presented and discussed in the report.

The critical planning period for development and use of available streamflow is the dry season. During this period (February, March and April), surface water availability throughout Bangladesh is lowest and the potential exists for conflict between multiple users of a limited resource. The February-April average flow is a measure of dry season streamflow. The five-year, one-month low flow (80 percent dependable) is a measure of the streamflow during critical drought conditions. The February-April period is the lowest flow period for all regions except the northwestern region, for which the January-March period is the lowest flow period for over 50 percent of that region.

Analysis of streamflow records, streamflow estimates, and estimates of water available for development must take account of present surface water abstractions. These include diversions and pumping for irrigation and other uses. Extraction data are needed over several years to show trends and growth and throughout the year to show seasonal variations. Extraction data are generally not available and other parameters are used to estimate extractions. These include irrigated area, number and sizes of pumps, hours of pump operation, surface area and volume of standing surface water, etc. Data sources include BBS, agricultural sector censuses of small-scale minor irrigation equipment and MPO. Assessing the available data to determine extractions can be difficult. For example, in a catchment area or thana, the number of pumps may be enumerated but there is no data on the sources of water from which they pump, whether flowing streams or ponds. Reports of irrigated area are difficult to correlate with reports of the number of pumping units, etc. Thus, estimates of surface water abstractions will most often require field verification.

#### 8.2.5.3 Static Water Bodies

Existing data on standing water bodies is sparse, but since they are an important surface water resource, they need to be accounted for in project assessments. These water bodies not only are used as an irrigation source but also as a fish habitat and for fish culture. Though they may be small, they can also serve as a source of water in the dry season.

Where standing water bodies are deemed important, project assessments need to determine the volume of the water that is available for use. Standing water body areas may be determined from map studies such as those done by SPARRSO and MPO. Before the water volume can be estimated, however, the depth of the water body must be determined. Since few data are available, field measurements of depths need to be made where warranted and the water levels of important bodies monitored over a period of time. In lieu of this, information on these bodies may be gathered with a rapid rural appraisal. Data gathered by the RRA should allow for a realistic estimate of available depths and usable volume.

#### 8.2.5.4 Instream Storage Potential

During the dry season, water is taken from many sources including wells, *beels*, *haors*, ponds and small streams. In order to help meet water demand, water can be stored in the drainage channels, *khals* and small rivers near the end of the wet season by means of volume control structures such as regulators, dams and weirs. The volume of water that can be stored at bankfull stage in the aforementioned areas may be defined as instream storage potential or artificial static water. The instream storage may be a significant source for winter irrigation, fishery production and other purposes if its development is economical.

In order to estimate instream storage potential, instream cross-sectional data and the length of the channel would be required. These data can only be obtained through detailed field surveys. A less accurate method would be to estimate the surface area and instream depth of the channels. Surface areas can be determined from large aerial photographs, such as those available from SPARRSO, or by using field-measured river width and length data. Estimates of instream storage depth can only be determined in the field. RRAs could be used to get a representative indication of depths for use in estimating potential in conjunction with surface area.

### 8.2.5.5 Floods

The planning and design of water projects requires careful analysis of flooding and the environmental impacts of interventions. Flood analysis consists of assessing past or historical flooding and determining design flood levels for which protection is to be provided. It also comprises hydraulic analysis of flooding and of flood levels and flood depths "before" and "after" the proposed intervention. This should include not only the impacts within the project area but also upstream and downstream of the area, where higher water levels, reduced streamflows, sedimentation, etc., can also cause problems. The hydraulic analysis of interventions normally requires the use of hydraulic models such as those being developed for use in FAP studies. The models can be used to predict the extent of any upstream and downstream impacts, such as changed water levels due to embanking a reach of a river.

#### Flooding

This section of the EIA report should present an analysis and description of historical flooding in the area. This would consist of a description of major flood events, peak discharges and water levels, and the extent of flooded area, including quantified estimates of damaged resources such as infrastructure, households, livestock, etc. The report should also include a general description of flooding under normal conditions. Sources of flooding and a list of areas prone to flooding, occurrence of flash floods, drainage problems, etc. should be identified. In general, the section should present a complete description of the existing hydrologic/hydraulic problems in the study area. Extensive use should be made of tables, figures and maps to present the information in a concise format.

#### Flood Discharge

Records of gauging stations recording discharge and water levels should be collected for review and analysis. Stations with less than 10 years of data (the minimum requirement for reliable determination of floods having recurrence intervals of 20 years or less) normally are excluded from analysis. A frequency analysis of annual and maximum daily discharges should be made to determine flood peak discharges for various recurrence intervals. The main objective of flood discharge frequency analyses is to provide a criterion for design flow determination for flood protection facilities, drainage works and other water control structures. Standard methods such as Log Pearson Type III are used in the frequency analysis. Results are normally plotted on log probability paper to check the reasonableness of the frequency curves.

#### Flood Level and Depth

The primary purpose of flood level and depth analyses is to provide basic input for engineering studies that are used for economical design of levees, identification of flood protection needs, and investigation of the requirements for drainage and other water management and control facilities. The planning analyses should produce flood depth maps that can be used to determine the amount of land that can be developed or improved by different project types. The maps also are useful to agronomic studies, for which they can be used to develop the damage functions due to flooding.

The analysis of station water levels is similar to the analysis of flood discharges. Frequency analyses are made of maximum average daily water levels to determine the flood levels for different recurrence intervals. For streams with well defined stage discharge rating curves, flood level frequency can be determined best by transforming the discharge frequency to stage frequency by means of the rating curves. However, determination of reliable rating curves requires considerable judgement. Moreover, when the rating curves are extended for discharges higher than the measurement ranges, the error in resulting flood stage may be large. For these reasons, unless the rating curve can be proved to be reliable, flood level frequencies are determined directly from water level data. In addition to maximum one-day levels, flood levels of 10-day duration are often required for planning and design analysis.

Water level in the tidal area of Bangladesh is subject to storm surge, which causes heavy damage crops and properties and can take many human lives. These surges are normally wind-generated and require special analysis to estimate. Empirical relationships between wind speed and surge height need to be derived. MPO has made analyses of the effects of storm surge on water level based on the BMD data (MPO 1987).

Flood depth maps for water levels of different recurrence intervals should be prepared based on the frequency analyses. Using water level data, isolines for water levels are drawn on maps. The flood depths can be determined by subtracting ground levels from the corresponding water levels. Finally, the flood depth maps can be constructed by drawing depth isolines. The generation of water levels needed to prepare flood depth maps is best done using the SWMC models, if available. Correspondingly, the GIS, DEM model can produce the most accurate flood depth maps. When these tools are not available, manual methods will need to be employed.

#### 8.2.5.6 Hydraulic Analysis

In general, the planning and designing of flood control measures require that defense levels be set to prevent inundation for a specified flow condition. Hydraulic models are used to determine pre- and post-project water levels and flood depths, as well as impacts of the intervention both inside and outside the project area. Many runs of the models normally are required to analyze and compare various alternatives to determine the optimum project configuration.

The types of hydraulic analyses conducted must be clearly stated and presented in the report. Comparisons between alternatives should be presented and discussed, ending with a recommended alternative. The results of the hydraulic analyses must show the "without" and "with" project conditions as well as impacts in other areas. These data are needed by other members of the study team to determine costs, benefits and economic viability.

#### 8.2.5.7 Drainage

Storm depth-duration frequency analyses are needed for the planning and designing of drainage structures and facilities. These types of studies also provide data for agronomic analyses including determination of drainage requirements for various crops. Analysis of rainfall events form the bases for the studies. Rainfall data analysis techniques are discussed in Section 8.1.5.1.

Storm depth-duration frequency analyses are normally made of annual maximum rainfalls of a fixed duration (2, 5 and 10 days are common) to determine storms of recurrence intervals of 2.33 (annual), 5, 10 and 20 years. The duration and frequency to be used for design varies with the importance of the structure and the area being protected. Criteria for the drainage requirements should be given in the project design criteria. For example, in the Greater Dhaka Protection Project (FAP 8A) a two-day-five-year storm was recommended for the design of pump drainage structures, while design of drainage pipes and culverts are based on rainfall intensity of several hours' duration.

Another important parameter in the design of drainage systems and structures is the tailwater condition at the outlet. Tailwater levels can best be determined from the output of hydraulic models. The drainage system and structures must be able to perform over a wide range of tailwater levels. Thus, their performance may need testing over complete flood seasons of known severity.

Storm depth-duration maps can be prepared from water level data in much the same manner as flood depth maps. These are isohyetal maps for a given storm frequency and duration. They may be used in determining the area benefitted by improved drainage.

#### 8.2.5.8 Morphology

Sedimentation and erosion processes (or sediment transport) in alluvial rivers are controlled by many variables including discharge (or velocity), depth of flow, sediment particle size, water temperature, etc. Change in river discharge, either by diversion or augmentation, will cause change in the river sedimentation and erosion pattern, and this, in turn, will cause change in river geometry including the flow depth. Change in river geometry will affect inland navigation and river salinity, which are highly dependent on river cross sections and flow.

Several methods may be used to assess the morphological implications of project proposals. These range from desk studies to more detailed studies that may involve using a morphological computer model. Desk studies are appropriate for the early stages of project appraisal. These might involve sediment transport and regime theory calculations and would screen proposals for the likely magnitude of their impact on morphology. Subsequently, the most promising proposals should be subjected to more detailed study to determine the impact of any long-term morphological change.

For water management studies, morphological modelling capability is to be included in the SWMC modelling program. The current MIKE 11-ST sediment transport model is not suitable for long-term morphological studies when used in conjunction with the event-based MIKE 11-HD hydrodynamic module. This is because the computational requirements of modelling 20 or more years' flow are prohibitive. However, Danish Hydraulics Institute intends to add a long-term morphological model to the MIKE 11 system in the near future. If this model is available, it should be used in the morphological studies. If it is not available, consultants may need to resort to other models if they can be shown to apply to the Bangladesh river regime.

### 8.2.6 Impact Analysis

Any project has impacts—either positive or negative—on the surface water environment. Projects may directly or indirectly affect:

- surface water availability (water quantity),
- flooded area,
- drainage conditions,
- groundwater recharge,
- river and channel morphology, or
- water quality.

The above list is neither exhaustive nor complete, but it is indicative. Those conducting the surface water hydrologic/hydraulic analyses will need to identify all potential impacts (Table 8.6). The impact analysis is based on a comparison of future "without" and "with" project conditions. As far as possible, the impacts need to be quantified for use in benefit-cost analyses. The impact analysis also must not be limited to just the project area, it must assess the impacts of the project on upstream and downstream areas as well.

### 8.2.7 Mitigation

Mitigation is the elimination, reduction or control of the adverse environmental impacts of a project. Mitigation strategies involve either making alterations to the project design or offering compensation. Compensation may be made in many forms, among them: restoration of damaged resources, money to affected persons, concessions on other issues, or off-site programs to enhance some other aspect of the environment or quality of life for the community. All mitigation measures cost something, and this must be quantified, too. A mitigation strategy would involve comparing various measures, weighing trade-offs between alternative measures, and the EIA study team proposing one or more actions, usually combining a number of measures. Table 8.6 lists potential negative impacts of development related to surface water

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## Table 8.6 Potentially Negative Surface Water Impacts and Mitigating Measures

| Project Component or Action | Effects | Mitigating Measures |
|---|---|---|
| Channelization/ embankments | Reduction of river cross section increasing severity of flooding upstream due to back-water effects.<br>Bed and bank erosion.<br>Downstream flooding and sedimentation. | Careful selection of engineering options at planning stage, limitation of degree of channel modification or maintenance, mitigating measures after construction stage. Planning of embankment locations to maintain floodplain cross section. |
| Embankment | Interruption of hydrologic continuity between river and *haors/khals*. | Mitigation difficult; some compensation through improved road travel. |
| Embankment | Wet season reduced surface water inflow causing reduced aquatic habitat. | Controlled inflows.<br>Enhancement and regulation of remaining open water fishery.<br>Aquaculture development. |
| Embankment and/or drainage | Drainage congestion during wet season high river water levels. | Pumped drainage.<br>Compartmentalization and controlled flooding. Change in land use of perennially flooded area. |
| | Induced waterlogging of agricultural land as tidal rivers silt up after embanking. | Dredging of silted waterways.<br>Improved surface and/or subsurface drainage. |
| Embankment and/or drainage | Reduction of shallow flooded area with reduction in residual soil moisture and resultant decrease in dry season crop production. | Dry season irrigation in areas of reduced flooding. |
| Drainage | Dry season reduction in residual surface water in *beels*, *haors* and *khals* leading to reduced aquatic habitat. | Controlled drainage.<br>Aquaculture development.<br>Dedication of groundwater to fish ponds. |
| Irrigation by LLPs | Reduced water in source river or *khal* causing reduced channel depth and increased sedimentation affecting fish habitat or hindering navigation. | Controlled volume of pumping.<br>Aquaculture development.<br>Increased channel maintenance by dredging. |
| Irrigation by surface canals | Waterlogging of soils through canal seepage. | Canal design, impermeable materials, lining, lowering canal. |
| | Soil salinization. | Freshwater flushing of soil.<br>Improved drainage. |

resources and possible mitigation measures. The table is indicative of the types of impacts that could occur. Impacts and mitigating measures for specific project studies need to be identified and evaluated by the EIA study teams.

Heavy rainfall in the monsoon season can cause flooding when drainage is impeded—drainage already is naturally impeded by the high river levels in the monsoon. Embankments tend to exacerbate this problem as shown in the various review studies of existing projects. Pump drainage, a mitigating measure that has been advocated in the past, is very expensive and may not be economic. A new measure, being tested under the FAP pilot studies, is the concept of controlled flooding. In this approach, sections of land (compartments) adjoining a river are embanked on all sides, with the section of embankment facing the river being provided with structures necessary to ensure control over inflow and outflow of water, and thereby level of flooding within the compartment. Controlled flooding may well provide mitigation for other common negative impacts often associated with embankments such as waterlogging, fish movements, sedimentation, scouring, etc.

#### 8.2.8 Monitoring

A plan to monitor the environmental effects of the project should be developed. The monitoring program is designed to detect, through regular data collection and evaluation, impacts on the environment due to project activities. Decisions on which factors to include in the plan should take account of the relative importance of and ability to collect the data, and need to be made on a project-by-project basis. Only the most important variables should be monitored, as time, personnel and funds of the monitoring agency are normally limited.

Factors that normally should be monitored on at least a seasonal basis include: stream discharge, seasonal water levels, changes in drainage, sediment content of river water, sedimentation and erosion problems in downstream areas and changes in the river course and river bed. These are the most important hydrological indicators of the impact of an intervention on the surface water resource.

Stream discharge, water levels and sediment content are already being measured as part of Bangladesh's hydrological network, but it may be necessary to establish a few new measuring stations. Other factors such as sediment and erosion problems, inside or outside the project area, can be monitored by conducting annual field inspections of the area and facilities. This might be considered part of a normal annual inspection and maintenance program.

### 8.3 Groundwater

#### 8.3.1 Baseline Studies

The groundwater section of the water resources assessment should present a qualitative and quantitative description of the groundwater resource. This includes groundwater potential, present use, and volume available for future development.

Baseline data and/or studies should provide the following information.

- The general pattern of present groundwater development by mode, i.e., hand tubewell (HTW), shallow tubewell (STW), deep-set shallow tubewell (DSSTW) and deep tubewell (DTW).
- Present use by mode, including abstraction volumes, area served (irrigated), population served, industrial use, etc.
- Groundwater levels.
- Potential recharge.
- Constraints to development.
- Usable recharge by mode.
- Future development potential by mode.

Project planners use these data to assess the resource potential and pre-project conditions. They are also needed to analyze development potential by mode and potential project impacts, such as the effect of DTW development on village hand tubewells or the effect of an intervention on groundwater recharge.

### 8.3.2 Existing Data Sources

As Table 8.4 shows, there are four agencies in Bangladesh that collect primary data on groundwater: BWDB, BADC, DPHE and the WASAs (Dhaka and Chittagong). They collect data on the groundwater table, aquifer tests and drilling tests.

#### 8.3.2.1 Groundwater Levels

The Groundwater Circles (GWC) of the BWDB are responsible for collecting and analyzing a major portion of the available data on groundwater. The BWDB maintains about 1,250 groundwater observation wells. Twenty were reported to have water level recorders in 1989, but only five were in operating condition. Weekly observations are made in the wells and the data are entered into BWDB computers. Records can be obtained on floppy disk from BWDB.

The DPHE is mainly interested in potable water. It monitors water levels in selected wells in each union two to three times a week. It collects the data and prepares a yearly inventory of conditions, especially water level variations.

The BADC installs most of the deep tubewells used for irrigation. In addition, it monitors groundwater levels in approximately 10 thanas every month, the chief concern being water quality. Data from this monitoring program has not been published since 1983.

A list of BWDB, BADC and DPHE groundwater observation stations is in Appendix 2 along with maps showing the location of the stations and examples of station records. The list indicates the period of record of each station as well as the frequency and units of measurement.

The WASAs supply domestic water and monitor groundwater levels in the Dhaka and Chittagong areas. They also predict water levels for different time periods and with different growth patterns.

#### 8.3.2.2 Aquifer Tests

The BWDB has conducted more than 200 well tests at production wells installed by the BADC. The wells are pumped at a constant discharge for 72 to 96 hours, and water levels are observed both during pumping and during recovery. Some step pumping tests have also been performed. The collected data are then processed and the aquifer characteristics of transmissibility and specific yield determined.

#### 8.3.2.3 Well Logs and Boring Data

The BWDB records the logs of its wells and has more than 400 wells on file. Above 500 feet, the materials are sampled with a split spoon sampler. Below 500 feet, the wash material is examined and logged. The sample material is analyzed in the laboratory. The BWDB has also undertaken an investigation of the potential of shallow tubewells by sinking a few wells and evaluating their performance.

BADC and DPHE also maintain well logs in some districts. A list of data stations for each agency, their locations, and sample logs are also available.

#### 8.3.2.4 Groundwater Recharge

An assessment of the development potential of groundwater resources depends on an accurate determination of groundwater recharge. Recharge is the replenishment of groundwater storage that has been reduced by groundwater discharge. Future groundwater potential is the difference between recharge and present groundwater consumption. In Bangladesh, recharge occurs primarily through infiltration and percolation from relatively large amounts of rainfall and flood water. Additionally, during periods of high stream stages, streams discharge into the shallow groundwater reservoir—providing there is storage space. Low topographic relief and extensive flooding, along with large areas of relatively pervious soils and permeable underlying sediments, are all conducive to high recharge rates. Direct infiltration is demonstrated by the rapid recovery of groundwater levels at the outset of the monsoon season. The dominant component of groundwater movement in Bangladesh is vertical.

During the dry season, a certain amount of groundwater discharges horizontally into streams and contributes to the base flow, while vertical flow reverses, and water moves upward to meet evaporation and transpiration requirements at the surface. This upward movement is enhanced by the high capillarity of surface clays and silts.

Essentially all annual replenishment of the groundwater resources occurs during the annual monsoon season, which begins in June and ends in October. Study of groundwater level hydrographs show that, generally, early May rainfall satisfies the soil moisture requirements and recharge only commences in late May or early June. Since recharge stores excess monsoon surface water it is the most efficient and significant means of conserving and transferring water between seasons.

Observation wells record the fluctuation in groundwater levels over a period of time. Thus, they indicate the historical rate of annual withdrawal and recharge. These records can be used to estimate the status quo or present conditions; they do not indicate the future or maximum recharge potential.

Recharge functions are a measure of how much groundwater can be abstracted from an aquifer system on a "safe yield" basis; safe yield is defined as the abstraction that can be sustained in the long term (theoretically ad infinitum) without major deleterious effects. Unfortunately, it is difficult to accurately estimate recharge (and consequently safe yield) because the necessary calculations involve generalizations, imponderables and coarse assumptions. Moreover, recharge is a dynamic concept that can be strongly affected by changes in annual rainfall, land use patterns, and most important, by aquifer management; particularly the level and pattern of groundwater abstractions.

### 8.3.3 Primary Data Collection

Primary data collection for groundwater analyses should be done as part of the baseline studies. Primary sources of data are those described in the previous section. The length of the feasibility cum EIA studies would determine how much and what types of additional primary data could be collected. Unless groundwater is a major project component, the program can be expected to be limited.

Primary data collection for the EIA study probably would be limited to conducting field surveys to supplement and/or verify existing information. The most important would pertain to present use of groundwater by modes of development.

Field surveys to supplement existing information can be made by conducting a rapid rural appraisal (RRA) of the study area. For example, data are available (from AST, BBS, and others) on the numbers and types of wells (STWs, DTWs, MOSTIs, etc.) using the groundwater resource, the uses of each type (domestic, industrial, agriculture), and estimated volumes by well types. No information currently is available to indicate types of user dependency (casual use, required use, etc.), relationship of use to the hydrologic cycle or the availability of alternative water resources. This type of information, called for in the EIA Guidelines, can only be obtained by conducting an RRA. The RRA should be done in several representative traverses, determined during scoping sessions. It would make use of a questionnaire designed to obtain the information through interviews.

There were instances in MPO's National Water Plan (NWP) assessment where estimates of present use exceeded estimated available recharge to the technology (well type). This could mean that the aquifer is under stress or that one or both of the estimates needs revision. The RRA could determine if there are any groundwater shortages, particularly in the critical dry season months. The RRA could also assess whether there are any conflicts between modes or whether there is any evidence of groundwater pollution.

The EIA Guidelines call for analyzing apparent trends in groundwater exploitation and examining the linkages to these changes, particularly in respect of socioeconomic factors. Most of this will be accomplished through examination and interpretation of data in hand. However, the RRA questionnaire can be designed to ask questions that may give some insight. For example, farmers could be asked about what is happening. Have DTWs replaced STWs? If so, why? Have dry season surface water flows changed? Is there any evidence of salt water intrusion, etc.? Responses to these questions can help in interpreting data.

#### 8.3.4 Maps and Mapping

The EIA report requires maps showing locations of data stations and illustrating results of analyses. Map sizes should be standardized throughout the report. The same base map used for surface water illustrations can be used for groundwater. Types of information that can be shown include locations of observation and test wells; distribution of HTWs, STWs, DTWs; areal distribution of percentage change in minor irrigation equipment over a specific period (e.g., growth in STWs); and any other graphics that serve to illustrate present or future project conditions.

#### 8.3.5 Data Analysis

The data collected from all sources will need to be analyzed and presented in formats suitable for presentation in the EIA report. The EIA Guidelines outline the type of groundwater information that needs to be presented. The following paragraphs present a description of how to prepare and present the required information.

##### 8.3.5.1 Quantity and Quality

The quantity and quality of the groundwater resource need to be described in both a local and a regional context. The report should note the aquifer conditions and any evidence of overuse (withdrawals exceeding recharge) or pollution.

The report should comment on groundwater quality and any evidence of groundwater pollution in the study area. An analysis of groundwater quality sampling sites in or adjacent to the study area plus information gathered by RRA will provide the basis for these comments. In general, groundwater quality in Bangladesh has been found to be quite good in terms of overall mineralization, except in the southeastern and southwestern regions where the rivers are tidal and the land almost at sea level. No significant groundwater pollution has been identified so far in Bangladesh, but this may well be because no relevant surveys and analyses have been done.

##### 8.3.5.2 Recharge

The report should describe groundwater recharge patterns in the area and their relationship to seasonal rainfall, river discharges and flooding. A study of groundwater observation wells in or adjacent to the study area will provide the information required for this part of the report. The data being analyzed should be recent, that is, it needs to reflect patterns corresponding to the current use of the groundwater resource. Data more than a few years old give no real indication of what is happening at present. For future development, MPO has made estimates of groundwater depletion for various levels of development. Data on seasonal groundwater depletion and recharge can best be presented graphically in the report in the form of a hydrograph covering the entire cycle.

##### 8.3.5.3 Present Use

The report should include an assessment of the present use of the groundwater resource in the study area. This is needed to determine the potential for future development as well as potential impacts of water sector developments on the resource. Data and methods available to make an assessment of present use have been discussed in detail in Sections 8.3.2 and 8.3.3.

Specifically, the report should try to quantify the numbers and types of groundwater users in the study area. Tables should be developed to show the types of wells, their number and use, the area or number of people served, and estimated annual abstraction volume. The report should use information from the RRA to indicate, as far as possible, the relationship of use to the hydrologic cycle, i.e., is the use year-round or seasonal? The report should also note the dependency of the users on groundwater and whether alternative water sources

Table 8.7 Changes in Irrigated Area, 1985-1990

| Mode | Area in 1985 ('000 ha) | Area in 1990 ('000 ha) | Net change (%) | Percent of total net change |
|---|---|---|---|---|
| LLP | 600 | 639 | +39 | +5.6 |
| STW, DSSTW, MOSTI | 481 | 889 | +408 | +58.4 |
| DTW | 288 | 542 | +254 | +36.3 |
| Major | 123 | 186 | +63 | +9.0 |
| Traditional | 432 | 367 | -65 | -9.3 |
| Total | 1,924 | 2 623 | +699 | 100.0 |

Source: MPO, Phase I and Phase II

are available to them. For example, many rural areas are dependent on HTWs as their only source of potable water.

#### 8.3.5.4 Development Trends

There has been a significant increase in the use the of groundwater for irrigated agriculture through the development of minor irrigation equipment. In particular, there has been a large increase in the use of STWs since the privatization policy came into effect. The EIA report should present an analysis of apparent trends in groundwater exploitation in the study area during the past 10 to 20 years and possible future trends. Where possible, the report should indicate changes due to:

- HYV agriculture and increasing use of STW and DTW irrigation,
- previous water schemes,
- changes in river discharges,
- reductions in dry season surface water flows,
- increasing urban in-migration from rural areas shifting the geographic locus of groundwater demand, and
- salt water intrusions.

The report should also attempt to examine the linkages to changes particularly in respect of socioeconomic factors such as:

- drinking water and public health,
- agriculture,
- industrial water use,
- replacement of STWs by DTWs,
- effects on local and/or regional economies, and
- avoidance of contaminated groundwater supplies.

Trends in groundwater exploitation can be determined by examining and interpreting relevant data over a period of time. A good source would be development that has taken place over Bangladesh's five-year plan periods (one through four). Table 8.7 shows an example of an analysis of recent trends in irrigated agriculture.

Reasons for changes can not readily be determined from analysis of existing data, but an RRA may be able to provide enough information to draw conclusions. Similarly, determining linkages to changes with socioeconomic factors will be difficult and requires obtaining information through a well designed RRA.

#### 8.3.5.5 Groundwater Modelling

The only significant assessment of the groundwater resource using a mathematical model has been the work conducted by MPO from 1983 to 1991. MPO's groundwater model is not a single model but a suite of related models consisting of four major programs.

*Recharge Model*—consists of a main program and associated subroutines to compute potential recharge for individual thanas for hydrological years 1972/73 to 1988/89. The model is an adaptation of one developed during NWP Phase I, which was made operational again in September 1989. The old model is still operational and can be used to assess, in detail, the mechanism of potential recharge for individual years. A full description of this model and its usage is in a manual prepared in September 1990. The adapted model allows for rapid simulation of potential recharge. The computation of potential recharge for one thana for the 17-year simulation period takes only about 25 seconds.

*Depth/Storage Model*—used to compute the net available storage in the aquifer system available for groundwater abstraction. This model is an adaptation of one used during the NWP Phase I. The methodology has been slightly modified and a range of specific yield values rather than single values are used in the simulation.

*Resource Assessment Model*—used to combine results obtained from the recharge model and the depth/storage model and to compute groundwater resource development potential for different flood phases and modes of pumping.

*Multi-Cell Model*—used for the detailed analysis of groundwater behavior in the MPO special study areas. It can also be used in a single cell mode for individual thanas. The main purpose of the model is to obtain a better definition of the parameters that most strongly affect the computation of potential recharge and the net available storage. It also allows checking the results of thana studies when some groundwater records are available.

The processed output of the family of groundwater models includes several tabulations and diagrams, specifying:

- depth/storage capacity of the subsoil to a depth of 22 m,
- usable recharge with $\pm 20$ percent confidence limits,
- development potential for STWs and DSSTWs (14 l/s discharge) and DTWs (28 and 57 l/s discharges) for land elevations expressed as flooding phases,
- estimates of abstractions that might affect village hand pumps, and
- a diagram entitled "Groundwater Potential" summarizing the usable recharge and the development potential by different pump technologies.

The tables of model output are numerous and complex. The tables for the resource potential model present matrices of estimates of development potential limits for a given pumping mode over a thana. One table is required for each pumping mode. A graphical presentation (diagram) was developed to summarize the tables.

There are several points that need to be made about MPO's groundwater model and its estimates of recharge and development potentials. First, they assume an idealized case without any physical constraints. Second, they have been used for a country-wide treatment of development potential, but despite the apparently detailed output of the models, detailed calibration was done only for a few representative sample areas. This was adequate for the NWP, which needed to establish general planning criteria rather than define exact safe-yield limits. The existing models can be used at more detailed levels, but only if they are recalibrated for specific local conditions. Future detailed uses of the model probably will be applied to areas smaller than a thana, and for such uses feedback from field-level monitoring will be essential to recalibrate and reassess resource potentials.

Similar words of caution should be given about the estimates of the development potential for different pump technologies. The basic assumptions of the modelling exercise are: (1) that the groundwater table is flat and horizontal with only the cones of depression of individual wells superimposed, and (2) that there are no lateral transfers of groundwater from one area to another. These assumptions provide a valid generalization for broad planning guidelines, but are manifestly untrue in detail for cases of wells near surface water bodies and uneven development of adjacent areas. The avail-

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Table 8.8 **Potential Negative Impacts on Groundwater and Possible Mitigation Measures**

| Project Component or Action | Effects | Mitigating Measures |
|---|---|---|
| Embankments | Reduction of groundwater recharge. | Careful geohydrology studies. Monitoring of groundwater abstraction and recharge. Limit abstraction to safe yield. |
| Irrigation: STWs & DTWs | Dry season: lowering of groundwater level resulting in loss of water for village hand pumps. | Provision of tara pump. Provision of village shallow or deep tubewell for domestic water. Cooperative development of STW and DTW for combined domestic and irrigation use. |
| Irrigation: DTWs | Dry season: extreme lowering of groundwater level and loss of water for STWs. | Regional planning and monitoring. Control of placement of STWs and DTWs. |
| Irrigation: STWs & DTWs | Dry season: in coastal areas abstraction of groundwater may draw in saline groundwater. | Careful geohydrology studies and control of total groundwater abstraction. |
| Irrigation: STWs & DTWs | Overpumping of groundwater. | Continued monitoring and evaluation of the groundwater resource. Limitation of withdrawal so that it does not exceed "safe yield" (recharge rate). |

able modelling technology can be used for the treatment of such detailed cases, but again, only with recalibration for local factors and when applied to areas smaller than thanas.

### 8.3.6 Impact Analysis

An impact analysis of water management projects on groundwater resources involves the same procedures as discussed in Section 8.2.6 for surface water resources. The analysis is based on a comparison of future "without" and "with" project conditions. As far as possible, the impacts need to be quantified for use in benefit-cost analyses. Common impacts on groundwater include increased extraction, depletion due to reduction in flood-related aquifer recharge and lowering of water tables by increased tubewell pumping for irrigation, surface pollutants reaching the groundwater, and various secondary social and economic effects.

### 8.3.7 Mitigation

Table 8.8 lists potential negative impacts of development related to groundwater resources and possible mitigation measures. The table is indicative of the types of impacts that could occur. Impacts and mitigating measures for specific project studies need to be identified and evaluated by the EIA study team.

In Bangladesh, concerns have been expressed that increased flood management will, by reducing groundwater recharge, lead to a damaging fall in the water table. Similar concerns have been voiced that extensive development of STWs and DTWs for irrigation will lead to overpumping of the aquifer. These concerns, though valid, are not supported by the estimates made by WARPO (NWP 1991) using conservative assumptions. These estimates suggest that annual recharge is quite sufficient to support development of irrigation.

However, drawdown of the aquifer has been noted in such areas as Rajshahi and Bogra. Therefore, groundwater monitoring programs are needed to ensure that there is no damaging reduction in recharge and/or continuing and damaging drawdown.

Increased tubewell irrigation by STWs and DTWs has been reported to have an effect on existing village hand pumps (HTWs), particularly at the end of the dry season, when the lowered water table can exceed the suction limits of the HTWs. Monitoring is needed to detect this problem, and where it occurs, mitigation will be required. The mitigation should not limit irrigation development but, rather, use improved pumping technologies and conjunctive use of facilities, etc., to improve water supplies.

#### 8.3.8 Monitoring

All recharge estimates, as pointed out in the preceding sections, are approximate and should be used as planning guidelines rather than absolute limits. As development proceeds and new data become available, groundwater development targets should be reviewed and revised. Most existing recharge estimates are conservative, and it is likely that in some areas of Bangladesh the present planning horizons can be exceeded while still remaining within the "safe yield" of the groundwater resource.

An essential component to the success of future groundwater development policy and more refined evaluation of the resource is a comprehensive system of groundwater monitoring. The monitoring programs of various agencies should be reviewed, complemented if necessary, and coordinated to give a full picture of groundwater abstractions, water table movements and groundwater quality changes. Sound development decisions in the future will require such a base.

The NWP Report (June 1991) indicates that there are many places where current abstractions are approaching or exceeding the indicated potential, and the groundwater resources in such areas should be showing signs of stress. Two early symptoms of such stress would be mass conversions of STWs into DSSTWs or suction-type tubewells going out of operation because of declining water levels.

EIA studies in areas where there are indications of stress or the potential for stress need to recommend a comprehensive hydrogeological monitoring program centering around heavy groundwater abstractions. The program should include more accurate monitoring of groundwater development in terms of numbers of operating units, groundwater levels, and actual abstraction characteristics. The monitoring program should be continuous, as the data is needed continually to refine estimates of recharge and potential for development, as well as to determine if limits are being reached. Groundwater levels need to be monitored over the monsoon and dry seasons, as they are now. The other data are needed primarily for the dry season and should be tied in or correlated with data on irrigated area and type of crops. Special field studies would be needed to collect these data.

## 8.4 Water Quality

#### 8.4.1 Baseline Studies

The water resources section of the EIA should include an assessment of water quality in the project area. This includes an evaluation of surface and groundwater quality and salinity conditions. Baseline data and/or studies should provide the following information.

- The major physical, chemical and biological properties of the surface water and indications of linkages inside and outside the area that affect the water quality characteristics.
- Water pollution problems in the area (if any), including the sources and types of pollutant and severity of the problem.
- Pollution assimilation capacities of the water bodies through dispersion and dilution.
- Human activities that may contribute to water pollution and measures (if any)

being taken to avoid pollution problems.

- Major water uses in the area that affect flow conditions in water bodies, including domestic water supply, irrigation, livestock, fisheries, village industries, wildlife and recreation.
- Water quality conditions over the past 10 to 20 years.
- Effects of seasonal flooding cycles on water salinity and/or soil salinity in the study area.
- Evidence of salinity changes due to human activities.
- Extent to which local resource uses have been adapted to changes in salinity.
- Water and/or soil salinity conditions over the past 10 to 20 years.

The water quality section of the EIA report should provide a qualitative and, as much as possible, quantitative description of the baseline information. Since existing data is quite limited, most of the necessary information will have to be acquired during the study through rapid rural appraisals (RRA) of the study area or, where necessary, detailed field investigations. The level of study determines the level of data detail required for analysis. Data acquired through RRAs should be sufficient for prefeasibility and regional studies. For feasibility studies, sampling and testing of water should be done in representative areas of the project. Detailed sampling and testing programs would be required only for a major project that may impact a large area or population center.

### 8.4.2 Existing Data Sources

Water quality data are used to assess the suitability of water for specified need such as potable water supply, agricultural irrigation or other uses. As Table 8.4 shows, there are only four agencies that collect data on water quality. They are DOE, DPHE, the WASAs and BWDB. DPHE and the WASAs are primarily concerned with potable water supplies and mostly monitor groundwater quality. BWDB monitors both surface water and groundwater quality, but its surface water monitoring is limited to salinity. DOE is concerned with all aspects of water quality monitoring. However, since the agency is newly initiated it has no well-established monitoring program.

#### 8.4.2.1 Surface Water Quality

There are very few data on surface water quality in Bangladesh. DPHE and the WASAs reportedly make some measurements of surface water quality, as Table 8.4 indicates. Since most rural water supplies come from groundwater, available data can be expected to be quite limited.

#### 8.4.2.2 Groundwater Quality

Several agencies collect groundwater quality data. The BWDB monitors 14 parameters, including conductivity, pH, total dissolved solids (TDS), Fe, dissolved oxygen (DO), Mg, etc. at about 117 stations. Samples are taken yearly and analyzed in the River Research Institute laboratory. Photocopies of the test results are readily obtainable. BADC, WASA and DPHE all monitor groundwater quality for different purposes.

#### 8.4.2.3 Salinity

Streamflow salinity has been measured by BWDB since 1965. The measurements are reported both as electrical conductivity, in $\mu$mhos, and chloride concentration, in milligrams per liter (mg/l). There have been three types of salinity measuring stations in Bangladesh: (1) monitoring stations, (2) static stations and (3) dynamic stations. All of these are located in the Southwest and South Central Regions. There are also extremely limited salinity data available from several industries in the Southeast Region.

At dynamic stations, water samples were taken from a moving boat along the river reaches. In the past, there were as many as 267 stations, but these stations have been discontinued since November 1980. At static stations, water samples are taken hourly at a single midstream vertical during a complete tidal cycle concurrent with tidal discharge measurements. In 1976-78, there were more than 40 stations, but since 1980 there have only been three.

Salinity is also measured at monitoring stations that take samples from the river bank at high and low flows from November through June. There were 80 such monitoring stations operating in 1988. Samples are taken every two weeks and sent to the laboratory, which measures the conductivity and chlorides in the samples. The laboratory processing of the samples is very slow, with delays ranging from 18 to 24 months. The data are kept by BWDB in non-computerized format. Photocopies of the data are furnished upon request to government-approved users.

#### 8.4.2.4 Standards and Testing

Analysis and characterization of water quality should always be done with regard to the anticipated use of that water. Thus, water to be used for human consumption is analyzed by a different set of standards than that for destined to be used irrigation or industrial processes. Basically, quality is measured in terms of the types and amounts of dissolved oxygen (DO), suspended chemicals and biological organisms present in the water. These water quality characteristics are measured using a standard set of tests such as those discussed in Section 8.4.3.

Water is used in Bangladesh for drinking, irrigation and industry, as well as for recreational and fishing purposes. Many countries have adopted standards of water quality for different uses. Several agencies have suggested standards for Bangladesh. Table 8.9 shows standards and limits for domestic, fishery and irrigation uses adopted by the Department of Environment (DOE) as of 1991. As indicated, some standards have not yet been finalized.

Prior to the creation of DOE, the MPO, during preparation of its National Water Plan, established tentative water quality standards for Bangladesh. They are not reproduced in this manual but can readily be found in Appendix E of MPO's Technical Report No. 20 (April 1987). MPO's tentative standards were based on the following water uses: (1) drinking water (2) recreational water and (3) fishing water. The standards for some of these uses were classified according to the characteristic of pollution including physical, chemical, bacteriological and toxic substances. Since very few independent studies of water quality have been made, studies and standards made elsewhere have been used as guidelines for the Bangladesh standards proposed by both DOE and MPO.

Eleven agencies in Bangladesh have the capability to perform water quality tests, among them:

- Department of Public Health Engineering (DPHE)
- Department of Environment (DOE)
- International Center for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)
- Bangladesh Agricultural University (BAU)

No standards have been developed for salinity levels in Bangladesh, particularly for irrigated agriculture. FAO's Irrigation and Drainage Paper 29 indicates that the threshold level for irrigation water is an electrical conductivity of 750 $\mu$mhos. It indicates that conductivity between 750 and 3,000 $\mu$mhos presents increasing problems for agriculture, while conductivity greater than 3,000 $\mu$mhos causes severe problems. Leedshill-DeLeeuw, in a 1968 office report on the Coastal Embankment Project Area, indicated that 2,000 $\mu$mhos of conductivity is the permissible limit for supplemental irrigation with only a slight reduction in yield of rice crops in the coastal region. MPO in its NWP studies adopted 2,000 $\mu$mhos as the threshold salinity level for determining fresh water requirements and defining existing salinity conditions.

### 8.4.3 Primary Data Collection

Section 8.4.1 describes the type of information and data that should be provided from baseline studies for the EIA report. These are the same as given in the EIA Guidelines. Most of the information indicated will not be readily available and will need to be obtained through a well-designed RRA. The RRA questionnaire, designed by the project economist, sociologist and water resources engineer, should ensure that as much of the quantitative and qualitative data as possible is obtained.

## Table 8.9 Standard Values for Water (DOE)

| Parameters/ Determinants | Unit | Drinking Water | Recre-ational Water | Fishing Water | Indus-trial Water | Irriga-tion Water | Live-stock Water | Coastal Water |
|---|---|---|---|---|---|---|---|---|
| Acidity | l | NYS | NYS | less than 20 | NYS | NYS | NYS | NYS |
| Alkalinity (total) | mg/l | NYS | NYS | 70-100 | NYS | NYS | NYS | NYS |
| Aluminum | mg/l | 0.2 | NYS | NYS | NYS | 1 | NYS | NYS |
| Ammonia ($NH_3$) | mg/l | 0.5 | 2 | 0.075 | NYS | 3 | NYS | NYS |
| Ammoniacal Nitrogen (as N) | mg/l | NYS | NYS | 1.2 | NYS | 15 | NYS | 60 |
| Arsenic | mg/l | 0.05 | 0.2 | NYS | NYS | 1 | 1 | 1 |
| Barium | mg/l | 0.5 | NYS | NYS | NYS | NYS | NYS | NYS |
| Benzene | mg/l | 0.01 | NYS | NYS | NYS | NYS | NYS | NYS |
| Bicarbonate | mg/l | NYS | NYS | NYS | NYS | NYS | 500 | NYS |
| B.O.D | mg/l | 0.2 | 3 | 6 | 10 | 10 | NYS | NYS |
| Boron | mg/l | 1 | NYS | NYS | NYS | NYS | NYS | NYS |
| Cadmium | mg/l | 0.005 | NYS | NYS | NYS | 0.01 | 0.5 | 0.3 |
| Calcium | mg/l | 75 | NYS | NYS | NYS | NYS | 700 | NYS |
| Carbon dioxide ($CO_2$) (dissolved) | mg/l | NYS | NYS | 6 | NYS | NYS | NYS | NYS |
| Chloride (as Cl) | mg/l | 150-600[1] | 600 | 600 | NYS | 600 | 2000 | NYS |
| Chlorinated alkanes | | | | | | | | |
| - Carbon tetrachlo-ride | mg/l | 0.01 | NYS | NYS | NYS | NYS | NYS | NYS |
| - 1.1 dichloroethy-lene | mg/l | 0.001 | NYS | NYS | NYS | NYS | NYS | NYS |
| - 1.2 dichloroethy-lene | mg/l | 0.03 | NYS | NYS | NYS | NYS | NYS | NYS |
| - Tetrachloroethylene | mg/l | 0.03 | NYS | NYS | NYS | NYS | NYS | NYS |
| - Trichloroethylene | mg/l | 0.09 | NYS | NYS | NYS | NYS | NYS | NYS |
| Chlorinated Phenols | | | | | | | | |
| - Pentachlorophenol | mg/l | 0.03 | NYS | NYS | NYS | NYS | NYS | NYS |
| 2.4.6 Trichlorophenol | mg/l | 0.03 | NYS | NYS | NYS | NYS | NYS | NYS |
| Chlorine (residual) | mg/l | 0.2 | 0.3 | <0.01 | NYS | NYS | NYS | 2 |
| Chloroform | mg/l | 0.09 | NYS | NYS | NYS | NYS | NYS | NYS |
| Chromium (hexava-lent) as $Cr_6$ | mg/l | 0.05 | 0.05 | NYS | 0.5 | NYS | NYS | NYS |
| Chromium (total) | mg/l | 0.05 | NYS | 0.05 | NYS | NYS | NYS | NYS |
| COD | mg/l | 4 | 4 | NYS | $3\text{-}10^2$ | NYS | NYS | 8 |

[1]For coastal area, 1000, and in extreme situation in coastal area, 1500.

## Table 8.9 Standard Values for Water (continued)

| Parameters/ Determinants | Unit | Drinking Water | Recre-ational Water | Fishing Water | Indus-trial Water | Irriga-tion Water | Live-stock Water | Coastal Water |
|---|---|---|---|---|---|---|---|---|
| Coliforms (fecal) | n/100 ml | 0 | NYS | NYS | NYS | 10 | NYS | NYS |
| Coliforms (total) | n/10 0ml | 2[3] | 200 | 5000 | NYS | 1000 | 100 | 1000 |
| Color | Hazen unit mg/l | 15 | Clear | Normal | Normal | Normal | Normal | Normel |
| Copper | mg/l | I | NYS | <0.4 | NYS | 0.2 | NYS | 0.3 |
| Cyanide (as CN) | mg/l | 0.1 | 0.1 | NYS | NYS | NYS | NYS | 0.2 |
| Detergents | mg/l | 0.2 | NYS | NYS | NYS | NYS | NYS | NYS |
| DO | mg/l | 6[2] | 4-5 | 4-6 | 5 | 5 | 4-6 | 6 |
| EC | μmhos/cm | | 500 | 800-1000 | NYS | 750 | NYS | NYS |
| Fluoride (as F) | mg/l | 1 | 1.5 | NYS | NYS | NYS | 4 | NYS |
| Formaldehyde | mg/l | NYS | NYS | NYS | NYS | NYS | NYS | NYS |
| Hardness (as $CaCo_3$) | mg/l | 200-500 | NYS | 80-120 | 250[4] | NYS | NYS | NYS |
| Hydrogen Sulfide ($H_2S$) | mg/l | | | | 1-5[5] | | | NYS |
| Iodine | mg/l | NYS | NYS | NYS | NYS | NYS | NYS | NYS |
| Lead | mg/l | 0.05 | NYS | 0.05 | 0.01 | 0.1 | 0.05 | 0.2 |
| Magnesium | mg/l | 30-50 | NYS | NYS | NYS | NYS | 250 | NYS |
| Manganese | mg/l | 0.1 | NYS | NYS | 0.1-1[6] | 2 | NYS | NYS |
| Mercury | mg/l | .001 | NYS | .001 | NYS | NYS | NYS | NYS |
| Nickel | mg/l | .1 | NYS | NYS | NYS | 0.5 | NYS | 0.2 |
| Nitrate (as N) | mg/l | 10 | NYS | NYS | NYS | NYS | 250 | NYS |
| Nitrite (as $NO_2$) | mg/l | <1 | NYS | 0.03 | NYS | NYS | None | NYS |
| Odor | | Odorless | Unobjec-tionable | Normal | Normal | Normal | Normal | Normal |
| Oil and grease | mg/l | 0.01 | 0.1 | .01 | NYS | NYS | NYS | 15 |
| Organo phosphorous compounds | mg/l | 0 | 0 | NYS | NYS | NYS | NYS | NYS |

[2]For boiler feed water, depending on boiler pressure.

[3]2 per 100 ml. in two consecutive samples or in more than 100 percent of the samples examined.

[4]For boiler feed water, 2-40, depending on boiler pressure. For tanning, 5-130.

[5]For cooling water, 5, for air-conditioning water, 1.

[6]For air-conditioning water, 0.5, for textile dyeing, 0.2., for tanning, 0.2.

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## Table 8.9 Standard Values for Water (continued)

| Parameters/ Determinants | Unit | Drinking Water | Recre-ational Water | Fishing Water | Indus-trial Water | Irriga-tion Water | Live-stock Water | Coastal Water |
|---|---|---|---|---|---|---|---|---|
| Organo chlorine compounds | | | | | | | | |
| - Aldrin & dieldrin | mg/l | 0 | 0 | NYS | NYS | NYS | NYS | NYS |
| - Chlordane | mg/l | 0 | 0 | NYS | NYS | NYS | NYS | NYS |
| - DDT | mg/l | 0 | 0 | NYS | NYS | NYS | NYS | NYS |
| - Hexachlorobenzene | mg/l | 0 | 0 | NYS | NYS | NYS | NYS | NYS |
| - Heptachlor and heptachlorepoxide | mg/l | 0 | 0 | NYS | NYS | NYS | NYS | NYS |
| - Lindane (BHC) | mg/l | 0.003 | NYS | NYS | NYS | NYS | NYS | NYS |
| - Methoxychlor | mg/l | 0.03 | NYS | NYS | NYS | NYS | NYS | NYS |
| - 2,4 D | mg/l | 0.1 | NYS | NYS | NYS | NYS | NYS | NYS |
| Percent Sodium | % | - | - | - | - | 60 | - | - |
| pH | | 6.5-8.5 | 6-9.5 | 6.5-8.5 | 6-9.5 | 6.0-8.5 | 5.5-9 | 6-9 |
| Phenolic compounds (as $C_6H_5OH$) | mg/l | .002 | .001 | NYS | NYS | NYS | NYS | 1 |
| Phosphate (as $PO_4$) | mg/l | 6 | 6 | 10 | NYS | 10 | NYS | NYS |
| Phosphorous | mg/l | 0 | NYS | 1.0 | NYS | NYS | NYS | NYS |
| Potassium | mg/l | 12 | NYS | NYS | NYS | NYS | NYS | NYS |
| Radioactive materials[7] | | | | | | | | |
| - Gross Alpha activity | Bq/l | 0.01 | NYS | NYS | NYS | NYS | NYS | NYS |
| - Gross Beta Gamma activity | Br/l | 0.1 | NYS | NYS | NYS | NYS | NYS | NYS |
| Selenium | mg/l | 0.01 | 0.05 | NYS | NYS | 0.05 | NYS | NYS |
| Silica | mg/l | NYS | NYS | NYS | NYS | NYS | NYS | NYS |
| Silver | mg/l | 0.02 | NYS | NYS | NYS | NYS | NYS | 0.05 |
| Sodium | mg/l | 200 | NYS | NYS | NYS | NYS | 1000 | NYS |
| Sodium absorption ratio | | - | - | - | - | 8-16 | - | - |
| Sodium carbonate ($NACO_3$) (residual) | mg/l | NYS | NYS | NYS | NYS | NYS | NYS | NYS |
| Sodium chloride | mg/l | NYS | NYS | NYS | NYS | NYS | 2860-12000 | NYS |
| S.S | mg/l | 10 | 20 | 25 | 75 | NYS | NYS | 75 |
| Sulfide (as S) | mg/l | 0 | NYS | NYS | NYS | NYS | NYS | NYS |
| Sulphate (as $SO_4$) | mg/l | 400 | NYS | NYS | NYS | 100 | NYS | NYS |

[7]These values are indicative. Detailed values, on radio nuclides basis, will be set by the Bangladesh Atomic Energy Commission in due course.

Table 8.9 Standard Values for Water (continued)

| Parameters/ Determinants | Unit | Drinking Water | Recre-ational Water | Fishing Water | Indus-trial Water | Irriga-tion Water | Live-stock Water | Coastal Water |
|---|---|---|---|---|---|---|---|---|
| Tar | mg/l | 0 | 0 | 0 | NYS | NYS | NYS | NYS |
| Taste | | Not offensive | Normal | Normal | Normal | Normal | Not offensive | Normal |
| T.D.S. | mg/l | 1000 | NYS | NYS | 1500[8] | 2000 | 5000 | NYS |
| Temperature | C | 20-30° | 20-30° | 20-30° | 20-30° | 20-30° | 20-30° | 30 |
| Tin | mg/l | 2 | NYS | NYS | NYS | NYS | NYS | NYS |
| Turbidity | J.T.U. | 10 | 10 | NYS | 50 | NYS | NYS | 75 |
| Zinc | mg/l | 5 | NYS | 10 | NYS | 5 | NYS | NYS |

There are numerous tests that can be performed quickly and reliably to indicate changes in water quality. It should be noted that the tests for many of the constituents mentioned above require complex laboratory equipment, highly trained personnel and significant amounts of time. There are, however, less complex field test kits available which, in the hands of a knowledgeable person, can be used to make preliminary evaluations of water quality for specific projects. With additional backup, more complete information and interpretations can be made for project evaluation, design and operation.

#### 8.4.3.1 Physical

Simple physical tests of water quality include temperature, dissolved oxygen (DO), suspended solids, conductivity, and color. Conductivity, color, temperature, and DO may be determined almost instantaneously (with appropriate field meters), while measurement of suspended solids requires the capability to filter a sample, evaporate the water to produce a residue, and finally weigh the products.

#### 8.4.3.2 Chemical

Easily measured chemical constituents include pH, alkalinity, and $BOD_5$. All of these tests require specific metering instrumentation or a moderately equipped field laboratory. Other tests of use, requiring more equipment, include those for chlorides, nitrogen forms and phosphates.

#### 8.4.3.3 Biological

The single most important test of biological water quality is the test for coliform bacteria. This test, which requires a moderately equipped laboratory, is an indicator of potentially harmful biological pollution.

Additional important water quality information may be gained through analyzing biological samples for the presence of certain indicator organisms—organisms that have been shown through historical and documented collection to become overabundant or absent in response to certain water quality criteria. Tubifex worms, for example, are known to occur in great numbers under conditions of high organic pollution. In employing indicator species, great care must be taken in the correct identification and preservation of the organisms through knowledge of their distribution and tolerances.

### 8.4.4 Maps and Mapping

Standard project base maps can be used in the EIA report to indicate the location of sampling sites and to identify areas where there are water quality or salinity

[8] For boiler feed water, 50-500, depending on boiler pressure.

problems. There are no other specific maps or mapping needs for this section of the report.

### 8.4.5 Data Analysis

General water quality characteristics fall into four major groupings: chemical, physical, physiological, and biological.

The analytical expression of many water quality measurements is in units of milligrams per liter (mg/l). This unit is, with few exceptions, interchangeable with parts per million (ppm). There are some measurements of water quality, most notably physiological and biological, which are not expressed in mg/l. These are discussed below with their respective grouping.

#### 8.4.5.1 Chemical Characteristics

The chemical characteristics of water are divided into three major subgroups: organic, inorganic and gaseous chemicals.

**Organic**

Organic compounds are composed primarily of a combination of carbon, hydrogen and oxygen and may sometimes contain nitrogen. They may be found either free (dissolved or suspended in water) or bound into living material, such as plankton or algae.

The total organic content of water is commonly measured by one of several laboratory tests designed to determine the amount of organic matter that is oxidizable. The most common measure of organic strength is the five-day biochemical oxygen demand test ($BOD_5$). This test measures the dissolved oxygen concentration before and after storage at 20°C for five days, and represents the amount of oxygen necessary to stabilize organic matter.

Specialized tests, usually involving well-equipped laboratories, can determine specific quantities of defined organic material that in total is represented by the $BOD_5$ test. The more important constituents are described below with reference to the type of water use requirements.

**Inorganic**

The inorganic constituents of concern in water quality management include pH, halogens, alkalinity, nitrogen, phosphorus, sulfur, heavy metals and toxic compounds. Tests for all of these, with the exception of some heavy metals and toxic compounds, can usually be performed with simple metering or packaged titration kits (most of which can be readily ordered and come complete with necessary chemicals, glassware and instructions).

The elements nitrogen, phosphorus, and sulfur are all essential to life. Nitrogen and phosphorus, and to a limited degree sulfur, when present in high concentrations, may cause excessive growth of algae. Algae, in turn, may limit many beneficial uses of the water by exerting a significant oxygen demand when dead and decaying, imparting a undesirable taste to the water, and creating a generally unpleasant appearance. High concentrations of the nitrate form of nitrogen in drinking waters may cause a disease known as methemoglobinemia in infants fed the water.

Small concentrations of many trace metals are important to the support of various organisms that live in water. Quantities of some of these metals in excess of these essential concentrations may, however, exert adverse effects on living organisms (toxicity, carcinogenicity, or other debilitation). Certain toxic compounds may also adversely affect the beneficial use of water. In addition to the heavy metals, these include other anions such as chromate and cyanide.

**Gases**

Dissolved gases are important to maintaining aquatic life. The most important of these is dissolved oxygen (DO), which is required by all aquatic aerobic organisms. Oxygen is only slightly soluble in water. Therefore, the balance of oxygen entering the water at its surface and oxygen being used up by aquatic organisms is exceedingly important. Dissolved oxygen may be simply measured by commercial potentiometric metering or by using a standard titration test (Winkler Test).

#### 8.4.5.2 Physical Characteristics

The physical characteristics of water may be divided into three major subgroups: temperature, turbidity/solids, and color.

**Temperature**

Temperature is a significant characteristic of water for a variety of reasons. Perhaps of prime importance is susceptibility of aquatic organisms to variation in water temperature. Other concerns for temperature relate to beneficial uses of water such as drinking water supply and industrial cooling water application. Temperature is perhaps the simplest parameter to measure, and one of the most variable.

**Turbidity/Solids**

There are three categories of solid content for water: dissolved, colloidal, and suspended. The total solid content is the sum of the three group. Suspended solids are generally defined as particles greater than one micrometer ($10^{-6}$m) in diameter. Colloidal material is defined as those solids between $10^{-9}$ and $10^{-6}$m. Material in solution of particle size smaller than that of colloidal material is classified as dissolved. Turbidity is a measure of the light transmitting properties of water and indicates the quality of water with respect to colloidal matter.

The solids content of water may interfere with the beneficial uses of water. Each beneficial use has certain standards with respect to solids content. Measurements of suspended and dissolved solids can be carried out in almost any laboratory equipped with filtration apparatus, drying ovens and analytical balances.

**Color**

Color is generally a qualitative measure of water quality and may result from either man-made or natural causes. Water color is primarily an aesthetic issue, but it often may indicate the presence of undesirable constituents. It may also indicate low oxygen conditions in the water. True color can only be accurately measured by spectrophotometric means employing standard platinum cobalt reference blanks.

#### 8.4.5.3 Physiological Characteristics

The physiological characteristics of water comprise two major subgroups: taste and odor.

**Taste**

Certain constituents in water will produce an undesirable taste and therefore principally affect the use of water as a drinking source. Constituents that produce an unwanted taste include ABS (surfactants), chlorides, copper, zinc, iron, manganese, phenols (when in the presence of chlorine), and dissolved solids. Excessive growth of certain species of algae may also produce undesirable taste in water.

**Odors**

Odors are due to dissolved gases present in the water and may effect the use of water for drinking. Hydrogen sulfide (the odor of rotten eggs) is a common dissolved gas of this nature. Other gases may be those emanating from anoxic decomposition of organic material in or underlying the water.

#### 8.4.5.4 Biological Characteristics

Biological characteristics of water consist of three major subgroups: protista, viruses and plants and animals. The presence of protista and viruses in water is usually of interest because of potential disease problems. Plants and animals present in water supplies may be of interest both from the point of view of disease transmission and for establishing the "health" of an aquatic ecosystem.

**Protista**

Protista include bacteria, fungi, protozoa, and algae. The disease-producing potential of water is most often tested by the presence of coliform organisms. The presence of coliform bacteria (not strictly pathogenic themselves) indicates the potential for the presence of other disease-causing organisms, both bacterial and viral.

The most common method for determining the number of coliform organisms present is with the use of the multi-dilution lactose fermentation test. Test results are interpreted as the most probable number of coliforms per 100 ml. The test setup lends itself to statistical expression. The number obtained is, therefore, a statistical estimate.

**Viruses**

Virus organisms are the smallest known biological units containing the information necessary for reproduction. Because of their size, viruses may be viewed only with the aid of an electron microscope. Disease-causing viruses are known to be contained in the excreta of many animals, so that the control of these wastes becomes of critical importance for a variety of beneficial uses of water.

**Plants and Animals**

Plant and animal indicators of water quality range from microscopic rotifers and worms to larger crustaceans and fish. The presence and diversity of these organisms in water bodies and bottom deposits often indicate the general health or suitability of the water for various uses.

### 8.4.6 Impact Analysis

An analysis of a project's impact on water quality involves the same procedures as discussed in other sections of this manual. The analysis is based on a comparison of "without" and "with" project conditions. As far as possible, the impacts need to be quantified for use in benefit-cost analyses.

### 8.4.7 Mitigation

Proper project design and provision of adequate sanitary facilities are important mitigating measures. Sanitary domestic water supply must be made available to avoid the temptation to use the convenient irrigation system as a source of drinking water. Good sanitation habits are an important factor for good health. Proper design of waste disposal pits and/or proper collection and handling of waste can make low-technology alternatives effective in promoting good health. An important companion activity for an irrigation project, or a rural water supply and sanitation project, is educating the users about sanitary habits.

Modern water management techniques and a wide variety of available water treatment processes make possible the use of raw water of almost any quality to produce an acceptable public water supply. However, management and treatment techniques must be consistent with the amount of capital and degree of technology available to meet appropriate standards.

Some raw (untreated) surface waters may meet all drinking water standards with no treatment other than disinfection. Usually, however, drinking water that comes from surface sources should be subject to treatment. The treatment processes used should employ appropriate technology.

Unlike surface water, groundwater characteristically contains little or no suspended sediment and is largely free of, and easily protected from, bacterial and viral contamination. Therefore, no defined treatment is assumed for groundwater, although this does not preclude the need for treatment as determined by careful testing. The major problem with increased water development is contamination by agricultural chemicals contained in surface runoff; this can be prevented only through extension programs and education to ensure correct handling and application of agricultural chemicals.

### 8.4.8 Monitoring

The importance of an effective sampling and monitoring program cannot be overemphasized, particularly for rural water supplies. Multiple sampling of the water source, from different locations and at different times, should be done, and a monitoring station should be set up at the point of entry to the supply system. Care should be taken to recognize two possible hazards:

- the chronic hazard where constituent concentrations are near the limit of acceptability much of the time; and
- the periodic hazard caused by upstream releases of wastes or accidental spills.

Especially for drinking water, initial sampling and subsequent monitoring programs should be designed and supervised by a qualified technical specialist (sanitary engineer, public health specialist, water quality chemist).

For most projects, the simplified tests described in Section 8.4.3 can be used to implement a program to monitor changing conditions and to determine the source of the changing conditions. Where changing conditions are serious, mitigating measures such as water treatment can be designed and implemented on a timely basis.

## 8.5 Water Transportation

### 8.5.1 Baseline Studies

Baseline data and/or studies should provide the following information.

- Description of the extent of navigational use of waterways (rivers, streams, *beels*, etc.), including:
  - geographic distribution and navigable lengths;
  - ports or landings;
  - infrastructural facilities;
  - changes in relation to the annual inundation cycle; and
  - key linkages that affect navigation, such as:
    - water flowing into the area from outside,
    - sedimentation of channels,
    - presence of embankments and regulators, and
    - aquatic vegetation (e.g., water hyacinth).
- Data to evaluate the socioeconomic importance of the navigation system, including:
  - numbers of people directly dependent on the waterways for transportation (expressed in numbers and as a percentage of the population);
  - classes of users, such as:
    - boat owners and operators,
    - cargo handlers,
    - shippers of goods, and
    - passengers;
  - seasonal changes in use and relationship to annual inundation cycle; and
  - extent to which local and regional economies depend on river transportation, including:
    - movement of goods (tonne-km, by category of goods),
    - movement of people (passenger-km), and
    - income to the sector;
- Description of apparent trends in factors affecting navigational use of waterways in the area, including erosion, sedimentation, flow reductions, water developments, etc.;
- Information that can be used to evaluate the socioeconomic responses to any trends, including such factors as increased use of road transportation, breaching of embankments and economic impacts; and
- Mechanization of country boats using STW engines.

The water transportation section of the EIA report should provide a qualitative and quantitative description of the baseline information. Most of the information required should be obtainable from existing data sources, supplemented by a rapid rural appraisal (RRA) of the study area or, where necessary, detailed field surveys. The level of study determines the level of data detail required for analysis. Existing data should be adequate for regional and prefeasibility studies, but these data

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**Table 8.10 Dry Season Draught Restrictions Imposed by BIWTA**

| Depth (ft) | Miles of Waterway with Restrictions 1973 | 1977 | 1979 |
|---|---|---|---|
| 10-12 | 498 | 193 | 177 |
| 8-10 | 120 | 68 | 188 |
| 6-8 | 220 | 122 | 199 |
| 4-6 | 1497 | 232 | 169 |
| 3-4 | 317 | 127 | 31 |
| <3 | 313 | 637 | 560 |

Source: Review and Updating of Bangladesh Transport Survey (BTS) Study P.3, Vol. 3 of Part 2, 1980

probably need to be supplemented for feasibility and detailed EIA studies. In particular, supplemental quantitative data would probably be required to evaluate the socioeconomic importance of the navigation system (Table 8.10). The importance of the navigation system in the study area and level of field studies needed to acquire data should be determined during project scoping sessions.

A project map showing the extent of the navigation use of waterways will be required. It should including geographic distribution and navigable lengths, depth classification (if available), locations of ports or landings, infrastructural facilities, etc. This should be coordinated and integrated with the preparation of the description of the general pattern of important surface water distribution systems described in Sections 8.2.1, 8.2.3 and 8.2.4.

### 8.5.2 Existing Data Sources

The Bangladesh Inland Water Transport Authority (BIWTA) is responsible for maintaining and conserving the inland waterways. It is the primary source of data on the extent and condition of the navigation system. BIWTA's 1988 Bangladesh Inland Water Transport Master Plan (BIWTMAS) is the most recent and complete source of information on the inland water transport system.

Other important sources of information and data are the various studies and sectoral reports conducted by the government, donor agencies and consultants in recent years. A list is included in the bibliography.

### 8.5.3 Primary Data Collection

Primary data collection probably would be limited to conducting field surveys to supplement and/or verify existing information. As noted in Section 8.5.1, for a detailed feasibility study or EIA, where navigation is an important element, quantitative data to evaluate the socioeconomic importance of the navigation system will probably need to be collected. The level of the field survey and type of data required will vary depending on the type of project and should be determined during the scoping sessions. Planning of the field investigation program should be done jointly by the project sociologist, economist and water resources engineer.

RRAs will probably be needed to supplement information describing the extent of navigational use of waterways, in particular, the key linkages that affect navigation. RRAs will also be useful in determining any trends in navigational uses of waterways in the project area. The survey should be designed to determine trends from such factors as erosion, sedimentation, flow reductions, water developments, etc. The appraisal should also provide indications of socioeconomic responses to trends, including increased use of road transportation, breaching of embankments and economic impacts.

### 8.5.4 Maps and Mapping

A standard project base map should be used to present graphic information on the navigation system in the study area. The information shown on maps (see Section 8.5.1) would include:

- geographic systems and navigable lengths, including seasonal changes;
- classification of routes using BIWTA's Least Available Depth (LAD) classification;
- ports or landings, infrastructure, etc.; and
- constraints to navigation such as embank-

ments, roads, regulators, heavy siltation, water hyacinth, etc.

Most of the information to be presented will come from existing baseline data and maps, and should be verified by RRA.

#### 8.5.5 Data Analysis

Data analysis should include interpretation to determine if there are any apparent trends in the use of waterways in the area and factors that may be influencing those trends. These include apparent impacts from erosion, sedimentation, flow reductions, water developments, etc. For example, the Padma River could once be navigated by large steamers in the dry season. Since the opening of the Farakka Barrage in India (1975), dry season flow has been reduced drastically. The river now can be crossed by foot at the Hardinge railway bridge for 7 months of the year. Reportedly, the river has deteriorated so rapidly that there are problems of navigation even in the wet season.

Another example of recent trends in the national inland water transport system is reduced navigability due to rapid deterioration of river systems through massive siltation. Table 8.10 shows evidence of such deterioration. The table shows an alarming decrease during the 10-year period in waterways with four-to-six-foot draughts and above for which BIWTA could impose restrictions. For example, waterways with a four-to-six-foot restriction decreased from 1,497 miles in 1973 to only 160 miles in 1979. Although the table seems to suggest that routes with less than a three-foot draught have remained stable, the BTS study cautions that such an impression would be erroneous. Routes with draughts less than three feet are preeminently country boat routes and BIWTA, overwhelmingly concerned with mechanized inland water transport, does not post draught restrictions for country boats.

Trend analysis is used to help predict future project conditions. The results of the analyses can best be presented in the report in tabular or graphical form.

#### 8.5.6 Impact Analysis

The major problem facing Bangladesh's inland water transport system is deterioration of the river system through massive siltation due to the increased volume of sediment being transported. More important than increases in the volume of sediment carried is reduction of flows in the river system and changes in river hydraulics. Water developments contribute to a change in river hydraulics and reduction of stream flows.

Embankments keep silt in the waterways, preventing its spread and deposition outside the river bed and banks. Contained sediment is then deposited in slack water areas such as the delta. Embankments and canals cause a change in river hydraulics, thereby changing morphological patterns of erosion and sediment deposition. In protected areas, the embankment causes an interruption of hydrologic continuity between the river and *haors/khals*, often resulting in a loss of access for boats and a hinderance to navigation.

Drawing irrigation water from either surface or groundwater sources causes a reduction of stream flows. This can be most detrimental in the dry season, leading to reduction of navigable reaches of waterways and increased deterioration of streams. Some feel that the deterioration of rivers in the northwest region appears to be in part due to such effects.

#### 8.5.7 Mitigation

Mitigation of morphological and hydraulic problems calls for flexible management and improvement strategies and methods. There are possibilities of improving hydraulic conditions, albeit mostly on a relatively small scale. In many cases, such opportunities will be economically feasible only if other sectors of water management, such as flood control and fresh water supply, benefit at the same time. Possible mitigation strategies are outlined below.

##### 8.5.7.1 Dredging

Most of the rivers of Bangladesh are gradually silting up, reducing least available depth (LAD) of many waterways in the dry season. This is a continuous process and a major problem for waterways. Dredging has been used in the past as a primary solution to the problem of keeping classified waterways navigable. However, the associated costs are very high and alternative solutions need to be identified and tried.

#### 8.5.7.2 Bandalling

"*Bandalling*" is an alternative low-cost maintenance dredging method that is mainly applied to deepen a single channel or close a secondary channel. It is done by attaching bamboo mat panels to a frame of bamboo poles. The mats are submerged in the river and positioned vertically about one foot above the bed level and at a 45 degree angle to the main flow. This results in local changes of sediment and water distribution due to induced spiral currents.

#### 8.5.7.3 Conservancy and Pilotage

This measure is directly concerned with day-to-day conditions on waterway systems, which includes inspecting and sounding the routes, marking the channels with navigational aids (lighted/unlighted buoys and beacons), issuing river notices, pilotage, rendering weather signals and telecommunications and canal toll collection.

#### 8.5.7.4 Narrowing of Rivers

Another method of maintaining the navigability of channels is by using groins to accelerate sedimentation along river banks, thus reducing river width. This will normally result in greater main channel depths and assist in the prevention of channel movement. According to BIWTMAS analysis, the Passur River (Mongla-Khulna) is a typical example of groin use. The control of river channels by groins for major floods would be very expensive, however.

#### 8.5.7.5 Rerouting of River Discharges

The main inland water transport objective of rerouting of river discharges is to concentrate the limited quantity of dry season flows in a smaller number of waterways, selected specifically to uphold navigability. This measure clearly would need to be planned in coordination with other users, taking into account environmental impacts, on a regional basis.

The complex river network in the southwest/central region supplied by the Ganges (Gorai) and the Arial Khan, Dubaldia (Nullah) rivers offer possibilities in this respect. The concentration of discharges in a reduced number of channels can, at the same time, help to resolve the type of siltation problem mentioned in the previous section (Passur River), and also restrict salt water intrusion problems in the lower reaches of the channel network.

#### 8.5.7.6 Water Level Regulation

In particular cases, such as in tributaries, it may be possible to create backwater effects by using weirs in combination with a navigation lock. This is most attractive in gently sloping rivers, but it is expensive. It will not work in most connector type of rivers, where the water would simply flow by another route.

Recent developments in flexible weir design, whereby an inflatable rubber body is laid across a river on a concrete foundation supported between concrete pylons might provide a suitable solution for certain conditions in Bangladesh. In the planning of such projects, due consideration must be given to fisheries impacts as well as the likely induced sedimentation and general changes in river morphology.

#### 8.5.7.7 Removal of Water Hyacinth

For small canals, beels and landing sites obstructed by water hyacinth, physical removal is a practical option for maintaining open passage. Herbicides have been tried in some countries, but they are expensive and potentially dangerous in terms of aquatic toxicity and human health.

### 8.5.8 Monitoring

Routine hydrologic data collection programs conducted by BWDB and BIWTA, as well as

BIWTA's monitoring of the need for draught restrictions, should provide data needed to evaluate project development impacts on the inland water transportation system. The greatest need for a well-designed monitoring program would be an expansion of the number of data collection stations, particularly for sediment and salinity monitoring and evaluation. The project EIA study should evaluate whether the existing network is adequate to monitor potential impacts of a specific project. If it is not adequate, the study should identify and recommend the additional requirements, including estimated costs. For example, annual or biannual hydrographic surveys, conducted after the wet season, would probably be needed to adequately monitor changing morphological conditions in major waterways. Hydrographic surveys provide information on river bed levels, cross sections, and profiles. Conduct of these surveys may be outside the normal implementation or budgetary capacity of BIWTA or BWDB. The EIA study's monitoring program would need to address this aspect and make recommendations to ensure that an adequate program is undertaken.

Chapter 9

# LAND RESOURCES

With the exception of the Chittagong Hill Tracts in the southeast and the uplifted areas of the Madhupur and Barind Tracts in the central and northwestern areas, respectively, almost all of Bangladesh is a delta floodplain with a maximum elevation of about 100 m in the north and east. The country has an area of about 145,000 km$^2$, of which about 80 percent is floodplain, 12 percent hills, and 8 percent slightly elevated terraces. Brammer (1990) categorizes the floodplains in six physiographic units:

- piedmont plains in the northeast and northwest;
- active river floodplains;
- river meander floodplains (previous river courses);
- major floodplain basins in the northwest, northeast and north-central areas;
- estuarine floodplains; and
- tidal floodplains in the southwest and southeast.

## 9.1 Land Types

There have been several methods for categorizing flooded land in Bangladesh. Each of these so-called land type systems seek to classify land according to particular flood depths during the maximum flooding period in an average year. Over a period of about 20 years the Soil Resources Development Institute (SRDI) developed a system of 11 such land types, which it uses in its Soils Data Processing System (SODAPS). The Agro-Ecological Zoning (AEZ) system devised by FAO/UNDP (1988) adopted the same scheme (Table 9.1). A second system, introduced by MPO (1986), is in general use for agricultural assessments in Bangladesh (Table 9.2). The MPO classification system is generally recommended for use in EIAs and agricultural assessments.

Land type classifications are based on an assumed level of flooding. At the prefeasibility level of study the land types can be identified from field reconnaissance coupled with farmer interviews and reference to reconnaissance soil survey mapping. For feasibility design purposes, e.g., embankment heights, the BWDB has designated the assumed water levels to be those occurring with a one in two year rate of occurrence and having a duration of three days (often referred to as the Polder Water Level (PWL) within the BWDB). This criterion assumes that the likelihood of crop damage within any particular cropping pattern in the land types is about one year in every five and that most rice crops will be damaged by flooding for a period exceeding three days.

### 9.1.1 Baseline Studies

A general description of the land types of the project area is required in order to understand flooding and drainage patterns. Baseline studies should be conducted to generate areas under different land types based on MPO or AEZ classification. Data required to generate this include:

- area elevation curve for the project area;
- calculated one in two year maximum water level of duration longer than three days during monsoon season; and
- maximum one in five year water level of more than three days' duration in the monsoon season under post-project conditions.

Table 9.1 AEZ Land Type Classification System Developed from the SODAPS Classification

| No. | Land Type | Flooding Depth (cm) | Nature of Flooding |
|---|---|---|---|
| 1 | Highland | 0 | Flood-free or intermittently flooded |
| 2 | Medium Highland 1 | 0 - 30 | Seasonally flooded |
| 3 | Medium Highland 1 (Bottomland) | 0 - 30 | Seasonally flooded, wetlands persist through part of dry season |
| 4 | Medium Highland 2 | 30 - 90 | Seasonally flooded |
| 5 | Medium Highland 2 (Bottomland) | 30 - 90 | Seasonally flooded, wetlands persist through part of dry season |
| 6 | Medium Lowland | 90 - 180 | Seasonally flooded |
| 7 | Medium Lowland (Bottomland) | 90 - 180 | Seasonally flooded, wetlands persist through part of dry season |
| 8 | Lowland | 180 -300 | Seasonally flooded |
| 9 | Lowland (Bottomland) | 180 -300 | Seasonally flooded, wetlands persist through part of dry season |
| 10 | Very Lowland | > 300 | Seasonally flooded |
| 11 | Very Lowland | > 300 | Seasonally flooded, wetlands may persist through dry season |

Source: Soil Resource Development Institute

### 9.1.2 Existing Data Sources

Land type descriptions and mapping generally have to be developed specifically for each project area, based on available topographic mapping and hydrological analysis. There is as yet no standard land type map covering all of Bangladesh.

Surface water data for estimating flood levels are described in BWDB maps at scales of 16 inches to

Table 9.2 MPO Land Type Classification System

| Land Type Designation | Flooding Depth (cm) | Nature of Flooding | Agricultural Significance |
|---|---|---|---|
| $F_0$ | 0 - 30 | Intermittent | Suited to HYV rice in wet season |
| $F_1$ | 30 -90 | Seasonal | Suited to local varieties of aus and T. aman in wet season |
| $F_2$ | 90 -180 | Seasonal | Suited to B. aman in wet season |
| $F_3$ | > 180 | Seasonal | Suited to B. aman in wet season |
| $F_4$ | > 180 | Seasonal or Perennial | Depth, rate and/or timing of flooding do not permit cultivation of B. aman in wet season |

Source: MPO (1986)

the mile (1:3,960) and 8 inches to the mile (1:7,920) are normally used as a basis for the extraction of land elevation and contours. These show one-foot contours, spot elevations on a 400 m grid and the locations and elevations of benchmarks. The elevational data on these maps are approximately 30 years old and have to be used with care. A program of mapping onto 1:10,000 orthophotos is currently in progress (FINNMAP) and will, in time, be available for many sites.

### 9.1.3 Primary Data Collection

Contour mapping and flooding data are generally available for most areas in Bangladesh and it is not expected that collection of such primary data would be required for the EIA. Both types of data would be required for the engineering feasibility studies.

### 9.1.4 Maps and Mapping

The EIAR will require maps showing the distribution of land types under both the pre-project and post-project conditions. Maps are best presented in standard scales (1:20,000 or 1:50,000) with full legends, direction indicators and key maps for location, if necessary. Map sizes should be standardized throughout the report. Most information can be presented on a map of a scale such that the project area can be shown on a standard report page (A4 or 8.5" x 11" size) or a foldout (A3 or 11" x 17" size). Land type maps may be combined with other maps to show key relationships such as:

- cropping patterns
- settlements
- seasonal and perennial water bodies
- selected infrastructures, e.g., roads and embankments.

Land type maps are generated, both manually and with GIS, by combining maps showing land elevation classes and an estimate of the one in two year maximum flooding levels from the hydrological analysis. Contour maps can easily be converted to land elevation maps by shading the various contour intervals. Superimposition of the one in two year maximum flooding level may require interpolation between contour lines, which may lead to some error. This can be checked by comparing total planimetered land type classes with a similar total described from the area elevation curve. $F_3$ and $F_4$ land types would be grouped using this approach and additional mapping based on field inventories and surveys to determine areas not cropped in the kharif-2 season.

GIS can provide more accurate delineation of land type boundaries and computation of land type areas through combining digital elevation models (DEMs) with water level estimates from the MIKE-11 model. Present BWDB maps (as well as newer maps in production) present spot elevations (on an approximate 200m x 300m grid for BWDB maps). These spot elevations are digitized into the GIS database and converted by the software to metric equivalents. GIS software, such as ERDAS, creates a representational elevation surface comprised of a rectangular grid (raster) from such spot heights, with each grid element assigned an interpolated elevation value. The grid elements (picture elements or pixels) can be of variable size but are normally uniform (e.g., 40m x 40m). The optimum size for the grid representation is determined chiefly by the usage and required display scale.

Other vector-based terrain modeling techniques interpolate elevation over an irregular network of triangles, formed between known elevations and breaks in slope due to features, such as rivers and escarpments. The accuracy of the representational elevation surface with either technique depends on the selection and spacing of elevation points, as well as the search radius and method of interpolation. Grid elements are small enough that an output map of nominal scale (e.g., 1:50,000) can be produced with seemingly smooth boundaries to any given elevation categories. Contour lines can also be generated by a similar approach. Land types are simply groups of flood depth elevation classes within specific limits, such as 30-90 cm for $F_1$.

In addition to flood depths, classification and mapping of land types requires information on the duration of flooding (at least three days' duration). Such information is not easily obtained under typical field conditions and surrogate approaches may be used to approximate these. One approach, when MIKE-11 modelling is available, is to use consecutive estimates of water levels separated by at least three days. Another approach is to use the obvious correlation between depth and duration and assign a greater flooding depth to areas where flooding duration is known to be a significant factor in cropping and land use.

### 9.1.5 Data Analysis

An area elevation curve of the project area is normally generated by planimetering areas within unit contours from BWDB maps showing contour lines at one-foot (or the metric equivalent) intervals and plotting cumulative areas against elevation. The one in five maximum flood level at designated gauging station(s) is generated by frequency analysis of historical water level data and superimposed on the area elevation curve to compute area under different flood depths (Figure 9.1). Classification of land types adopted by MPO and AEZ are slightly different, and so the computations of elevations that would be flooded to a certain depth are different (Table 9.3).

To determine the net area available for crop production in a particular land type, areas under settlements, roads, orchards, etc., should be deducted from the gross area. In addition, any area under wetlands and water bodies should be deducted. When using GIS to generate these data, maps of settlements, roads, embankments, water bodies, etc., should be digitized and superimposed on the land type map.

The land type data for the pre-project condition may be presented in the report in table form. A similar table, showing each developmental option, should be prepared and presented for the post-project condition. These data should be generated using GIS facilities, if it is available. Table 9.4 is a suggested format for the table.

### 9.1.6 Impact Analysis

The impact of the proposed flood control interventions is the areal difference in each land type between the pre- and post-project conditions. Deduct the post-project area under each land type from the pre-project area under the corresponding land type and present the difference (Table 9.5). GIS can be used to com-

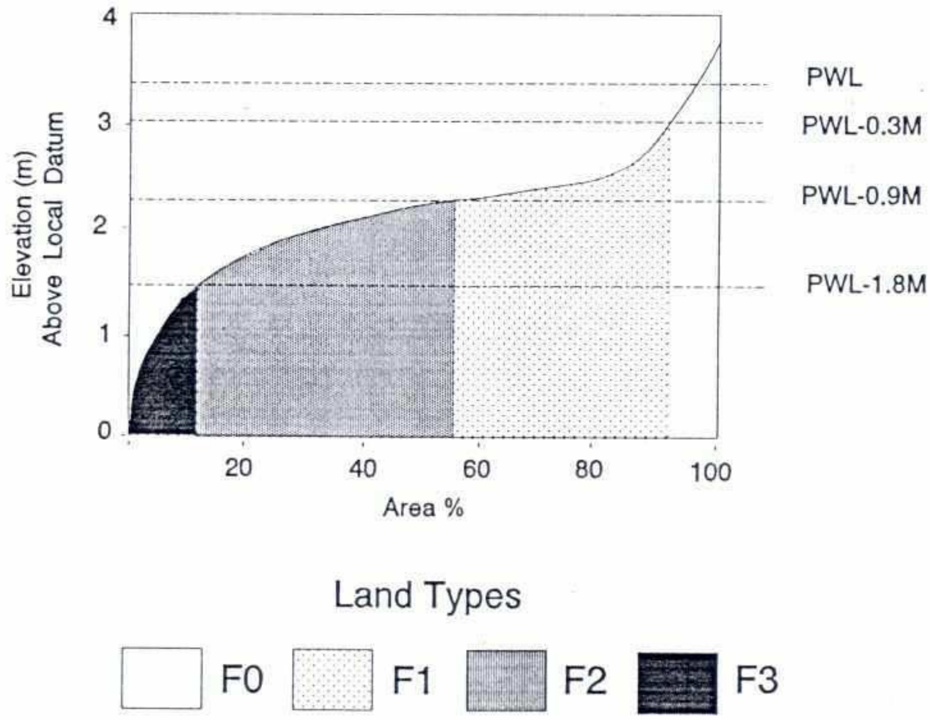


Figure 9.1 Example of Area Elevation Curve for a Typical Project Study Area

**Table 9.3 Computation of Land Types from the Area Elevation Curve***

| Land Type | Elevation (m) |
|---|---|
| $F_0$ | PWL† minus 0.3m |
| $F_1$ | Between $F_0$ and PWL - 0.9m |
| $F_2$ | Between $F_1$ and PWL - 1.8m |
| $F_3$ and $F_4$ | Between $F_2$ and PWL - 3.6m |

*Using the MPO land type classification
†PWL = Polder Water Level (estimated 1 in 2 year maximum flood level)

pute this, superimposing post-project polder water level data for every single project option on the maps already digitized for baseline studies.

#### 9.1.7 Mitigation

Mitigation strategies include excavation of drainage channels and/or construction of additional hydrologic structures so as to maintain water at the desired level. Mitigation also may only require people's participation in the proper operation and maintenance of the system without the addition of new structures. In the later case, institutionalization of people's participation should receive proper attention.

**Table 9.4 Presentation of Land Type Data in EIA***

| | Gross Area (ha) | Net Area (ha) |
|---|---|---|
| Land Types | | |
| $F_0$ | x | x |
| $F_1$ | x | x |
| $F_2$ | x | x |
| $F_3$ | x | x |
| $F_4$ | x | x |
| Settlements | x | |
| Roads | x | |
| Water Bodies | x | |
| etc. | x | |
| Totals | x | x |

*Using MPO land type classification system.

#### 9.1.8 Monitoring

Staff gauges may be installed at suitable locations to monitor the depth of flooding under post-project condition so that any deviation from the intended situation can be rectified.

## 9.2 Land Use

### 9.2.1 Baseline Studies

Water development project benefits are based on altered patterns of flooding and induced changes in land use, especially cropping patterns and crop types. Baseline studies should be carried out to determine and map the distribution and uses of land, to include:

- agricultural land, including cropping pattern boundaries;
- settlements, including villages and homestead vegetation;
- natural woodland and scrub;
- plantation forests, including orchards;

**Table 9.5 Presentation of Land Type Impact Assessment in EIA***

| | Gross Area (ha) | Net Area (ha) |
|---|---|---|
| Land Types | | |
| $F_0$ | *Indicate differences as gains (+) or losses (-) plus percentage differences* | |
| $F_1$ | | |
| $F_2$ | | |
| $F_3$ | | |
| $F_4$ | | |
| Settlements | | |
| Roads | | |
| Water Bodies | | |
| etc. | | |

*Using MPO land type classification system.

- perennial water bodies;
- urban areas and other infrastructure; and
- coastal areas, including forests, beaches and polders.

### 9.2.2 Existing Data Sources

In the early 1970s, land use maps and information, based on survey data from the 1960s, were published in the Reconnaissance Soil Survey Reports of the Soil Resources Development Institute (SRDI). These are now outdated. Land use data and maps of the project area may be available from previous or current feasibility reports. Information on cropping patterns is also available in the Thana *Nirdeshika* (Land and Soil Resources User's Manual) series prepared by SRDI, but these do not contain any land use maps, and the information provided does not cover many of the items necessary for an EIA.

Aerial photographs, required for land use surveys, are available through FPCO from the Survey of Bangladesh (SOB) and from FINNMAP. Available map and air photo resources in Bangladesh are listed in Chapter 12.

### 9.2.3 Primary Data Collection

Aerial photo interpretation and land use surveys should be utilized in a complementary fashion to prepare land use maps of the project area. Where suitable aerial photographs are available (see Chapter 12), interpretation on clear plastic overlays on 1:20,000 aerial photographs is appropriate for identification of land use in the project area. Mapping unit boundaries for major cropping patterns should be marked in the field on the aerial photographs, along with settlements, plantation forests, orchards, perennial water bodies, natural woodland and scrub, and all existing infrastructure including roads, embankments, hydraulic structures, canals, brickyards, etc.

Complete surface coverage of small project areas (up to about 4,000 ha) is possible, but larger areas will require stratified random sampling to verify map unit boundaries and identify land use types and cropping patterns. A useful sampling technique is to place traverse lines about 1 km apart in such a way that they transect all major physiographic units and land types of the project area. The survey team can then follow the traverse lines and use structured questionnaires to record information on land use either by direct observation or from knowledgeable farmers and informants.

### 9.2.4 Data Analysis

The mapping boundaries and the collected data should be compiled to combine identical cropping patterns. Land type boundaries should be superimposed on the cropping pattern boundaries. Normally, a close correlation will be found between these boundaries. The areas of each cropping pattern type within each land type should be planimetered or computed by GIS and presented in map and table form.

### 9.2.5 Maps and Mapping

It is advisable, for the sake of clarity, to prepare separate maps at appropriate scales showing land use. GIS, if it is available, should be used for preparing such maps.

### 9.2.6 Impact Analysis

The major impacts of any intervention that are expected to bring about a change in the hydrologic regime (land type) in the project area would be in the field of agricultural land use, particularly cropping patterns. Possible increases in $F_0$ and $F_1$ land types would be associated with proportionate increases in area under cropping patterns practiced and crop varieties, e.g., HYV boro, grown on these land types. Similarly, possible reductions in $F_2$ and $F_3$ area would result in reduced areas under cropping patterns practiced and crop varieties grown on these land types. The most practical and realistic approach in predicting future cropping patterns is to assume that cropping patterns practiced by farmers on the pre-project $F_0$ and $F_1$ land types, which have had no major problems or crop damage, would be adopted by neighboring farmers on identical land types under post-project conditions. Consideration should be given to whether the increased or changed inputs required for changed cropping patterns (e.g., higher fertilizer needs for HYVs) are practically attainable under post-project conditions or whether they themselves might develop into significant constraints on cropping pattern change. Loss of land and the taking of topsoil for constructing embankments and hydraulic structures may result in displacement and reduced soil fertility and should be taken into full consideration.

#### 9.2.7 Mitigation

Land use may be negatively affected by project development in two major ways: land may be removed from production in order to construct embankments and drainage canals, etc.; or there may be negative changes in soils and water following more intensified or altered use under post-project conditions.

Land cannot be practically recreated for mitigation purposes, although non-allocated *khas* land, if available, may be allocated for more productive uses. Increased use of fertilizers is the normal method of overcoming deficiencies following intensive use, although this may lead to deterioration in water quality through chemical run-off. Secondary effects requiring mitigation include resettlement of displaced families, and loss of land by marginal and small farmers. These are dealt with in Chapter 11.

#### 9.2.8 Monitoring

Post-project changes in cropping pattern, land allocation and housing of the displaced families, including small and marginal farmers, should be monitored for necessary corrective measures. The normal monitoring method is to repeat the basic land use surveys described above and compare the findings to pre-project conditions.

### 9.3 Soils

#### 9.3.1 Baseline Studies

Baseline data and studies are conducted to determine the following:

- soil association and series;
- physical and chemical properties;
- land capability and crop suitability; and
- agricultural limitations.

The main use of soils data in an EIA is to find correlations with the cropping patterns and land use, and to project likely land uses under the post-project conditions.

#### 9.3.2 Existing Data Sources

Basic soil surveys normally are not required for EIAs and the data and information should be procurable from secondary sources. These include the materials discussed in the following sections.

##### 9.3.2.1 Reconnaissance Soil Survey Reports

Reconnaissance soil surveys for all districts of Bangladesh were carried out in the late 1960s by the Soil Survey of East Pakistan, which are now in the possession of the Soil Resources Development Institute (SRDI) of Bangladesh. The reports were published in 23 volumes in the early 1970s and contain both data and maps. The volumes provide information on soil association and series, physical properties and some chemical properties, land capability, crop suitability, agricultural limitations, etc.

##### 9.3.2.2 Agro-Ecological Zones (AEZ)

AEZs are described in the *Land Resources Appraisal of Bangladesh for Agricultural Development*, published in 1988 (FAO 1988) in 27 volumes. Data collected through reconnaissance soil surveys in the late 1960s were updated and computerized under this study. Meteorological data were also computerized and superimposed on the land resources database to identify 30 agro-ecological regions. Data available from this report include soil association and series, physical properties and some chemical properties, crop suitability and agricultural limitations.

The Agriculture Sector Team (AST) of the Canadian International Development Agency (CIDA) has digitized the AEZ soil maps, and the digital data are also available through FAP 19 (Geographic Information System).

#### 9.3.2.3 Thana Land and Soil Resources User's Manual

These reports are popularly known as Thana *Nirdeshika*. The Bangladesh Agricultural Research Council (BARC) is coordinating the publication of the series of reports for each of the 460 thanas with the active participation of SRDI, the Department of Agricultural Extension (DAE), the Bangladesh Agricultural Research Institute (BARI) and the Bangladesh Rice Research Institute (BRRI). Reports for more than 150 thanas have already been published and the rest are expected to be published by 1993.

These reports contain valuable information on soil associations and series, as well as data on flood phases, post-monsoon drainage patterns, water holding capacity, pH, organic matter content, and nutrient content (calcium, magnesium, potassium, ammonium nitrogen, phosphorus, zinc, sulphur, boron, copper, iron, and manganese) by soil series.

### 9.3.3 Primary Data Collection Procedure

Most data needed for the EIA should be available from the reports referred to in Section 9.3.2. This essentially negates the need for any primary data collection except determining the location and describing the extent of erosion and sedimentation. Ground truthing of some of parameters may be required.

### 9.3.4 Data Analysis

Soil associations occurring within the defined project area should be described and quantitatively summarized on the basis of area, and physical and chemical properties. If GIS facilities are available, the various soil associations should be digitized and their physical and chemical properties used as attribute data.

### 9.3.5 Maps and Mapping

Soil association maps at appropriate scales (usually 1:50,000) should be included in the EIAR, either separately or in conjunction with cropping patterns and land use. The extent of erosion, sedimentation and problem soils, if any, should be displayed on the soils map(s).

### 9.3.6 Impact Analysis

Impact analysis should be carried out for each proposed development option. GIS facilities, if available, should be used for impact analysis. Changes in hydrologic regime may bring about the following changes.

#### 9.3.6.1 Soil Phase

Reduced water level will increase areas of high land and medium high land soil phases, while medium low and low land soil phases will decrease proportionately.

#### 9.3.6.2 Plough Pan

An effective plough pan usually develops at the base of the plowed layer ($A_p$) due to the practice of puddling for transplanted rice. A plough pan may retard the growing of dry land rabi crops. Projects leading to increased transplanted rice cultivation may lead to increased areas with plough pan.

#### 9.3.6.3 Fertility

Intensive use of soils of the project area will create a demand for proper soil management practices. This is all the more valid for projects with a higher proportion of HYVs. Unless proper attention is given to this aspect, such intensive land use may affect the fertility of the soil.

#### 9.3.6.4 Micronutrient Deficiency

Growing wetland crops in the dry season in the project area may lead to a continuous wet condition of the soil. This may lead to deficiencies of micronutrients, especially zinc and sulphur that results in reduced yield per unit area.

#### 9.3.6.5 Loss of Irrigation Water

Use of irrigation water in light textured soils may result in water loss through seepage and percolation. This water may accumulate in basins, creating waterlogged conditions.

#### 9.3.6.6 Soil Salinity

Soil salinity may be reduced when coastal region soils are protected from saline water inundation by tidal flooding, but these soils may become strongly acidic over time from the development of acidic sulfates.

#### 9.3.6.7 Contamination of Surface Water and Groundwater

Indiscriminate and continuous application of harmful pesticides may contaminate surface water and groundwater.

### 9.3.7 Mitigation

The negative impacts of project interventions on soils include development of a plough pan, degradation in soil fertility, micronutrient deficiency, loss of irrigation water, increased acidity in soils protected from saline water inundation and contamination of surface water and groundwater. The following mitigation measures may rectify these negative impacts of project interventions on the soil.

#### 9.3.7.1 Plough Pan

Adequate tillage (knifing) is needed to open up plough pans for satisfactory growth of rabi crops. However, total breakdown of the plough pan must be avoided for rice cultivation under wetland conditions.

#### 9.3.7.2 Soil Fertility

Soil fertility can be maintained, even under intensive cultivation practices, through intensive use of organic manures, judicious and balanced application of fertilizers, green manuring and occasional flushing by operating the regulators. The rotating of leguminous crops with rice is also of value.

#### 9.3.7.3 Micronutrient Deficiencies

Growing of one dry land crop between two wetland rice crops will create occasional drier soil conditions, which helps avoid micronutrient deficiencies. Applying chemical fertilizers to micronutrient-deficient soils will overcome the problem.

#### 9.3.7.4 Loss of Irrigation Water

Better soil and water management practices and lining of irrigation canals can prevent high percolation losses of coarse textured soils and seepage losses in irrigation canals.

#### 9.3.7.5 Acidity in Saline Soils

Proper liming is needed to reduce acidity in saline soils.

#### 9.3.7.6 Contamination of Surface Water and Groundwater

Judicious application of less harmful pesticides with increased adoption of integrated pest management practices can reduce contamination of surface water and groundwater. Judicious and balanced doses of fertilizers are also essential.

### 9.3.8 Monitoring

The impact of the project should be monitored to assess the achievement of intended benefits and the need for adjustments in the mitigation plan. The following aspects should be included in the monitoring program.

#### 9.3.8.1 Changes in Soil Phase

To monitor changes in soil phase, staff gauges should be installed to record flood depths at specific locations.

#### 9.3.8.2 Soil Fertility

Soil samples should be collected from fixed points and depths and analyzed at regular intervals to check for any change in its chemical properties.

#### 9.3.8.3 Micronutrient Deficiency

Soil samples should be collected from irrigated basin soils from fixed depths and analyzed for micronutrient content.

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#### 9.3.8.4 Contamination of Surface Water and Groundwater

Surface water and groundwater samples should be collected and analyzed for possible contamination.

## 9.4 Agriculture

### 9.4.1 Baseline Studies

Baseline studies in agriculture are usually a component part of the project feasibility studies. Additional information may be required for the EIA to link agricultural land use to potential positive and negative land, fisheries, wildlife and social impacts. Agricultural baseline studies typically cover the following:

- area under different cropping patterns by land type;
- area under individual crops;
- inputs, including human and animal labor;
- crop damage;
- normal and damaged yield level; and
- crop production.

### 9.4.2 Existing Data Sources

Data are available from the publications of Bangladesh Bureau of Statistics (BBS). Data on areas under different crops and their production by thana are in the Thana Statistics series and the Bangladesh Census Report of Agriculture and Livestock (latest version is for 1983-84). Crop data from BBS are available only through 1982-83 and are reported by thana, so the area boundaries may not coincide with the boundaries of the project under study (which often cut across several thanas). Similar types of information are available in the thana-level office of the Department of Agricultural Extension (DAE), but these cannot officially be used since BBS has the final authority of publishing agricultural statistics.

### 9.4.3 Primary Data Collection

Cropping pattern data are best obtained from the land use survey of the project area (Section 9.2). An alternate procedure is to collect agricultural data through rapid rural appraisal (RRA). This could be done along traverses selected to represent the different land types and classes of farmers. Groups of farmers should be gathered on different land types in each traverse and interviewed. The data collected should include: cropping patterns by land type, area and extent of crop damage, yield level, input use, irrigation, agricultural labor use, etc. Sample data collection sheets are illustrated in Figures 9.2 through 9.6.

### 9.4.4 Maps and Mapping

Agricultural land use and cropping patterns are best shown in conjunction with the land use mapping (Section 9.2.5) unless the amount of detail requires separate maps for the sake of clarity.

### 9.4.5 Data Analysis

Data gathered from the field should be analyzed and tabulated to compile the information described in the following sections.

#### 9.4.5.1 Cropping Pattern by Land Type

The weighted average percentage of each cropping pattern on different land types should be computed from the data collected on Data Collection Sheet 1 (Figure 9.2). Net cultivated area under each land type should be multiplied by the percentage appearing against each cropping pattern in order to determine the absolute area in each case. Areas under different cropping patterns may be presented in tabular form (Table 9.6).

#### 9.4.5.2 Areas Under Individual Crops

Areas under individual crops should be computed from the cropping pattern table (Table 9.6).

#### 9.4.5.3 Crop Areas Under Irrigation

The amount of area irrigated for each crop type should be generated from the data collected on Data Collection Sheet 5. Information on irrigation equipment should be used to compute area irrigated from surface water and groundwater sources.

*Data Collection Sheet 1*: Cropping Patterns by Land Type

| Land Type | Kharif-1 | Kharif-2 | Rabi | % Coverage |
|---|---|---|---|---|
| $F_0$ | | | | |
| | | | | |
| | | | | |
| | | | Total | 100.0 |
| $F_1$ | | | | |
| | | | | |
| | | | | |
| | | | Total | 100.0 |
| $F_2$ | | | | |
| | | | | |
| | | | | |
| | | | Total | 100.0 |
| $F_3$ | | | | |
| | | | | |
| | | | | |
| | | | Total | 100.0 |
| $F_4$ | | | | |
| | | | | |
| | | | | |
| | | | Total | 100.0 |

**Figure 9.2 Example of Field Data Sheet for Cropping Patterns by Land Type**

*Data Collection Sheet 2:* Crop Damage

| Crop | Percent of Area Damaged | Normal Crop Yield (tonnes/ha) | Damaged Crop Yield (tonnes/ha) | Cause of Damage | Frequency of Occurrence |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**Figure 9.3 Example of Field Data Sheet for Recording Crop Damage**

*Data Collection Sheet 3:* Agricultural Inputs

| | | Fertilizers | | | | Pesticides | |
|---|---|---|---|---|---|---|---|
| Crop | Seed | Manure | Urea | TSP/MP | Other | Liquid | Granular |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**Figure 9.4 Example of Field Data Sheet for Recording Agricultural Inputs**

*Data Collection Sheet 4:* Human and Animal Labor Use per Hectare

| Operation | Crop 1 Man - Animal Days - Days | Crop 2 Man - Animal Days - Days | Crop 3 Man - Animal Days - Days | etc. |
|---|---|---|---|---|
| Seedling Raising | | | | |
| Land Preparation | | | | |
| Sowing | | | | |
| Transplanting | | | | |
| Thinning/Raking | | | | |
| Weeding: 1 | | | | |
| Weeding: 2 | | | | |
| Weeding: 3 | | | | |
| Fertilizer Application | | | | |
| Pesticide Application | | | | |
| Harvesting | | | | |
| Carrying | | | | |
| Threshing | | | | |
| Fibre Extraction | | | | |
| Winnowing and Drying | | | | |
| TOTALS | | | | |

**Figure 9.5 Example of Field Data Sheet for Recording Human and Animal Labor Use**

*Data Collection Sheet 5:* Modewise and Cropwise Irrigation

| Village/Union/ Thana | Mode* | Equipment Number | Irrigated Area per Equipment (ha) | Type of Crop Irrigated | Total Area Irrigated (ha) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

*Low-lift pump (LLP), shallow tube well (STW), deep tube well (DTW), traditional, etc.

**Figure 9.6 Example of Field Data Sheet for Recording Irrigation Use**

**Table 9.6 Cropping Patterns by Land Type**

| | Cropping Pattern | | | |
|---|---|---|---|---|
| **Land Type** | **Kharif-1** | **Kharif-2** | **Rabi** | **Area (ha)** |
| $F_0$ | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| Totals | | | | |
| $F_1$ | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| Totals | | | | |
| $F_2$ | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| Totals | | | | |
| $F_3$ | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| | - | - | - | - |
| Totals | | | | |

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#### 9.4.5.4 Crop Damage

The area of crop damage should be generated by multiplying the total area of each crop by the weighted average percentage of damage to that particular crop calculated from Data Collection Sheet 2.

#### 9.4.5.5 Normal and Damaged Yield of Crops per Unit Area

Weight average normal and damaged yield ("damaged yield" is the colloquial term for yield obtained from a damaged crop) per unit area for each crop should be generated from the information on yield obtained with Data Collection Sheet 2.

#### 9.4.5.6 Production of Rice and Non-Rice Crops

The normal area under each crop should be multiplied by the weighted average normal yield and the estimated damaged area per crop should be multiplied by the weighted average damaged yield. These two sets of data should be added for computing total production of all types of rice and non-rice crops using the format in Table 9.7.

#### 9.4.5.7 Input Use

The average weighted level of inputs (seed, manure, all types of fertilizers, pesticides, human and animal labor) used in different crops should be computed from the data procured with Data Collection Sheets 3 and 4 (Figures 9.4 and 9.5).

#### 9.4.5.8 Agricultural Employment by Crop and Season

Agricultural employment by crop can be generated from the data gathered with Sheet 4. The team agronomist should identify the month when an agricultural operation of a crop is carried out and use the suggested format for showing monthly requirements of agricultural labor (Table 9.8). The total can be computed by multiplying the area by the amount of labor required per crop unit during the month and then adding the requirements during the month for all crops.

### 9.4.6 Impact Analysis

Impacts on agriculture are measured by changes in crop production, which are a function of changes in cropping pattern, crop type, level of crop damage, input use, etc. These should be compared with future production without any intervention over a given period (e.g. 20 years) so as to take upward or downward trends into consideration. Comparing post-project conditions with the baseline situation indirectly includes growth rate resulting from other factors as a benefit of the project, which is not correct.

The major impact of any intervention that brings about a change in area under different land types in the project area would be a change in cropping pattern. Possible increases in $F_0$ and $F_1$ land types

Table 9.7 Crop Production in the Project Area

| Crop Type | Damage-free production | | | Damaged area production | | | Total Production |
|---|---|---|---|---|---|---|---|
| | Area (ha) | Yield (t/ha) | Production (tons) | Area (ha) | Yield (t/ha) | Production (tons) | |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |

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Table 9.8 Agricultural Labor Requirements by Crop and Month

| Total Crop Area (ha) | Monthly Labor Requirement | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - |

are normally assumed to be associated with proportionate increases in area under cropping patterns practiced and crop varieties grown on those land types. Similarly, possible reduction in $F_2$ and $F_3$ area would result in reduced areas under cropping patterns practiced and crop varieties grown on those land types. The most practical and realistic approach would be to assume that patterns practiced by the farmers on problem- and damage-free pre-project $F_0$ and $F_1$ land would be adopted by neighboring farmers on identical land types under post-project conditions. The baseline proportion of HYVs and local varieties on each land type should be assumed to be maintained, rather than assuming that HYVs would be planted on 100 percent of the potentially suitable area. This approach indirectly takes care of the socioeconomic factors that influence the farmer's decision-making process. It is essential to avoid overly optimistic projections as past experience shows that these are seldom achieved.

The level of inputs used by farmers on problem- and damage-free pre-project land should be considered as the expected use level for neighboring farmers under similar (post-project) conditions. It should not be expected that all farmers will use the recommended level of inputs. Similarly, the potential yield level of different crops and varieties should not be targeted. The yield levels achieved on problem- and damage-free pre-project land should achievable with identical conditions under post-project conditions. Likely damage to crops, albeit at a reduced rate, should be properly accounted for in impact analysis.

GIS can and should be used in impact analysis to generate post-project land type boundaries using polder water levels for different development options, then superimposing proportionate cropping pattern boundaries following the assumptions described above. The assumptions for input use, crop damage and yield level should be used for computing crop production for every option using GIS facilities.

### 9.4.7 Mitigation Strategies

Mitigation strategies for agricultural losses include support services such as agricultural extension, input supply, and integrated pest management.

### 9.4.8 Monitoring

Monitoring programs should be established to collect data on changes in cropping pattern, crop type, crop damage, input supply and use, yield level, agricultural extension service and integrated pest management under post-project conditions.

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# Chapter 10

# BIOLOGICAL RESOURCES

## 10.1 Capture Fisheries

### 10.1.1 Baseline Studies

Four studies are required to obtain baseline data and information to make an adequate assessment of project impacts on capture fisheries:

- limnological surveys to identify aquatic habitat types and collect data and information on limnological characteristics;
- household surveys to gather data and information on capture fisheries and the socioeconomic conditions of fishermen;
- surveys of fish landing centers and bazaars to obtain fish landing and marketing data and information, as well as data for the study of fish population and community structures;
- a survey of existing data and interviews with officers in district deputy commissioner offices and in district and thana fisheries offices, secretaries and members of fishermen's associations, local fishermen, and leaseholders to obtain information on fisheries management practices.

### 10.1.2 Existing Data Sources

Useful data on a variety of concerns related to fisheries and fish use may be obtained from the following sources in Bangladesh. The quality and quantity of data available may differ from one region or thana to another.

- Space Research and Remote Sensing Organization (SPARRSO): aerial photographs of surface water and villages.
- Department of Fisheries: annual catch statistics of open-water fisheries; statistics include catches by districts and by types of aquatic habitats.
- Thana offices: names and locations of villages (fisherman villages) and lists of households.
- District Deputy Commissioner Offices: data and information on fisheries management practices (the new fisheries management policy and the old short-term leasing system).
- District and thana fisheries offices: information on fishing practices, fisheries management, management intervention, and fishermen's associations.
- Bangladesh Water Development Board (BWDB): water flow data, and information on flood-control, irrigation and drainage projects.
- Scientific journals and publications: information on life history, population dynamics, habitat requirements, migratory behaviors, and general biology of fish.

### 10.1.3 Primary Data Collection

Reliable baseline data and information from the limnological, household and fish landing center and bazaar surveys are best collected over an 18 month period. A six-month reconnaissance phase and a 12-month study phase are recommended for acquiring biologically relevant and defensible data. The study phase should ideally cover a full hydrologic cycle. Fisheries management information need be collected only once in the reconnaissance phase.

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#### 10.1.3.1 Reconnaissance Phase

The reconnaissance phase comprises of the following steps.

1. Collect existing data and information required for the surveys.
2. Conduct literature survey to gather information relevant to the surveys.
3. Conduct field reconnaissance survey to verify the information collected and also to collect additional information required for designing and implementing the survey programs.
4. Design in detail the sampling schemes of the surveys, including sampling methodology and data collection procedures.
5. Test the data collection methods and procedures in the field.

#### 10.1.3.2 Limnological Survey

The recommended survey design procedure consists of the following steps:

1. Collect from existing data sources information on types and distribution of aquatic habitats, sources of pollution, and other environmental modification.
2. Conduct literature survey to collect information relevant to the limnological survey.
3. Conduct a field reconnaissance survey to verify the information obtained and to collect general ecological data (size, depth, soil types, vegetation, shore conditions, etc.) of each type of aquatic habitat.
4. Establish six to eight sampling stations representing ecological characteristics for each type of habitat.
5. Design the sampling scheme including sampling frequency and sampling methods.
6. Implement the scheme in the study phase.

Data collection procedures are as follows:

- collect water samples weekly with procedures and analytical methods described in Sections 8.2 (Surface Water) and 8.4 (Water Quality).
- conduct vertical sampling with plankton net to collect phytoplankton and zooplankton, set sampling frequency at one week, make a duplicate sampling at each station, preserve the samples in 5 percent formalin water solution, and quantify them later in the laboratory.
- conduct monthly sampling by diver to collect macrophytes, collect duplicate samples of 1 $m^2$ area of substrate at each station, sort the samples by species, and quantify them.
- conduct monthly sampling with an Ekmann dredge to collect three samples of bottom substrate at each station, screen the samples with the US Standard No. 30 sieve to collect benthos, preserve the benthos samples in 15 percent formalin water solution, sort them by species, and quantify them.
- collect bottom soil from the dredge samples of benthos study for chemical analysis.

#### 10.1.3.3 Household Survey

The recommended survey design procedure is as follows:

1. Collect from existing sources data and information required for the survey;
2. Conduct a field reconnaissance survey to verify existing information and to collect additional information required for designing and implementing a sampling scheme;
3. Design in detail the sampling schemes, including selection of study villages and study households, and a define a procedure for data collection for fisheries and socioeconomic condition of fishermen;
4. Test the data collection procedure in the field, and improve its methodology and operation procedure; and
5. Implement the sampling scheme in the study phase.

The recommended procedure for selecting study villages is:

- obtain names, locations and distribution of villages and lists of households in the

project area from thana offices;
- select about 30 villages randomly;
- conduct a field reconnaissance survey to verify the selected villages;
- conduct a full household census to determine the number of households in each of the selected villages;
- estimate mean and variance of the number of households in the selected villages;
- based on the mean and variance, determine the number of study villages required at an acceptable sampling error;
- select randomly the number of study villages required; and
- establish a list of household names in each study villages as the household sampling frame.

Generally, similar approaches can be used for selecting study households.

- Estimate the number of major domains (sub-populations) by category of fisherman and by type of gear; e.g., three categories of fishermen and five major types of gear make 15 major domains;
- Use the sample size of 30 as the number of fishermen to interview for each domain to estimate the initial sample size, e.g., the sample size is 450 (30 x 15) for 15 domains;
- Assuming 50 percent of study households are fishing households and each household has an average of 1.5 fishermen fishing 1.5 days in the last three days (2.25 fisherman-days), estimate the total number of study households required for all major domains; e.g., the sample size of 450 needs 400 study households;
- Allocate the number of study households to the study villages in proportion to the village sizes (number of population);
- From the household sampling frame, randomly select the allocated number of households as the initial study households;
- Collect data from the initial study households in the reconnaissance phase and adjust the number, if required, and then implement it in the study phase.

The procedure for collecting fisheries data is as follows.

- Conduct data collection monthly;
- For each month complete data collection for all study households;
- Visit each study household and obtain the address, name of household head and number of household members;
- Ask whether any member(s) of the household engaged in fishing today, yesterday and the day before yesterday;
- For a household that did not engage in fishing in the last three days, ask whether there are fishermen in the household, then stop the interview;
- For a household where members did engage in fishing in the last three days, obtain fisheries and catch information on each day.
- The information to be collected is:
  - name of fisherman
  - category of fisherman
  - fishing date
  - location of fishing ground (inside or outside the project area)
  - types of fishing grounds (river, floodplain, canal, *beel*, *haor*, *baor*, etc.)
  - type of gear
  - number of fishermen in fishing unit
  - daily fishing hours
  - daily total catch (all species combined) and relative size
  - daily catch by species and size
  - daily individual share of catches.

The procedure for collecting socioeconomic data is as follows.

- Conduct the socioeconomic survey only once in the first month of the study phase;
- Collect socioeconomic data simultaneously with the collection of fisheries data by attaching socioeconomic questionnaires to fisheries questionnaires;
- Collect data from all study households,

including fisherman households and non-fisherman households;

- Socioeconomic data to be collected are:
  - number of household members
  - name, age, sex and education of each member
  - religion
  - number of fishermen
  - assets (value of house, fishing boat, gear, land, pond, livestock, etc.)
  - type, interest rate and source of loan and indebtedness.

#### 10.1.3.4 Landing Center and Bazaar Survey

The suggested survey design procedure is as follows.

1. Conduct a reconnaissance survey to locate fish landing centers and local bazaars;
2. Identify landing centers and types of bazaars (daily bazaar and weekly bazaar), and their locations and fish landing periods;
3. Determine the number of fish landing periods of each center and bazaar in a given month.
4. Design in detail the sampling scheme for fish landings periods and a data collection procedure;
5. Test the sampling method and data collection procedure in the field;
6. Implement the sampling scheme in the study phase.

The procedure for selecting study landing periods is:

- establish a landing period table listing names and types of landing centers and bazaars, and the hours of daily landing periods in a given month;
- use systematic sampling method with constant time intervals (day) to select about 30 landing periods from the table for each of the centers and bazaars. The sampling must provide an equal opportunity for each landing period to be sampled.

The procedure for collecting data for estimating fish landings during a landing period is:

- interview all fishermen upon their arrival with daily catches and get information on their fishing ground;
- obtain names, categories of fishermen, and types of gear used for all of those fishermen fishing in the project area;
- collect catch data from the first arrival to the next new arrival (skip those between) from the beginning to the end of the landing period;
- catch data consists of the weight (kg) of each species in the catch and the total catch.

The procedure for collecting data for the study of fish populations during landing periods is:

- collect data once a month for commercially and ecologically important species;
- measure the length and weight of about 200 individual fish of each species from catches of non-selective or less selective gear;
- determine the sex of the fish. For small species, preserve the samples in 15 percent formalin water solution and bring them back to the laboratory for analysis.

#### 10.1.3.5 Collection of Fisheries Management Information

The procedure for the collection of fisheries management information consists of the following steps.

1. Collect information on water bodies under old short-term leasing system from district deputy commissioner offices and district fisheries offices. The information to be collected is:
   - location and type of each of the leased water bodies;
   - leaseholder's name and address;
   - leasing period;

- auction practice;
- auction price (revenue collected);
- leasing frequency.

2. Interview leaseholders to obtain information about:
   - fishing practices;
   - benefit sharing with fishermen;
   - fishing period;
   - benefit.
3. Collect information on water bodies under the new fisheries management policy (also from district deputy commissioner offices and district fisheries offices). The information to be collected is:
   - name and location of the water bodies;
   - management practice;
   - types and number of fishing licenses;
   - costs of licenses;
   - fishermen's associations managing fisheries;
   - fishing period;
   - fisheries resource conservation practices;
   - revenue collection.
4. Interview secretaries and some members of fishermen's associations to obtain information about:
   - number of fishermen in the association;
   - fishing practices;
   - costs and benefits for management systems (interview fishermen associated with the new fisheries management policy and the old leasing system to obtain information on the impacts of the two management systems on their incomes and livelihood).
5. Obtain information from district fisheries offices about management interventions such as fish stocking programs and enforcement of fishing regulations.
6. Collect all available information on subsistence fishing.

### 10.1.4 Maps and Mapping

The EIA should include maps displaying:

- distribution of aquatic habitats, villages, and study villages in the project area;
- locations of sampling stations for the limnological survey;
- distribution of fish landing centers and local bazaars; and
- distribution of water bodies practicing the new fisheries management policy and the old short-term leasing system.

### 10.1.5 Data Analysis

#### 10.1.5.1 Limnological Survey

- Determine the types of aquatic habitats.
- For *beels*, determine types (permanent or temporary), their number and total areas.
- For floodplain and river, estimate monthly mean surface area and depth.
- Plot the surface area and depth against time (month) to establish the hydrologic cycle,
- According to the hydrologic cycle, determine the flooding period including the time inundation starts, peak of flooding, and the time water recedes.
- Plot each of limnological parameters against time (month) to establish seasonal cycle and compare them with the hydrologic cycle.
- Determine limnological parameters associated with the hydrologic cycle.
- Determine limnological parameters that have been affected by pollution and environmental alternation.

#### 10.1.5.2 Household Surveys

Estimate fisherman population and composition.

- Tabulate the total number of residents and number of different categories of fishermen in each of the study villages.
- Estimate mean number of total residents and mean number of each category of fishermen per study village.
- Estimate total population in the project area by multiplying the mean number of total residents per study village by the total number of villages.
- Estimate the population of each category of fishermen in the project area by multi-

plying the mean number of the fishermen per study village of that category by the total number of villages.

- Calculate the percentage composition of different categories of fishermen in the project area.

Estimate the number of fishing gears.

- Separate the data collected from the study households according to the categories of fishermen.
- For each category of fisherman, determine types of gear used and tabulate their numbers.
- Estimate total number of each type of gear used by each category of fisherman in the project area by multiplying the number obtained from the study households by the ratio between the total population in the project area and the total residents in the study households.
- Determine the percentage composition of gear types used by different categories of fishermen.

Estimate catch per unit of effort (CPUE).

- CPUE is defined as the quantity of fish (in kg) caught per fisherman per gear per day (catch/fisherman/gear/day); the catch is total catch of all species combined or catch by species.
- Based on the data collected in a given month, separate the study households into fishing households and non-fishing households.
- For the fishing households, estimate CPUE for each fisherman on each fishing day.
- Separate the CPUEs into domains (sub-populations) by categories of fishermen and by types of gear; and
- Estimate mean CPUE for each domain for the given month.

Estimate fishing intensity.

- Fishing intensity in this study is defined as the total number of fishing efforts (number of fisherman-gear-days) in the project area for a specific period of time (day, month and year).
- Estimate daily fishing intensity for each domain by multiplying the sample size of the domain, the ratio of the total population in the project area and the number of residents in the study households.
- Estimate monthly fishing intensity by multiplying the daily fishing intensity by the number of days in the month (number of fisherman-gear-days).

Estimate fish production.

- Fish production is total fish catch (in kg) by fisheries in the project area in a specific period of time.
- Estimate daily fish production of each domain and all domains combined in a given month by multiply the mean CPUE and their daily fishing intensity.
- Estimate monthly fish production by multiplying the daily fish production and the number of days in the given month.
- Estimate annual fish production by summing 12-month fish productions.

Analyze socioeconomic information. Determine percentage compositions of fisherman households, each category of fisherman household and non-fisherman household from the study households. For each category of fisherman household and non-fisherman household, determine or estimate the following.

- Average number of household members.
- Average number of dependents per household.
- Male/female ratio.
- Number and percentage composition of religion groups.
- Daily mean fish and meat intakes (grams per capita).
- Percentage composition of ownership of house, fishing boat, gear, land, pond, and livestock.
- Mean assets per household.

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- Daily mean income per capita and per household.
- Mean amount of loan and indebtedness per household.
- Types of loan and indebtedness and their interest rates.
- Compare the above socioeconomic structures between fisherman households and non-fisherman households, and among the different categories of fisherman households.

#### 10.1.5.3 Fish Landing Centers and Bazaar Surveys

Estimate fish landing periods.

- Separate the data into fish landing centers, daily bazaars and weekly bazaars.
- Estimate the number of their landing periods in a given month.

Estimate fish landing intensity.

- Fish landing intensity is the number of fishing units landing their daily catches from the project area at fish landing centers or bazaars during a specific period of time (day or month).
- Estimate mean daily landing intensity (number of fisherman-gear/landing period/day) for each domain and all domains combined from data collected from the study landing periods in a given month.
- Estimate monthly landing intensity by multiplying the mean daily intensity and the total number of landing periods in the given month.

Estimate fish landings.

- Estimate mean daily fish landings (kg) per landing period (kg/landing period/day) for each domain and all domain combined in a given month for the landing centers and bazaars.
- Estimate monthly fish landings by multiplying the mean landing per landing period and the total number of landing periods in the month.

Fish community and population structure.

- Using fish landing data, establish monthly changes in fish community structure and occurrence of species in relation to hydrologic cycle to identify the floodplain-resident and -dependent species, and to determine their floodplain resident periods and possible their floodplain-related migratory behavior.
- Using the length data, establish the monthly length frequency distribution of species and its relationship to the hydrologic cycle to determine the growth and life stage of immigration and/or emigration of the floodplain-dependent species; and
- Establish the time-gonad relationship to determine the spawning time and its relation to hydrologic cycle to identify the spawning migratory behavior of floodplain-dependent species.

### 10.1.6 Impact Analysis

#### 10.1.6.1 Impacts on Aquatic Habitats

Changes in aquatic habitats can be projected from the data on monthly changes in the area and depth (m) of each type of aquatic habitat and the sources of inundation water (river or rain). Based on consideration of the intervention, i.e., engineering structure and/or operation, the estimated or predicted changes (loss or decrease) of the following should be made.

- Changes in land types due to changes in flooding patterns (see Chapter 6).
- Area and depth of each type of aquatic habitat during the peak flooding period;
- Time of onset (delay) of inundation and amounts of intake water from adjacent river during the early monsoon season.
- Period of flooding during the monsoon season.
- Time of water receding in the post-monsoon season.

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- Water retention period and amount of the retention in *beels*, *haors* and *baors* during the dry season.
- Possible modification of limnological characteristics.

#### 10.1.6.2 Impacts on Fish and Fisheries

Loss of fish recruitment.

- Using the delay in time of onset and the duration of inundation of river water in the early monsoon (April to July), estimate the loss of fish production due to possible failure of recruitment of floodplain-dependent species (adults spawn in the river and larvae or juveniles enter the floodplain with inundating river water).
- Use the loss or decrease in the water areas, particularly *beels*, in the dry season to estimate possible changes (decrease) in fish production due to the decrease in recruitment of the floodplain-resident species.

Changes in fish production.

- As the fish production in a water body is proportionate to the water surface area and depth, estimate the change in fish production due to change in the area and depth of each type of habitat (change in areas of fishing ground).
- Estimate changes (loss of gain) in fish production of floodplain-resident species due to the limnological modification of aquatic habitats.
- Estimate the loss of fish production due to shortening the growth period of fish and fishing periods as the result of shortening the flooding period.

Changes in fish species and diversity.

Use the predicted changes in aquatic habitats, limnological characteristics, recruitment and fish production to estimate or predict:

- loss of species (diversity), particularly rare and endangered species;
- changes in fish community and population structures.

#### 10.1.6.3 Impacts on Fish Markets

Assume that changes in fish landings are directly proportional to changes in fish production, calculate the change (usually loss) in fish landings at landing centers and bazaars; and estimate possible changes in local fish supply and prices.

#### 10.1.6.4 Impacts on Fishery Management

Using the loss and/or modification of fishing grounds (aquatic habitats) and their associated changes in fish production and fish community structure, estimate:

- changes from *jalmahal* fishery to agricultural land;
- possible decrease in benefits of leaseholders and revenues of the government from water bodies under the leasing system and its impact on the leasing practice;
- decrease in license fee, number of licenses to issue etc. for the new fisheries management policy;
- impacts of the loss of species (diversity) on the conservation practice.

#### 10.1.6.5 Impacts on Socioeconomic Conditions

Estimate the impact of changes (loss) in fish catches of fishermen in the following categories:

- family income;
- fisherman population;
- unemployment;
- nutritional (fish) intake, particularly for occasional fishermen;
- indebtedness among religion and caste groups.

### 10.1.7 Mitigation

A number of potential mitigation strategies for reducing fishery losses can be considered.

- establishing controlled floodplain(s) in the project area for open-water fisheries.
- developing fish and aquatic sanctuaries (protected from fishing) to maintain species diversity and natural fish stocks in the parts of controlled floodplains.
- designing fish passages in engineering structures, particularly for fish larvae and prawn juveniles.
- stocking fish inside the project area to enhance production.
- implementing the New Fisheries Management Policy to protect fish stocks and provide a livelihood for fishermen of limited resources.

#### 10.1.8 Monitoring

A fisheries and aquatic resources monitoring program should cover the construction period and at least the first two years of operation following construction. Monitoring procedures should consist of the same survey, data collection and analysis techniques applied in the limnological survey, the household survey and the fish landing center and market survey.

### 10.2 Culture Fisheries

#### 10.2.1 Baseline studies

Pond surveys for assessment of culture fisheries are best undertaken at the end of the dry season.

#### 10.2.2 Existing Data Sources

The Bangladesh Department of Fisheries maintains annual fish catch records. This data includes the type, number, total area of ponds and production of fish by types of ponds and districts. Thana fisheries officers maintain records and a knowledge of culture fisheries operations in their areas. Aerial photographs of study areas are useful sources of primary data on the location and number of small water bodies, some of which will be used for culture fisheries.

#### 10.2.3 Primary Data Collection

For primary data on the location, number and type of fish culture ponds, proceed as follows.

1. Obtain mauza (land ownership registration) maps from thana offices, and aerial photographs of the project area
2. Count the number of mauzas in the project area from the mauza maps;
3. Identify the mauzas where the study villages of the household survey are located; use them as the study mauzas for the pond survey.
4. Count the number of ponds in each of the study mauzas from the aerial photographs.
5. Calculate the mean and variance of the number of ponds in the study mauzas and determine the sample size (number of mauzas) required for acceptable sampling error. Adjust the sample size, if required.
6. Set the initial sample size of study ponds at 200 to sample enough for three types of ponds and two social groups (3 types of ponds x 2 social groups x 30 ponds = 180 ponds);
7. Calculate the proportion of the study ponds and total ponds in the study mauzas. Use this proportion as the sampling interval (the number of ponds to visit between two sample ponds):
   - conduct an intensive field survey at the end of the dry season (February-April).
   - establish the survey route from aerial photos, and visit and count all existing ponds in each study mauza.
   - pick up a sample pond at each sampling interval, measure its size and collect the following data from the pond owner.

*Fish culture activities:*

- number and names of owners.
- type of pond (culture, potentially culturable and derelict).
- reason for dereliction (flooding, lack of capital, ownership problem, etc.).

- reason for idling culturable pond (lack of capital, ownership problem, lack of culture technology, etc.).
- source of water (river or rain) for inundation of derelict and culturable ponds.
- culture practice (species, stocked, stocking ratio, stocking density, fertilization, culture period, harvest time, etc.).
- total fish production (kg) and fish production by species for the year.

*Socioeconomic conditions:*

Use the same questionnaire as used for open-water capture fisheries.

#### 10.2.4 Maps and Mapping

EIA maps should indicate the distribution of culture fish ponds, including potentially culturable and derelict ponds (relative to flooding).

#### 10.2.5 Data Analysis

The total number of ponds should be computed.

- estimate mean number of each type of pond per study mauza.
- estimate total number of each type of pond in the project area by multiplying the mean number per mauza in the study area by the total number of mauzas in the project area.
- estimate the total number of ponds in the project area by summing the numbers of three types of ponds.

The overall surface area of ponds should be calculated.

- estimate the mean area of each type of pond from the sample ponds in the study mauzas.
- estimate the total area of each type of pond in the project area by multiplying the mean area and the total number of that pond type in the project area.

Fish production from culture facilities is estimated as follows.

- estimate total fish productivity (kg/ha) (all species combined) and productivity by species for each type of pond by dividing total fish production by the total area for the pond type.
- estimate fish production of each type of pond in the project area by multiplying its fish productivity and its total area in the project area.
- estimate total fish production from the ponds in the project area by summing the production of three types of ponds.

The number of derelict ponds and culturable ponds receiving inundated water from adjacent rivers and canals, and those from rain water, should be computed or estimated. The fish culture practices of farmers in the area should be summarized from the questionnaire data collected. The socioeconomic structure and condition should be described, and a comparison made of the various types of pond owners belonging to different social groups.

#### 10.2.6 Impact Analysis

For changes in underground water level, and of sources of water for inundation (river or rain water), estimate:

- loss of fish production for culture ponds due to drying up or to water shortage caused by decreasing groundwater levels.
- loss of fish production for culturable and derelict ponds due to loss of natural recruitment from rivers.
- number and area of derelict ponds to become culturable due to decrease in flooding.

#### 10.2.7 Mitigation

Some mitigation approaches to reducing any expected losses to culture fisheries operations include:

- enhancing fish production in culture ponds by providing extension services to improve cultivation technology;
- constructing wells to provide water for culture ponds affected by the project;
- promoting fish culture in culturable ponds by setting up an incentive management policy and providing financial assistance and extension services; and
- converting derelict ponds into culture ponds.

### 10.2.8 Monitoring

Pond surveys should be conducted once a year at the end of dry season during the construction period and for the first two years after construction. Data to be collected and their collection method and procedures are similar to those used in the baseline studies.

## 10.3 Forests and Homestead Vegetation

### 10.3.1 Baseline Studies

Forest cover in an area may comprise natural forests and/or plantations, and should be characterized by:

- general distribution within the area, by forest type if necessary;
- uniformity (evenly distributed, bunched in one region, etc.);
- total area;
- percent of land cover;
- trends (increases/decreases);
- flood-susceptible species;
- socioeconomic importance; and
- products and uses (in terms of local, regional or national importance and including fuel wood, timber, wildlife, tourism, etc.).

Forest values should be stated in terms of economic value, volumes of products and number of users, as well as in trends of these values.

If, following the scoping process (see Section 3.3) the forest resources of the area are considered to have significant socioeconomic importance as measured by the complete spectrum of values indicated above, the following information should be obtained.

- Continuity: sizes and shapes of parcels; minimum, average and maximum sizes; types of land between; trends.
- Forest types: use a conventional classification (see Section 10.3.2); successional stage.
- Species composition and diversity: dominants and co-dominants (if any); important shrub and ground cover species; trends.
- Morphology: general structure of each type of forest in terms of height, canopy continuity, layers and undergrowth.
- Ecological relationships: soil associations, climate, topography, flooding, drought and drainage.
- Ownership and management: regulatory basis for management; uses and abuses; actual management (if any); problems and trends.

Woody and herbaceous vegetation maintained within homesteads constitute important personal, local and regional resources. The EIA should characterize this resource in terms of:

- flood susceptible species;
- general distribution within the area: percent coverage; relationship to population;
- individual characteristics: average size, layout, number of trees per homestead family;
- species composition: percent, average number;
- vegetables: types, areas per land holding;
- ecological relationships and artificial inputs: planting, chemicals; irrigation; relationship to flooding cycle;
- socioeconomic and ecological importance: products extracted, volumes, disposition, value; wildlife use.

### 10.3.2 Existing Data Sources

- *Forest Classification*

Champion, H.G., and S.K. Seth. 1968. A revised survey of the forest types of India. Forest Research Institute, Dhera Dun, Delhi 6, India.

Choudhury, A.M. 1981. Wood and wood products: Bangladesh country paper on government policies and procedures for joint venture industries for ESCAP trade cooperation group venture.

Kamaluddin, M. 1984. Forest ecology. Khanjan Maha, Chittagong University, Chittagong. (Chapter on Forests types of Bangladesh.

Hossain, M. 1991. Agriculture in Bangladesh: performance, problems and prospects. University Press Limited, Dhaka.

- *Tree, Shrub and Other Plant Identification*

Alam, M.K., N.A. Siddiqui and S.Das. 1985. Fodder trees of Bangladesh. Bangladesh Forest Research Institute, Chittagong.

Davidson, J. 1985. Species and Sites. UNDP/FAO Project BGD/79/0110.

Hooker, J.D. 1872-1896 (revised first time in 1973 also in 1975). Flora of British India (vol. 1-7). Bishen Singh and & Mahendra Pal Singh, Dhera Dun, India, and L.Reeve & Co., Kent, U.K.

Huq, A.M. 1986. Plant Names of Bangladesh. Bangladesh National Herbarium/BARC, Dhaka.

Kamaluddin, M. 1984. Forest ecology. Khanjan Maha, Chittagong. (Chapter on Forest types of Bangladesh.

Khan, M.S., and Halim. 1987. Aquatic angiosperms of Bangladesh. Bangladesh National Herbarium/BARC, Dhaka.

Mukherji, H. 1960. Plant groups. Central Library, Calcutta, India.

National Academy of Sciences. 1980. Firewood Crops: Shrub and tree species for energy production. National Academy of Sciences, Washington D.C.

Prain, D. 1903 (revised in 1963 and 1981). Bengal plants (Vols. 1 & 2). Bishen Singh & Mahendra Pal Singh, Dhera Dun, India, and L. Reeve & Co., Kent, U.K.

Tiwari, K.M., and R.V. Singh. 1984. Social forestry plantations. Oxford Publishers Co., New Delhi, India.

- *Homestead Forests and Vegetation*

Abedin, M.Z., C.K. Lai and M.O. Ali. 1988. Homestead plantations and agroforestry in Bangladesh. BARI/RWEDP/Winrock International, Dhaka.

Khandakar, K. 1991. Homestead agroforestry in Bangladesh and its development. BFRI, Chittagong

Rahman, M.M., M.H.Khan, R.N. Mallick and R.E. Hudgens. 1989. Guidelines for farming systems research methodology. BARC, Dhaka.

- *Agencies Concerned with Forests and Homestead Vegetation*
  - Bangladesh Agricultural Research Council
  - Bangladesh Agricultural Research Institute
  - Bangladesh Agricultural University
  - Forest Research Institute
  - Department of Agricultural Extension
  - Forest Department
  - Institute of Forests, Chittagong University
  - National Herbarium

- *NGOs*
  - Proshika Manobik Unnayan Kendra
  - Bangladesh Rural Advancement Committee (BRAC)
  - Poribesh Unnayan Shangstha (POUSH)

### 10.3.3 Primary Data Collection

A preliminary land use map, indicating forested areas, should be prepared from remote sensing imagery. This map will provide an idea of the distribution and size of forests. Areas selected for field study should be those that appear to represent the complete spectrum of forest variation in the area. Enough time should be spent in each of the study areas to obtain a complete picture of the forest tract. The following characteristics should be noted.

- *Morphology*: structure, height, percentage distribution of trunk diameters (by species); uniformity of age (presence of juveniles); canopy continuity; openings and clearings; undergrowth and ground cover. Representative photos should be taken and carefully documented.
- *Species composition*: all species present should be documented in the field or herbarium specimens should be collected for subsequent identification; edge species should be distinguished from those in the forest interior; juveniles should be identified (indicative of regeneration and succession).
- *Condition and use*: primary use for wood, fuel, cash, food; secondary use for sheds, shelter, erosion control; lopping and pruning for fodder and fuel; die-off or insect damage; clearing for agriculture, grazing, or homesteads (determined by observation or interview); livestock incursion (with or without herders); wildlife use.
- *Management activities*: determine by observation or interview; incursion by public infrastructures (roads, canals, borrow areas, military, etc.)

#### 10.3.4 Maps and Mapping

Land use mapping of the project area usually includes forest cover, roadside plantations and forested areas of villages and associated homestead forests. These categories may suffice for the baseline and project impact discussions of the EIA unless a particular forest type has special importance and is likely to be affected by the project. Homestead vegetation is normally a prominent feature on aerial photographs and is easily mapped.

#### 10.3.5 Data Analysis

The forest resources of the project area should be described in terms that indicate their ecological, social and economic value. For most forest areas, the quantitative data required for such an evaluation are lacking, and detailed field study is beyond the level of effort and the time normally allotted to the EIA. Available data should be used to provide the following descriptions.

- comparison of the project area resources with forests in a wider area, e.g., district, in terms of average tree size, biodiversity and extent of management.
- ecological value of the forest should be indicated by the wildlife sustained by it, both in biodiversity and biomass.

The social importance of the forest should be evaluated by one or more means. Both of the main data sources indicated above should be utilized. The socioeconomic survey should be able to provide some quantitative data on the role of the forest in the lives of local people. This is likely to include fuel wood, construction timber (including fenceposts), food and/or medicinal products. Biomass energy values should be expressed in terms of the volume of fuel wood or other products extracted or the number of people extracting them.

Biodiversity indices may be useful if forests or homestead vegetation are considered especially susceptible to project effects and require more quantitative appraisal. Such indices require determination of the number of individuals of each species present, calculation of the fraction of the total population, and expression to the log base *e*. This requires considerable field time and generally is not feasible on a regional scale. A general indication of diversity may be obtained by considering simply the number of species present, bearing in mind that a forest tract dominated by one species is less diverse that one in which the same species is more evenly represented among a number of others.

### 10.3.6 Impact Analysis

Direct and indirect impacts of water management interventions on forests and homestead vegetation should be analyzed with respect to increases or decreases of roadside plantations, homestead forest cover, homestead plantations and vegetable gardens. Secondary effects on availability of fodder, fuel, food and cash crops should also be analyzed. Linkages between development and forests and vegetation normally involve intensification of agriculture, increase in human population and pressure on vegetation resources, changes in groundwater and surface water availability, and decreased or increased soil fertility. Changes in inputs such as fertilizer and pesticides should be considered.

### 10.3.7 Mitigation

Steps to conserve and protect forest cover include sound forest management practices such as strict enforcement of forest protection measures, controlled cutting and afforestation. Social forestry measures aimed at using roadsides and embankments for plantation establishment and management should be encouraged. Homestead vegetation, as a privately owned resource, is usually well conserved under project implementation conditions, but villagers benefit from forest and horticultural extension programs.

### 10.3.8 Monitoring

Monitoring of newly established plantations associated with project implementation, e.g., along embankments and new roads, should be an integral part of the long-term environmental management plan for the project. The objective should be to provide data and information on the establishment and growth rates of new plantations, their productivity and protection status, so that appropriate management and protection measures can be instituted in timely fashion.

## 10.4 Wetlands

The term "wetland" comprises a wide range of inland, coastal and marine habitats sharing a number of common features. The Convention on Wetlands of International Importance (Ramsar Convention 1971), to which Bangladesh is now a signatory, defines wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine waters, the depth of which at low tide does not exceed 6m." Another useful definition is that used by CARE Bangladesh: "land that retains an excess of water for a frequency and duration sufficient to support organisms adapted to life in inundated or saturated soil conditions.

In Bangladesh the permanent and seasonal freshwater lakes and marshes of the floodplains are known as *haors*, *baors* and *beels*. *Haors* are bowl-shaped depressions between the natural levees of a river, or a succession of such depressions, which are filled every year by the monsoon floods; most retain some water throughout the dry season. *Baors* are abandoned cut-off river channels, converted to static water bodies (oxbow lakes). *Beels* are usually saucer-like depressions that generally retain water throughout the year. Many become overgrown with marshy vegetation during the dry season, and a few completely dry out. Wetland areas in Bangladesh fluctuate considerably from the dry to the wet season.

### 10.4.1 Baseline Studies

The information required to determine the effects of a project on a wetland area and evaluate its importance is described in the following sections.

#### 10.4.1.1 Classification and Characterization

The distribution of wetlands and their contours should be examined, with special reference to inundation and surface water flows, depth/time distribution of inundation, the source of water (overbank flooding from rivers, rainfall, runoff from rainfall, irrigation return flows, etc.), and the direction and duration of outflow. The seasonal maximum and minimum areas of various water depths in dry, average, and wet years should be determined, with special emphasis on areas of 0 to 200 cm depth, as these are the parts of the wetland where most of the primary productivity takes place.

Various classifications of wetlands have been used in Asia (Asian Wetlands Bureau 1989, IUCN 1989), but they have yet to be applied to Bangladesh conditions. A useful and recommended classification for EIA purposes (Table 10.1) is derived from the land type classification used in agriculture and elsewhere (Section 9.1)

As with land types, the classification is based on a 1 in 5 year flooding level with a minimum duration of three days.

Wetland areas can be identified and measured on satellite imagery and aerial photographs, but complete classification and habitat assessment requires ground truthing. Since wetlands are very dynamic in nature, repetitive sampling at least one-month intervals is normally required from mid May to mid October for adequate assessment.

#### 10.4.1.2 Water Quality

Water quality is one of the major factors determining wetland productivity. Water quality parameters determined during the study period should include the physical, chemical and biological characteristics described in Section 8.4. That section also describes the field and laboratory testing procedures for water quality.

#### 10.4.1.3 Primary and Secondary Production

More important than a complete cataloguing of flora and fauna is the identification of ecologically, socially or economically important species and determination of how their life cycles are linked to hydrologic conditions.

**Plankton**

The emphasis should be given to measuring the abundance of some indicative beneficial or harmful plankton (e.g., crustaceans = a group of zooplankton providing food for fish; *Mycrocystis* spp. = phytoplankton that forms algae blooms and produces a toxin that prevents the growth of other beneficial plankton). Water samples should be taken in each of the major seasons and preserved in 3 to 5 percent formalin solution. The samples should be examined by a microbiologist as early as possible. Common plankton species can be readily identified in the field with the help of portable microscopes.

**Macroinvertebrates**

Annelids and insect larvae are the most important benthic fauna that should be assessed. Agricultural, urban and industrial runoff inhibits the growth of such species. Mollusks are one of the main food sources for waterfowl. Macroinvertebrates should be collected from the bottom soil using an Ekmann grab. Samples should be washed and sieved through different mesh sizes to separate out species for identification.

**Macrophytes**

The presence of obligate hydrophytic plants is among the best indicators of long-term wetland conditions. Some uses of macrophytes are:

- fuel (e.g., *Ipomea* spp.)
- building materials (timber, reeds)
- grazing and browsing (e.g., *Hygorriza*

**Table 10.1 Wetland Classification System Based on the MPO Land Classification System**

| Wetland Type | Flooding Depth (cm) | Nature of Flooding | Description |
|---|---|---|---|
| $W_p$ | Variable | Permanent | Beels, haors, baors, etc. |
| $W_1$ | 1.8 - 3m | Seasonal | Flooded lowland |
| $W_2$ | 0.9 - 1.8m | Seasonal | Flooded medium lowland |
| $W_3$ | $\leq$ 0.9m | Seasonal | Flooded medium highland |

spp., facilitate cattle feed)
- aquatic food chains
- terrestrial food chains
- pest species (*Eichornia* spp.)
- human consumption (*Nymphaea* spp.)
- household works and handcraft

**Higher Secondary Producers**

See Sections 10.1 and 10.2 (fisheries) and 10.5 (wildlife).

Certain animals are obligate wetland users and are more likely than more adaptable species to be affected by wetland changes. These include most herons, waterfowl (ducks, geese), shorebirds (waders), kingfishers and otters. Others need some access to wetlands at certain times of year. The role of each wetland area in the regional and local capture fisheries should be carefully examined.

### 10.4.2 Existing Data Sources


Anonymous. 1992. Action programme for the conservation of wetlands in south and west Asia. AWB, Kuala Lumpur and IWRB, Slimbridge.

Asian Development Bank. 1990. Environmental and natural resources management—a sector review. Environment Division, Asian Development Bank.

AWB (Asian Wetland Bureau). 1989. A directory of Asian wetlands. Kuala Lumpur, Malaysia.

Ministry of Environment and Forest, and United Nations Development Programme. 1991. National Environment Management Plan—an action plan for Bangladesh. Second Draft.

IUCN—The World Conservation Union. 1990. Wetland conservation: a review of current issues and required action. p.96.

IUCN—The World Conservation Union. 1989. Rapid assessment of areas of environmental concern (Bangladesh). Gland, Switzerland.

IUCN—The World Conservation Union. 1987. Bangladesh: Directory of Indomalayan protected areas. Draft ms.

RAMSAR. 1990. Report of the Working Group on Criteria and Wise Use. Ramsar Bureau, Gland Switzerland.

Scott, D.A. 1989. Design of wetland data sheet for database on Ramsar sites. Ramsar.

World Resources Institute. 1990. Bangladesh: environment and natural resource assessment. Final report prepared for USAID.


- *Government Agencies*
  - Ministry of Environment and Forests (MOEF): responsible for overall environmental policy issues;
  - Department of Environment: technical arm of the ministry and responsible for environmental planning, management, monitoring and enforcement;
  - Forest Department: responsible for the management and development of wetlands, the management of protected areas and wildlife conservation; wildlife conservation capabilities were essentially abolished in 1983, one remaining individual in this department now maintains the government's interest in wildlife; there is no specific legislation relating to wetland conservation;
  - Department of Fisheries: protection and management of fish, shares responsibility for conservation and management of wetlands;
  - Bangladesh Water Development Board: flood control, irrigation and drainage;
  - Ministry of Land Administration and Land Reform, Department of Revenue: allocates and distributes land and leases fishing rights to private individuals;
  - Space And Remote Sensing Research Organization (SPARRSO): various image analyses including an inventory of wetland areas done in 1983-84 (SPARRSO 1985) on the basis of Landsat imagery.

- *NGOs*
  - Asian Wetland Bureau (AWB) based in Kuala Lumpur, Malaysia;
  - International Waterfowl and Wetland Research Bureau (IWRB), Slimbridge, U.K.

### 10.4.3 Primary Data Collection

If the wetlands are large or of known importance, substantial field study may be required in order to delineate, evaluate and characterize them. This should be planned into the whole series of environmental field studies, including the data collection programs in related areas (hydrology, fisheries, socioeconomic conditions).

*Flora*: Field studies should be conducted during wet and dry conditions. At both times boat transportation is required. A candidate list of obligate hydrophytic plants may be compiled from the literature, using the known flora of the nearest similar wetland, and used in the field. Such plants are likely to include cattails, sedges, many rushes, pond weeds, water lilies, and some grasses. If a plant cannot be identified in the field in terms of species or water requirements, an herbarium specimen should be taken. Local people are likely to be able to identify the plant (by common name) and indicate its importance.

*Fauna*: The mobility of higher animals and their ability to hide makes a complete inventory of animal species time-consuming and usually unreliable. Nevertheless, an attempt should be made to evaluate the use of the wetland by birds and mammals. The following procedures are recommended.

- Field visits of several days' duration should be made, preferably by a team of three or four persons. Some of these should be local hunters or fishermen, if possible. Tentative field lists should be made, supplemented by photographs, when possible. These lists should be compared with lists in the literature in order to identify improbable or special species. In some cases (as when an endangered species is seen) verification may be necessary.
- From the literature, the ecological requirements of the important species should be determined. From these, the potential impacts of the project intervention will be predicted.

### 10.4.4 Maps and Mapping

The major wetland areas should be identified on a map showing project area water bodies. The scale of that map may not be sufficient to show all of the characteristics of the wetland, e.g., topography, maximum and minimum water surface areas, inflow and outflow, ecologically critical areas, human use, and existing water quality problems. If the wetland as a whole is considered to have substantial social or ecological importance, one or more special maps should be presented, in order to show clearly these characteristics.

It may also be desirable to diagram some characteristic of the wetland, e.g., water inflow/outflow, nutrient cycles, or the relationship of fauna to the hydrologic cycle, in order to support subsequent discussion of impacts.

### 10.4.5 Data Analysis

Data on wetlands require analysis and presentation in standard fashion (i.e., maps, graphs and tables. Of cardinal value are data that indicate the dynamic relationships of wetland quantity and quality to the hydrologic cycle and to land use in the project area.

### 10.4.6 Impact Analysis

- *Direct Effects* result from changes in the hydrology and the demand for resources, e.g., soil, which might be taken from the wetland. Depending on the topography, the area may be broken into several smaller wetlands. If the water volume of the existing system can be determined and the inflow/outflow characteristics quantified, it should be possible to predict the limits of the wetland under with-project conditions.

- *Indirect effects* should be identified and evaluated on the basis of predicted direct effects. Habitat changes can be estimated through the knowledge of plant soil/water requirements. These changes will result in altered carrying capacity for various categories (and individual species) of fish and wildlife. For the analysis of these effects, see Sections 10.5 (Wildlife), 10.1 and 10.2 (Fisheries). The prediction of altered carrying capacity should take into consideration anticipated changes in water quality, stemming from altered assimilation capacities, waste loads, and drainage.

Wetlands may be affected by water sector activities in several ways:

- changes in the hydrologic cycle
  - reduced inflow, affecting water level, hence area of coverage
  - altered drainage, usually planned to ensure full drainage, reducing wetland coverage and amount of perennial wetlands;
- changes in water quality
  - formation of algae bloom
  - siltation decreases with reduced river inflows
  - siltation may increase with increased agricultural runoff
  - eutrophication following increased nutrient inflow
  - contamination by organic wastes from farms and homesteads;
- changes in land use and/or topography
  - borrowing of soil for embankments may create or expand wetlands (but usually rather deep ponds with steep edge contours)
  - embankments at the periphery of wetlands may inhibit drainage
  - recession zone is converted from seasonal wetland to permanent agriculture.
- changes in wetland biology:
  - change of species composition (e.g., water hyacinth infestation, change in the population of migratory birds);
  - Morphological/physiological changes (e.g., dyeing of dry parts of water hyacinth leaves);
  - Loss of species from the project area (e.g., loss of endangered/threatened species of fish/wildlife;
  - Outbreaks of fish disease;
  - decaying aquatic vegetation due to sudden reduction in flood inflows;

Prediction of the magnitude and significance of these impacts will depend on an understanding of the hydrology, ecology, and social importance of the wetland, which should result from properly conducted baseline studies (Section 10.4.1, above) and on the identification of aspects of the proposed intervention that are likely to exert effects.

### 10.4.7 Mitigation

There are two categories of mitigation: altering the design or operation of the project, or altering the environment to compensate for project actions. Both approaches may be applied to wetlands.

- *Alteration of the Project*: Controlled flooding can be used to ensure that the most important regions of a wetland are preserved. In general, some secondary water control structures are needed to retain water where it is needed. In some cases it is necessary to channel the inflow to the part of the wetland where habitat protection is most needed. Most projects, including those with submersible embankments, do not contain structures for the deliberate, controlled admission of water to protected areas, and alterations in project design would be required. However, in most cases this capability could be added at little cost and an existing waterway can be used to convey water into the wetland.
- *Compensatory Mitigation*: Actions to protect the ecological integrity of a wetland without affecting project design should be evaluated. Involvement of the local people (and/or regular visitors) using the resource is impera-

tive, since most wetlands are considered common property. All the relevant government agencies must be involved, e.g., Ministry of Land for leasing arrangements, Department of Fisheries for fish harvesting, Department of Forestry for wildlife, etc. Actions to be considered are as follows.

- *Zoning* the wetland for certain uses, including a no-use zone as a refuge for wildlife and fish. Enforcement of the zoning restrictions will be required. The local fishermen, reed cutters, fuel wood cutters, and others who enter the wetland to extract resources must participate in management decisions and activities, and must understand the need for long-term management.
- *Active management* of fisheries is needed to stabilize production and ensure equitable distribution of benefits. Generally the post-project wetland has a lower production capacity than the pre-project system, but the existing wetland may be so poorly managed and overexploited that good management practices will allow the extraction of as good or better fish crop. Actions considered should include limiting licenses, controlling gear (e.g., gill net sizes), limiting catch sizes, stocking of fry or fingerlings and, above all, enforcing the law.
- *Limitations* on the cutting of plant material to replacement levels can only be achieved through self regulation by the cutters. Plant production may be enhanced by planting, providing the planted areas are protected from grazing and premature cutting.

#### 10.4.8 Monitoring

A monitoring program should cover the project construction period and the first two to three years of operation. The procedures should consists of the same survey status applied in the baseline survey. Special attention should be given to quality improvement or declines in wetland productivity. The indicators mentioned above can be used for rapid assessment during the monitoring period.

## 10.5 Wildlife

### 10.5.1 Baseline Studies

#### 10.5.1.1 Habitats

The major categories of wildlife habitat in the project area should be described and quantified, where possible, in terms of total area and average plot size and shape. The interrelationships of habitat types should be analyzed and described, if they have wildlife importance. A mosaic of two or more types of habitat may be highly important for some species and unusable for others.

The following categories of habitat should be the minimum subdivisions used:

- wetlands (see Section 10.4);
- floodplain habitats;
- forest habitats:
  - mangrove forests;
  - open forest (may be divisible into deciduous and evergreen, may include some scrub formations);
  - closed canopy forest (same subdivisions);
  - village forests (see Section 10.3);
  - plantation forests.
- ecotones (especially edges of agricultural areas and around village forested areas).

Floodplain habitats may conveniently be classified into ecological zones, corresponding to land types (see Section 9.1).

The ecological characteristics of each habitat type in the project area should be described, including:

- environmental resource requirements (soils, water, temperature, nutrients, etc.)
- morphology (height, density, shape of plant dominants)
- dominant plant species (e.g., sal forest, cattail marsh)
- biodiversity in general terms.

#### 10.5.1.2 Species

The baseline study should concentrate on species deemed to have some special local, national or international importance. Such species fall into one or more of the following categories.

- *Ecologically Important Species*: numerically dominant or occupy key positions in the ecosystem as predators, insectivores or urban scavengers.
- *Game and Commercial Species*: their social or economic significance is based on their being hunted for meat, fur, hides, or other parts. The hunting may be illegal but of local importance.
- *Pest Species*: designated as pests because of activities considered inimicable to human interests. In some areas, an animal designated as a "pest" (sometimes unjustifiably so) is one that is revered and protected by the international community. The following categories should be examined:
  - crop pests (including those which attack stored crops)
  - burrowing rodents (damaging to embankments)
  - noxious or dangerous animals (e.g., poisonous snakes)
  - Reservoirs of human disease (e.g., rabies).
- *Endangered or Threatened Species*: listed in the IUCN Red Data books (Tables 10.2 and 10.3). Some of these species are regular or occasional visitors to Bangladesh. See also the lists of protected wildlife in Bangladesh (ISPAN 1992).

### 10.5.2 Existing Data Sources

Useful references for wildlife in Bangladesh include the following.

- *Birds*

Ali, S., and S.D. Ripley. 1983. A pictorial guide to the birds of the Indian Subcontinent. Bombay Natural History Society. 171 pp.

Forest Department, Government of Bangladesh. 1974. Wet lands and water birds of Bangladesh. Dhaka.

Harvey, W.G. 1990. Birds in Bangladesh. Dhaka Univ. Press, 188 pp.

- *Mammals*

IUCN. 1971 *et seq.* Red Data Books. [listed by taxonomic group]

Prater, S.H. 1980. The book of Indian mammals. Bombay Natural History Society.

Khan, M.A.R. 1985. Mammals of Bangladesh. Dhaka University, Dhaka. (*a checklist*)

- *Reptiles*

Daniels, J.C. 1983. The book of Indian reptiles. Bombay Natural History Society. 1141 pp.

- *General*

Khan, M.A.R. 1982. Wildlife of Bangladesh. Dhaka University, Dhaka. (*a checklist*)

Sarker, S.U. 1988. Checklist of wildlife of Bangladesh.

- *Other*

Bangladesh Bureau of Statistics. Statistics on forested areas and homestead forests provide some data on wildlife habitats.

- *Government Agencies*
  - Forest Department: responsible for the management and development of forests and wetlands, the management of protected areas and wildlife conservation; wildlife conservation capabilities were essentially abolished in 1983, one remaining individual in this department now maintains the government's interest in wildlife; there is no specific legislation relating to wetland conservation;
  - Forest Research Institute (FRI), Chittagong: research documentation on wildlife;
  - National Herbarium: plant lists, publications on flora.

Table 10.2 Threatened Wildlife Species in Bangladesh

| Scientific Name | Common Name | Status* |
|---|---|---|
| | **MAMMALS** | |
| *Hylobates hoolock* | Hoolock Gibbon | V |
| *Caprolagus hispidus* | Hispid Hare | E |
| *Platanista gangetica* | Ganges River Dolphin | V |
| *Orcaella brevirostris* | Irrawaddy Dolphin | K |
| *Cuon alpinus* | Dhole | V |
| *Vulpes bengalensis* | Bengal Fox | I |
| *Helarctos malayanus* | Sun Bear | V |
| *Melursus ursinus* | Sloth Bear | V |
| *Ursus thibetanus* | Asiatic Black Bear | V |
| *Aonyx cinerea* | Oriental Small-clawed Otter | K |
| *Lutra perspicillata* | Smooth-coated Otter | K |
| *Paradoxurus jerdoni* | Jerdon's Palm Civet | I |
| *Felis marmorata* | Marbled Cat | I |
| *Felis temmincki* | Asiatic Golden Cat | I |
| *Neofelis nebulosa* | Clouded Leopard | V |
| *Panthera pardus* | Leopard | T |
| *Panthera tigris* | Tiger | E |
| *Elephas maximus* | Indian Elephant | E |
| *Dugong dugong* | Dugong | V |
| *Didermocerus sumatrensis* | Sumatran Rhinoceros | Ex |
| *Rhinoceros sondaicus* | Javan Rhinoceros | Ex |
| *Rhinoceros unicornis* | Indian Rhinoceros | Ex |
| *Sus salvanius* | Pygmy Hog | E |
| *Cervus duvauceli* | Swamp Deer | Ex |
| *Bubalus bubalis* | Wild Buffalo | Ex |
| | **BIRDS** | |
| *Pelecanus philippensis* | Spot-billed Pelican | I |
| *Ardea imperialis* | White-bellied Heron | E |
| *Leptoptilos javanicus* | Lesser Adjutant | V |
| *Leptoptilos dubius* | Greater Adjutant | E |
| *Cairina scutulata* | White-winged Duck | V |

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Table 10.2 Threatened Wildlife Species (continued)

| Scientific Name | Common Name | Status* |
|---|---|---|
| *Rhodonessa caryophyllacea* | Pink-headed Duck | Ex |
| *Haliaeetus leucoryphus* | Pallas's Fish-eagle | R |
| *Francolinus gularis* | Swamp Francolin | V |
| *Perdicula manipurensis* | Manipur Bush Quail | R |
| *Houbaropsis bengalensis* | Bengal Florican | E |
| *Gallinago nemoricola* | Wood Snipe | I |
| *Columba punicea* | Pale-capped Pigeon | R |
| *Treron capellei* | Large Green Pigeon | V |
| *Athene blewitti* | Forest Owlet | Ex |
| *Alcedo hercules* | Blyth's Kingfisher | I |
| *Aceros nipalensis* | Rufous-necked Hornbill | R |
| *Pellorneum palustre* | Marsh Babbler | K |
| *Moupinia altirostris* | Jerdon's Babbler | V |
| *Paradoxornis flavirostris* | Black-breasted Parrotbill | I |
| *Paradoxornis ruficeps* | Rufous-headed Parrotbill | R |
| *Prinia burnesii* | Long-tailed Prinia | R |
| *Chaetornis striatus* | Bristled Grass Warbler | K |
| *Sitta formosa* | Beautiful Nuthatch | R |
| **REPTILES AND AMPHIBIANS** | | |
| *Chelonia mydas* | Green Turtle | E |
| *Eretmochelys imbricata* | Hawksbill Turtle | E |
| *Lepidochelys olivacea* | Olive or Pacific Ridley Turtle | E |
| *Dermochelys coriacea* | Leatherback | E |
| *Batagur baska* | River Terrapin | E |
| *Kachuga kachuga* | Red-crowned Roofed Turtle | I |
| *Kachuga sylhetensis* | Assam Roofed Turtle | I |
| *Melanochelys tricarinata* | Tricarinate Hill Turtle | I |
| *Indotestudo elongata* | Elongated Tortoise | K |
| *Trionyx nigricans* | Black Soft-shell Turtle | R |
| *Varanus flavescens* | Yellow Monitor | I |
| *Elachistodon westermanni* | Indian Egg-eating Snake | R |

Table 10.2 Threatened Wildlife Species (continued)

| Scientific Name | Common Name | Status* |
|---|---|---|
| *Crocodylus palustris* | Marsh Crocodile | V |
| *Crocodylus porosus* | Estuarine Crocodile | V |
| *Gavialis gangeticus* | Gharial | E |

Source: IUCN 1990

*Status according to the IUCN classification as follows:

Ex-Extinct: Species not found in the wild during the past 50 years (criterion used by the Convention on International Trade in Endangered Species of Wild Fauna and Flora).

E-Endangered: Taxa in danger of extinction and whose survival is unlikely if the cuasal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that are possibly already extinct but have definitely been seen in the wild in the past 50 years.

V-Vulnerable: Taxa believed likely to move into the "Endangered" category in the near future if the causal factors continue operating. Includes taxa of which most or all the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security has not yet been assured; and taxa with populations that are still abundant but are threatened by severe adverse factors throughout their range.

In practice, "Endangered" and "Vulnerable" categories may include, temporarily, taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category.

T-Threatened: A general term to denote species that are "Endangered," "Vulnerable," "Rare," "Indeterminate," or "Insufficiently Known." This term, used by IUCN to identify taxa comprised of several sub-taxa with differing status categories, should not be confused with the use of the same term by the U.S. Office of Endangered Species.

R-Rare: Taxa with small world populations that are not presently "Endangered" or "Vulnerable," but are at risk. These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

I-Indeterminate: Taxa *known* to be "Endangered," "Vulnerable" or "Rare" but for which there is not enough information to say which of the three categories is appropriate.

K-Insufficiently known: Taxa that are suspected but not definitely known to belong to any of the above categories, because of lack of information.

K* Taxa which are currently under review and which will be designated a category in the near future.

CT-Commercially threatened: Taxa not currently threatened with extinction, but most or all of whose populations are threatened as a sustainable commercial resource, or will become so, unless their exploitation is regulated. This category applies only to taxa whose populations are assumed to be relatively large. In practice, this category has only been used for marine species of commercial importance that are being overfished in several parts of their ranges.

Table 10.3 Tentative List of Threatened and Endangered Plant Species

| Serial No. | Scientific Name | Local Name | Probable Causes |
|---|---|---|---|
| 1 | *Acanthophippium sylhetense* | -- | Homestead Damage |
| 2 | *Aeschynanthus parasiticus* | Alok Jhar | Homestead Damage |
| 3 | *Aglaonema clarkey* | -- | Homestead Damage |
| 4 | *Aldrovanda vesiculosa* | Balanka Jhangi | Homestead Damage |
| 5 | *Aquillaria agalocha* | Agor Gus | Deforestation |
| 6 | *Centrantherum anthalminticum* | Shomraj | Over Exploitation |
| 7 | *Cirrhopetalum roxburghii* | - | Deforestation |
| 8 | *Cycas pectinata* | Moniraj | Over Exploitation and Deforestation |
| 9 | *Cymbopogon osmastonii* | Gondhi Ghus | Homestead Damage |
| 10 | *Dehaasia kurzii* | Modon Mosto | Over Exploitation |
| 11 | *Dendrobium formosun* | Bokphul Orchid | Homestead Damage |
| 12 | *D. chrysotaxum* | -- | Over Exploitation |
| 13 | *Elaeocarpus lucidus* | Bamun | Deforestation |
| 14 | *Eulophia mackinnonii* | Bhumi Orchid | Homestead Damage |
| 15 | *Gloriosa superba* | Olot Chandal | Over Exploitation |
| 16 | *Gynocardia odorata* | Chal Mugra | Over Exploitation |
| 17 | *Hipporcardia macrantha* | -- | Rare Existence |
| 18 | *Homalium schlichtii* | -- | Rare Existence |
| 19 | *Justicia orephylla* | Choto Arusa | -- |
| 20 | *Knema bengalensis* | -- | Deforestation |
| 21 | *Limnophila cana* | -- | Homestead Damage |
| 22 | *Mangifera sylvatica* | Jongili Aam | Deforestation and Homestead Damage |
| 23 | *Mantisia saltatoria* | Nritta Rata Ramoni | Deforestation |
| 24 | *M. spanthulata* | -- | Deforestation |
| 25 | *Marsdenia tinctoria* | Roiongo | Over Exploitation |
| 26 | *Phajus trancarvaillae* | -- | Homestead Damage |
| 27 | *Phrynium imbricatum* | Pitul Pata | Rare Existence |
| 28 | *Quercus acuminata* | Kanta/K ali Batana | Deforestation |
| 29 | *Rotala simpliciuscula* | - | Homestead Damage |
| 30 | *Sageraea listeri king* | Dhamon | Rare Existence |
| 31 | *Semicarpus subpanduriformis* | -- | Deforestation |

(continued)

Table 10.3 Threatened and Endangered Plant Species (continued)

| Serial No. | Scientific Name | Local Name | Probable Causes |
|---|---|---|---|
| 32 | *Sonneratia griffithii* | -- | Deforestation |
| 33 | *Spatholobus listeri* | -- | Rare Existence |
| 34 | *Strophanthus wallichii* | Strpen Gus | Deforestation |
| 35 | *Vanilla parishii* | -- | Rare Existence |
| 36 | *Vatica scaphula* | -- | Deforestation |
| 37 | *Vernonia thomsoni* | -- | Homestead Damage |

Source: IUCN, 1991

### 10.5.3 Primary Data Collection

The mobility of wildlife, especially birds, makes generating a complete wildlife list a difficult undertaking. Nevertheless, the EIA should contain an indication of whether the project area supports exceptional, average or meager wildlife resources and whether such resources are important to the local population, or are of special national or international importance. The following steps should produce the required information at a reasonable level of effort.

#### 10.5.3.1 Survey Initiation

From the literature sources listed above and any others readily available, draw up a hypothetical list of wildlife that might be in the area, on the basis of known habitat and distribution. List threatened and endangered species and those likely to be important as game or pests. Indicate seasonal occurrence and probable abundance, if these can be determined.

Use available aerial photographs and satellite imagery to prepare field maps (see Chapter 12).

#### 10.5.3.2 Field Surveys

July through December is the optimal period for wildlife observations in Bangladesh. Basic habitat units should be selected for sampling based on the classifications described in Section 10.5.1.1 and standard statistical approaches to ensure adequate sampling. The size of sampling units should be selected according to the distribution and size of the habitat, e.g., entire homestead forest clumps, entire small *beels* and *haors*, selected shoreline sections for large *haors* or large uniform forested areas, etc.

It is seldom feasible to attempt estimates of population densities or size. A practical approach is to use an abundance scale (i.e., abundant, present, scarce, etc.), which should be defined for the benefit of reviewers, and which should be estimated for each uniform habitat sampling unit.

Local hunters, fishermen and forest officers are likely to know local wildlife and should be consulted. Illustrated guides are required as the local names often do not fit scientifically accepted species. Local people may fail to recognize a familiar species from a painting or will identify it as a similar species that is much less likely to occur in the area.

Describe the status and ecology of the major species groups in the project area. A tabular presentation should be made, supported by maps. The text should contain a full discussion of how wildlife populations relate to the habitat types and how these in turn relate to flood levels and to land use management.

### 10.5.4 Maps and Mapping

The EIA should contain one or more maps showing the areas where wildlife constitute an important resource. These should be used to supplement the text. If rats are crop pests throughout the area, it is not necessary to show this on a map. Wildlife species or groups that are tightly linked to a single habitat (e.g., waterfowl to wetlands) need not be mapped separately if all parts of that habitat support the group equally. If not, it may be best to superimpose an indication of important wildlife use on the habitat or land use map.

### 10.5.5 Data Analysis

Most wildlife data collected on EIA field reconnaissance surveys are qualitative or semi-quantitative. Detailed statistical analysis is usually not feasible, but species lists and abundance ratings for the various habitat types should be examined for variation and similarities; non-parametric statistics are frequently useful in testing for significant differences between habitat types. It should be expected that there will be large differences in abundance for some species (those with a narrow ecological amplitude having value as "indicators" of certain habitats and habitat conditions), while others will be approximately equally abundant over several habitat types (wide ecological amplitude).

### 10.5.6 Impact Analysis

Wildlife populations are seriously influenced by habitat condition, with each species reacting in its own way to changes in its habitat. Some species also are seriously affected by human activities, such as hunting. Alterations in the habitat usually are accompanied by changes in the populations of a variety of animals. To predict such changes, one must understand the resource requirements of each species. Some general idea of a species' response may be gained by considering similar species or the species group as a whole. The resource requirements of tropical wildlife seldom are known with precision and estimates of habitat change rarely are quantitative at the species level.

When the area of a given habitat is decreased by a certain percentage, its ability to support a given species decreases by about the same amount. Rarely is the habitat simply reduced in area; there usually are qualitative changes such as fragmentation (often resulting in parcels below the acceptable minimum of some species). The ratio of interior habitat to edge is almost certain to change, and with it the populations of some species. For each species or species group an attempt should be made to determine the potential effects of project actions on habitat and other critical environmental variables.

- Reduction of wetland habitat reduces the carrying capacity for water birds and some mammals, due to:
  - reduction of food plants (usually in proportion to the amount of permanent water less than 2 m deep), affects primarily waterfowl.
  - reduction of food animals (frogs, fish). Affects herons, storks, kingfishers and otters.
  - disproportionate reduction in deep water areas more than a critical distance from shore (areas important to waterfowl for sleeping and loafing; increased vulnerability to shore-based disturbance).
- Reduction in biodiversity; conversion of multi-species natural ecosystems (mixed forest, grassland) to one-crop agriculture. Certain species are likely to become pests, due to:
  - abundance of food (when this was a pre-project limiting factor).
  - absence of predators.
- Provision of critical habitat components (or removal of a control) by some water development activities may cause some species to reach pest proportions.
  - embankments provide dry burrow sites for some rodents, which in turn may endanger the embankments.

### 10.5.7 Mitigation

Wildlife impacts involving habitat loss or changes are often difficult or impossible to control effectively since they involve competition for scarce resources. The most effective approach is likely to be an examination (as part of the baseline studies) of how the resource is managed and exploited under pre-project conditions. By devising better management of habitat without the project, one may develop sustained productivity under altered future conditions. The same principles applied to natural fisheries (Section 10.1) and forests (Section 10.3) may be applied to wildlife. Participation and cooperation of those using the resource is essential, and this is likely to require social organization, education, administration and enforcement. Some approaches to the maintenance of wildlife populations are as follows.

- Active habitat management: this means controlling the natural environmental factors that affect the quality of habitat through:
  - establishing plant species useful to wildlife or, conversely, avoiding or extracting species (e.g., *Eucalyptus*) that have little or no wildlife value.
  - supplementing environmentally deficient inputs (e.g., water) where the lack of it limits production.
- Consolidation: habitat fragmented by flood management activities may be enhanced by combining small parcels through purchase or swapping.
- Control of disturbance: if the local population can be persuaded (or forced) to refrain from intruding into wildlife habitat zones (perhaps only at critical times, such as the nesting season or at critical times of day, as when waterfowl are feeding), some of the impacts of reducing the available habitat area can be minimized. Similar control may have to be exerted on livestock.
- Control of extraction: it has always proven difficult in areas where population places high pressure on natural resources, to prevént illegal or excessive extraction of resources from public lands or commons, whether these resources are timber, fuel wood, game or anything else. Without such control, mitigation is impossible.

Sustained yield from wildlife populations may be achieved in many areas, at well above present levels of extraction, by:

- maintaining the production base at a high enough level to provide elevated output, i.e., preventing overextraction.
- enhancing natural replacement by artificial plantings; species provided should be selected to maintain biodiversity, not merely to produce a quick return.

#### 10.5.8 Monitoring

A monitoring program should be included in the EMP (Section 5.4) where wildlife habitats of high value are likely to be affected by project interventions. Monitoring programs should consist of repetitive field surveys as described above, carried out at key periods in the habitat-wildlife population cycle (e.g., peak migration period for waterfowl using specific wetlands). Monitoring should be linked closely to enhanced conservation measures for wildlife habitats, including enforcement of protective laws.

Chapter 11

# HUMAN RESOURCES

The purpose of the human resources section of an EIA is to describe the socio-demographic and socioeconomic characteristics of the project area, establish linkages between human and other resources and carry out a social impact analysis (SIA). In a water management context an SIA is primarily concerned with assessing how project impacts on land and water resources will affect the human communities that depend on those resources for their livelihoods.

A major social issue related to flood protection is the unequal distribution of benefits received and costs incurred by the human communities affected by flood control measures.

- where flood control measures are designed to benefit agriculture, the main beneficiaries may be the larger landholders, with fewer benefits and even some disbenefits distributed to groups lower on the social scale.
- poor households dependent on capture fishing are particularly vulnerable to flood interventions due to alterations in flooding cycles and river hydrology that disrupt fishing habitats, and also to the effects of fisheries leasing systems that affect traditional heritage rights.

It is the responsibility of the social scientists to research, assess and analyze all such potential effects of the project on the livelihoods of the program area population. To accomplish this task, social scientists on the EIA team have to work in an integrated process with three groups:

- local people directly affected by the program;
- other specialists on the EIA team;
- engineers and planners on the design team.

## 11.1 Socioeconomic

### 11.1.1 Baseline Studies

Baseline data on human resources should be collected both at the prefeasibility and feasibility stages. Given below are some of the methods of data collection at each stage.

#### 11.1.1.1 Prefeasibility Study

At the prefeasibility stage, data collection and analysis should be on a general scale. Both qualitative and quantitative information should be collected from primary (new) and secondary (existing) sources. A combination of several investigative techniques such as rapid rural appraisal (RRA), participatory rural appraisal (PRA) and household survey (HHS) can be followed to collect data on the following baseline conditions.

- a profile of all social groups that would be directly or indirectly (e.g., downstream communities) affected by the proposed program. The profile should include an estimate and identification of the number of households in each resource user group (e.g., cultivators, fisherfolk, etc.) and a description of the resources they depend upon.
- a general measure of resource dependence in the program area, e.g., crop harvests,

fish catches and other resources extracted.

- an analysis of how women function in all production systems and how scarce resources used by them can be affected by project interventions.
- description of the annual cycle of activities, particularly the agrarian calendar and the fishing calendar.
- identification and location of archaeological, historical and religious sites.
- identification of informal and customary rights to land use and to fishing sites.
- description of the village social organization including traditional organizations like *samajes*, etc.
- description of how authority, leadership and mediation (*salish*) are exercised and what capacity local organizations have to mediate the kinds of social conflicts that could emerge as a result of the project.
- identification and description of how groups, leaders and or government bodies exercise control over access and management of natural resources.

#### 11.1.1.2 Feasibility Study

The baseline for the feasibility study should be more extensive and provide quantitative data on the socio-demographic and socioeconomic conditions, as outlined in the EIA Guidelines (FPCO 1992). The data sources should be both primary and secondary. The findings from such a study should support conclusions and judgements on the possible impacts (positive and negative) by decision-makers. They can also be used by planners and monitors to judge the effectiveness of mitigation and compensation plans and their implementation.

### 11.1.2 Existing Data Sources

Useful data on issues relevant to human resources can be obtained from a variety of sources including government departments and ministries, donor agencies, NGOs and consulting firms. The Government of Bangladesh publishes a wide variety of official data, much of it in serial publications of the Bangladesh Bureau of Statistics (BBS). Other reference sources are as follows.

- Statistical Yearbook of Bangladesh (current volume): a compendium of data on all natural, social and economic sectors.
- Final Report of Bangladesh Population Census, 1981: useful for EIA studies are the District Series and the Thana/Community Series. The latter has socio-demographic data down to the mauza level.
- 1991 Population Census: field data collection for this census has been completed and initial reports may be available in 1992.
- Bangladesh Census of Agriculture and Livestock, 1983-1984: the Thana Series, which has landholding (by type and size) and livestock data down to the mauza level is the most useful for EIA work.
- Yearbook of Agricultural Statistics of Bangladesh: publishes cropping and yield data. It is useful for general reference and standards.
- Report on the Bangladesh Livestock Survey, 1983-84, (March 1986): resolved data down to the district level. The volume may be useful for historic reference.
- Bangladesh Census of Non-farm Economic Activities, 1986, (March 1990): district volumes contain data (to mauza level) on commercial, artisan, industrial, professional activities/occupations.

Other BBS publications that might provide useful information are as follows.

- Thana Statistics, Vols. I to III (land utilization and irrigation, agricultural output, minor crops, community level social data), latest data: 1987.
- Survey of Ponds, 1982.
- Bangladesh Mosque Census, 1983.
- Final Report on the Census of WAQF Estates, 1986.
- Socioeconomic Indicators of Bangladesh, (Second Edition), 1986.
- Rural Credit Survey of Bangladesh, 1987.
- Mauza Based Study of Rural Facilities,

1989: has data by mauza for police stations, *tahsil* office, hospitals/dispensaries, family planning clinics, veterinary clinics, schools, colleges, *hats*/bazaars, banks, post offices, and metalled roads. Data are given as distance in km from the mauza to the nearest such facility.

- Report on the Survey of Farm Forestry, 1988
- Report on Bangladesh Handloom Census, 1990
- Selected Statistics and Indicators on Demographic and Socioeconomic Situation of Women in Bangladesh. Proceedings of a National Workshop, Dhaka, May 29-30, 1989.
- Survey of Bangladesh: the Survey has topographical maps in fairly large scales: 1:7,000 ft.; 1:15,000; and 1: 50,000. Other maps are available with the Revenue Department (mauza and district maps), the BWDB (1:15,690 and 1:7,845 with 1 foot elevation contours), and the BIWTA. For other maps and series, and for sets of Bangladesh aerial photography, see: *GIS Resources in Bangladesh*, Draft Technical Report, Flood Action Plan, FAP 19 (June 1991).

Other sources of information are as follows.

- Floods and flood damage: check locally with the BWDB Executive Engineer at the district, or the Sub-divisional Engineer at the thana level to obtain reports on flood damage. Another source on flood damage and social disruption is the affected union parishad office.
- General, fish and livestock marketing: the records kept by market franchise holders and their toll collectors provide information on both the wholesale and retail movement of products through local markets.
- Fisheries management: for *jalmahals* above 20 acres, see ADC (Revenue) at the district level. For *jalmahals* between 3 and 20 acres, see the Thana Fisheries Officer, and for *jalmahals* below 3 acres, see the Union Chairman. The Bangladesh Rural Development Board (BRDB) has a program to develop fisheries cooperatives. Check with BRDB for cooperatives in the program area.
- Navigation system: check with the Bangladesh Inland Water Transport Authority (BIWTA) for passenger and freight data on large ferries. The BWDB also collects data on the use of rivers for transportation.

It is also worthwhile to check with local NGOs in the program area. Most NGOs do a socioeconomic baseline survey at the start of their program and update their information in subsequent periods.

Some of the libraries that can provide relevant information are:

- United States Agency for International Development (USAID)
- World Bank (WB)
- Food and Agriculture Organization (FAO)
- Centre For Integrated Rural Development For Asia And The Pacific (CIRDAP)
- Association of Development Agencies in Bangladesh (ADAB)
- Bangladesh Institute for Development Studies (BIDS)
- Water Resources Planning Organization (WARPO)
- Early Implementation Projects (EIP)
- Bangladesh Agricultural Research Institute (BARI)
- Bangladesh Rural Advancement Committee (BRAC)
- Bangladesh Academy of Rural Development, Comilla (BARD)
- Institute of Post Graduate Studies in Agriculture (IPSA)

### 11.1.3 Primary Data Collection

Primary (new) data collection should focus on obtaining more detailed and, where possible, quantitative information. This means systematic field data collection through a baseline socioeconomic survey (SES) or other investigative techniques. The information requirements of the socioeconomic baseline (Section 5 of the EIA Guidelines) and the prefeasibility study should relate to the size, scope, complexity and design of the proposed program. The SIA team should also use the integrated field seminar to help define the social, biophysical, and physical effects of the program.

As much as possible, data should be collected for a full annual cycle. This does not mean collecting data throughout the year, but data should be collected in each season of the year so that seasonally representative samples are available that can be extrapolated out for a full year.

There are a number of ways to collect primary data. Among them are the following.

- Household surveys (HHS): the collection of data through random and/or stratified sampling that is representative of the total universe. The method(s) and design(s) adopted for conducting HHS will depend on the nature, duration and purpose of the project. The socio-demographic and socio-economic data to be collected are already stated in the EIA Guidelines.
- Rapid rural appraisal (RRA): to supplement existing data, field surveys can be made by conducting an RRA in the project area. RRA techniques allow a fairly quick and effective perusal of an area by trained social scientists, who use trained observation, group and personal interviews, key informants, key indicators, and other simple tools to gain a comprehensive view of the main problems and general social trends in a program area.

A successful socioeconomic appraisal using RRA depends on the same elements and attitudes that make for success in involving local people in program appraisal and decision-making.

1. *Take Time to Prepare*: RRA teams must have an overall picture of the region to serve as a framework within which to interpret the information they gather. Several sources of information should prove useful.

   - Geographic Information System (FAP 19) and other maps, aerial photographs and satellite imagery.
   - Government statistics, district gazetteers, data accumulated by FCD, EIP, WARPO, FAP and academic studies. It is also important to look at project evaluation and monitoring reports for similar projects in the past.
   - Identify and consult with NGOs working in the proposed program area.

2. *Adopt a flexible approach*: depending on the magnitude and social complexity of a project, most RRAs can be completed in a month, but the duration should be flexible. To achieve optimal knowledge and appropriate precision, the following should prove useful.

   - Plan regular team meetings with multidisciplinary team members.
   - Develop a tentative work plan that ensures SIA team members cover all the major resource zones and social groups that depend on them for their livelihoods.
   - Keep working hours flexible to accommodate meetings with all socioeconomic groups.

3. *Recognize and offset biases in approach and attitude*: identify and consult with all the resource user groups in the area. Do not confine investigations to the nearest district town, thana, metalled road, or home of the local union parishad member. While in the field, as much as possible:

   - park the vehicle,
   - live in the program area, preferably in a village, and
   - travel by foot, bicycle, rickshaw or country boat.

4. *Carry out the RRA during the appropriate season*: if the contemplated program is a

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water management project, visit the program area during the flood season, as a dry season visit could implant unwitting biases in the appraisal that ignore or underestimate critical flood and drainage problems.

5. *Travel in the project area singly or in a small group*: do not pick up an entourage of local officials or notables. Strictly avoid formal meetings and be unimportant. Above all, approach the people with respect and appreciate their knowledge and wisdom.

- Listen and learn. Recognize that rural people have much valid knowledge about their environment and the resources they use. Be open to unexpected information and counter intuitive interpretations.
- Above all, ask local resource user groups to identify their needs, describe current social conditions including their perception of recent trends, major problems, and potential solutions.
- Use traditional scales of measurement or develop simple scales to quantify people's responses.

6. *Use multiple research strategies*: using more than one approach to research can help to cross-check information and identify social linkages that might not otherwise be perceived.

7. *Use participatory rural appraisal (PRA) methods*: PRA is a creative outgrowth of the RRA experience. It uncovers an enormous wealth of information in a very short time. PRA methods are successful because they are developed in the field by the villagers themselves. PRA/RRA methods may include:

- social/cultural mapping (social groups, homesteads, marriage networks, cultural and religious sites, social service outlets);
- transect walks and participatory transect walks (walks along a line or arc with key informants through a resource area or village);
- activity profiles and local histories (e.g., flood incidents).

8. *Use key indicators*: some methods, such as identifying and using key indicators, can reveal several variables to achieve a more general order or measurement which are of investigative concern. For example, a visual survey of house types (size and construction materials) would give an RRA team a rough feel for the relative levels of wealth in a village.

9. *Interviews*. These can be directed at groups or individuals, depending on the situation.

- Group interviews: group members should have the same economic and social standing, so that poorer or less powerful individuals are not forced to speak out in the presence of those who can do them social, political, or economic harm. A variation of the group interview is to convene specialized panels of local people who are knowledgeable on an aspect of resource use.
- One-on-one interviews: such interviews are more effective in eliciting social and economic information from the landless, poor women, religious minorities and ethnic groups.

10. *Direct observation*: this method provides a means of multiple checking on information about local customs, practices, activities and the interests of the people.

11. *Participant observation*: participant observation aids in interpreting the view/interests of the local people, especially those of the less advantaged groups, and provides some context for verbal reports based on those observations.

12. *Key informants*: local knowledgeable people, such as school teachers, journalists, lawyers,

doctors, development specialists, NGO staffer, leaders and religious teachers, often have valuable information about their area. They can also provide an insight into the kind of political dynamics that could affect the sustainability of the program.

13. *Aerial inspections and surveys*: this method can be used to supplement social and spatial information gathered on the ground or to direct ground investigators into new areas.

### 11.1.4 Maps and Mapping

Maps should accompany both prefeasibility and feasibility reports. Maps in the latter should be more detailed, since they will represent information gathered in the SES. For regional programs, it is better to have more maps with relatively simple data than to crowd a single map with too much information. Village maps can hold more information, as it is important to depict the spatial relationship between social indicators.

On a base map/maps showing land types, water bodies, and major infrastructures, the following information can be mapped:

- habitation sites, neighborhoods (paras);
- village boundaries (mauzas);
- resource areas such as *jalmahals* and other common property resources;
- areas where heritage rights obtain, all common resource and common access areas (includes rights to fishing areas);
- cultural properties (mosques, shrines, churches, temples, sacred trees/groves, historical and archaeological sites etc.);
- social services (schools, hospitals/dispensaries, government offices, banks, police stations);
- markets (*hat*, bazaar, market town);
- artisan centers (e.g., boat-building areas);
- rural industries (weaver's and potter's villages); and
- transportation routes (rivers, roads, railways, village pathways and infrastructures).

### 11.1.5 Data Analysis

Data analysis will depend on the type, quality and quantity of information collected, field observation, and the type and scope of the program. At a minimum, SIA data analysis should do the following:

1. Analyze how all human communities and social groups live spatially on the land and waters of the area potentially affected by the program. This means:

- identifying spatial interrelationships and dependencies between different communities (para to para, para to village and local market, etc.);
- identifying key spatial linkages and/or constraints in the area, e.g., central road or pathways, waterways, or isolated and cut-off areas.
- quantifying distances, e.g., from para to market, para to work sites (fields, fishing sites and other resource areas), para to educational institutions and other social services, para to cultural and religious sites, etc.

2. Analyze how all human communities and their social groups live economically within the area, with particular reference to the dependence of each on its natural resource base. This includes use of quantified data on the entire economic resource base of the area (such as annual yields from crop, capture/culture fishing, home gardens and other resources) determined by agricultural, terrestrial and biological resources teams. It also includes quantifying over a year average seasonal household livelihoods for each social group, including:

- the quantity of all food and non-food resources taken from the land and waters of the area and consumed within the household;
- the quantity of all food and non-food resources taken from the land and waters

of the area and sold for income (specify the income received).

- income received by any household member from wage labor.
- income received from money lending, brokerage, trade etc.
- any other income.

3. Analyze the local credit systems and note by season and household the annual average indebtedness of each social group in the area or subregion. Indebtedness can be a key monitoring indicator.

4. Analyze the economic system and subsystems of the area, with particular attention to interrelationships and dependencies between and within social groups.

5. Describe the "time organization" of rural life in the area, and analyze the interrelationships and dependencies between the following calendars:

   - annual cycle of inundation and flooding;
   - annual cycle of planting and harvesting (agrarian calendar);
   - fishing calendar, including:
     - capture fishing for significant food species (analyze interrelationships between cropping, flooding, and fish breeding and their social implications);
     - pond culture fishing;
     - shrimp culture (polders);
     - cultural calendar of seasonal festivals.

6. Describe the social organization of the area and analyze the interrelationships that exist between the systems of kinship, social status, traditional organization, political authority, and patron-client relationships. Note the characteristics of local level leaders, their organizational role and effectiveness, including the role and effectiveness of *salish* organizations. Note the presence and degree of social conflict in the area, analyze its causes, and project future trends.

### 11.1.6 Impact Analysis

The SIA attempts to identify and measure the effects of the proposed program on people in, adjacent to or downstream of the project area. These effects may be quantified by number of households affected by a specific impact, but there are other potential social effects that cannot be quantified. Among them are intergroup relations, changes in the local balance of power and influence and the disruption of credit and employment relationships within patron-client systems.

The best way to approach impact analysis is to link natural resources and household livelihoods as core concerns. This means measuring/assessing the biophysical impact of the program on each of the land and water resources of the area and then measuring/assessing how this range of impacts will affect the livelihoods of the social groups that depend on these resources. The biophysical impacts are more susceptible to scientific quantification, and are the responsibility of the other members of the EIA team.

With the biophysical impact estimates and the views of the affected social groups in hand, SIA should ask several general questions.

- How will this impact enhance or improve the socioeconomic life of the affected people?
- How can the enhancement or improvement be measured, if at all?
- How will this impact degrade or disrupt the socioeconomic life of the affected people?
- How can the degradation or disruption be measured, if at all?
- Which social groups will benefit from this impact and how many households will benefit and by how much?
- Which social groups will be disbenefitted by this impact, how many households will be disbenefitted and by how much?
- What are the implications of these effects for

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- the social security of the community?
- the economic viability of the community?
- the political stability of the community?

1. *Impacts on spatial relationships*: Using the above questions as a guide, assess the impact of the program on communications, transport, and access to resource areas, village centers, paras, markets, cultural sites, medical and educational facilities and government offices. In what ways will access be improved or disrupted? What local social and economic systems will be improved or disrupted by changes in the landscape and water regime? For example, new embankments serving as roads may aid access to key services or improve the marketing prospects of local farmers, new drainage channels cutting through established lines of communications may have opposite effects and also isolate small communities during periods of inundation. What social groups will be affected positively or negatively? (For each social group, estimate by number of households).

2. *Resource base*: Using the same list of questions, and the projected impacts on the physical resource base, calculate how much the livelihoods of the households depending on each resource will be affected by the proposed program.

3. *Social organization of the area*: This section of the analysis estimates and describes the effects of the program on the social organization of the area. The analysis here examines how conditions of social security, economic viability, and political stability will be affected by the changed balance among area social groups in income, wealth, and access to resources.

4. *Social security*: This section notes possible changes in access to common resource areas, patron-client relations, relationships between social groups that improve or degrade the web of interconnected relationships that enable social groups to function as self-sustaining human communities.

5. *Economic viability*: A estimation of changes in access to common areas, to the area resource base, patron-client, credit and employment relations, relationships between and within social groups that affect the capacity of area social groups to maintain or improve their livelihoods.

6. *Political stability*: Determining possible changes in wealth, authority, and political influence that enhance or degrade the access of social groups to the area's resource base and to government services and inputs. Political stability also examines whether the program enhances or retards prospects for social conflict in the area.

#### 11.1.7 Mitigation

Mitigation strategies are program elements that attempt to obviate the negative impacts of a proposed program on the local people. In all cases, mitigation plans should be developed in concert with the people. Mitigation planning should be a triangular process involving the PCC, the Assessment Team and the Project Team.

Mitigation strategies follow from impact analysis and can take many directions, depending on the nature of the problem and the wishes of the local people. These can include the following.

1. *Changing the whole thrust and purpose of the program.* In some cases, it may become clear that the program as originally conceived is entirely inappropriate because it is unwanted, unnecessary, or would in fact be damaging to local people. In this case, mitigation planning would redirect the development effort into a program that is more in keeping with local desires and realities.

2. *Altering the physical/infrastructural aspects of the proposed program.* This is a very common mitigation strategy that works well when such alterations follow local desires and information provided by cultivators, fisherfolk and other users of local resources. It can include the following.

- Major infrastructural change, such as eliminating or relocating an embankment or other flood control and drainage structure. Relocation can be used to mitigate an otherwise negative impact or even to improve an existing situation. Relocating an embankment and putting a road on it to improve local communications would be an example of this.
- Redesigning or otherwise changing the configuration of a flood control and drainage program. This might mean going from high, flood-proof embankments to submersible ones, or from narrow to broad embankments. The latter can include embankments that carry a major road, or even very wide embankments that can be used for resettlement, forestry development, or irrigated agriculture.

3. *Safeguarding heritage rights and access to common resource areas.* This is a directed effort to preserve informal, customary rights and usages that support the livelihoods of particular resource user groups, many of which include poor or marginal households. This might require agreements with government departments, as well as bringing in an NGO to help such groups organize to protect their interests and preserve and improve the resources upon which they depend. Such agreements must be part of the project plan and conditions.

4. *Ensuring that the affected people immediately and directly benefit in post-development stages of the program.* This requires agreements guaranteeing local participation in the construction, operation, and maintenance of the program. These agreements can be made with the PCC and should ensure that those households most directly affected with the loss of livelihood have priority in getting jobs during these stages of the program. (A work permit system, one to each household, could be used to ensure fairness.)

5. *Targeting special assistance to affected groups whose livelihoods or community integrity are significantly disrupted.* Groups that have to be resettled or that lose a key resource area due to flood control interventions will need a package of development options to help them maintain their livelihoods. Such a package could include temporary income maintenance, alternative skills training and inputs to develop alternative occupations.

6. *Targeting special enhancement programs to the massively impacted area.* This might mean establishing a government- or donor-assisted small or medium industrial estate in the area in consultation with the people.

7. *Ensuring that cultural properties, religious sites and archaeological/historical treasures are protected.* Sites/treasures of major significance should either be provided with physical protection or moved to a safe place for preservation.

#### 11.1.8 Monitoring

The purpose of social and economic monitoring is to determine two things. First, the degree to which design and mitigation agreements between the project designers and the local people have been carried out. Second, the impact of the program on wealth, household income, and social conditions inside and outside the program area. The monitoring should be executed by a team selected by the relevant authority.

The monitoring program should begin with the start of construction to ensure that agreements about design and work opportunities are carried out. Once the program is in operation, monitoring teams should visit the program area a minimum of twice a year for three years. At that point, the monitoring team should decide whether or how often monitoring teams should continue to visit the program area.

Monitoring requires both field observation and data collection:

- Field observation involves consulting with the PCC and social group leaders about the progress of the program. It would be useful to have members of the original SIA team, including the social organizers, brief the monitoring team and visit the field with the latter team at the outset of the monitoring effort so that the monitors have an accurate perception of the baseline social conditions in the project area. It also means following up information provided by the PCC and the leaders of affected resource user groups through RRA field work whenever the monitoring team feels such an effort is warranted.

- Data collection consists of identifying and following key indicators by periodic sampling throughout the monitoring period. The initial SIA can constitute a baseline for later data, provided the period between the SIA and the implementation of the program is not more than two years. If it is more than two years, the monitoring team should survey the area to create its own baseline. It will, in any case, need to identify and survey a control area near the program area to provide a comparative framework for analyzing time series data from the program area. Data for monitoring should include:

    - population growth, size and density;
    - migration (internal movements and movements in and out of the area);
    - resource productivity of the area (all resources, e.g., food grains, fish, wood, livestock, grasses, etc.);
    - sale prices of all resources (wholesale/retail by season;
    - household incomes (selected households by social group, which includes all "income" taken directly from the land or water and consumed in the household);
    - household work patterns (seasonal/daily);
    - household nutrition/food consumption patterns;
    - area occupational profile and employment data;
    - land prices, mortgage transactions;
    - area transportation costs; and
    - area development indices.

## 11.2 Public Health

Four categories of disease and public health concerns are closely related to water resource development:

- vector-borne diseases—those are transmitted by arthropods such as mosquitoes, which are dependent on aquatic or moist habitats and affected by hydrological conditions such as flooding or water stagnation;

- water-borne and water-washed diseases—viral, bacterial, fungal or parasitic diseases transmitted by drinking, bathing or contact with infected water;

- diseases caused by general sanitation conditions—diarrhoea and dysentery, which are affected by local hydrological conditions such as drainage and flooding (or the absence thereof), or by unsanitary conditions in construction or squatter camps;

- conditions related to nutritional status—malnutrition and protein and mineral deficiencies, which may be affected by project-induced crop and food availability changes.

### 11.2.1 Baseline Studies

Two types of studies pertinent to public health issues may be undertaken in an EIA.

- RRAs and collecting available data from a variety of sources to document present knowledge and to provide a basis for relating public health parameters to present and future hydrological conditions; these types of surveys and studies are typically undertaken by public health specialists or sociologists with expertise in community health concerns.
- Specific studies to investigate the epidemiology of a disease, the ecology of a disease vector or a specific subject related to disease transmission; examples are LSTM/NIPSOM/ISPAN (1992) and ISPAN (1993); such studies require specific professional expertise of ecologists, epidemiologists, entomologists, etc. Consideration should be given to contracting with specialists to examine potentially serious human health hazards and predict the likely consequences of development.

For standard baseline surveys conducted by the Assessment team, the following information should be collected from available specialist sources or via structured questionnaires administered to a statistically valid sample of people or households in the study area.

- Present health situation, in quantifiable measures, or the study and project area human population:
  - existing extent of infectious, vector-borne and other diseases, expressed as percentage morbidity and mortality per age and sex grouping;
  - existing occurrence of infectious diseases by specific measures such as indices of parasite abundance in local people;
  - measures of nutrition, including reported sources and daily intake levels of protein and calories; signs of malnutrition, goiter, etc.
- Present ecological, hydrological or demographic conditions that affect disease incidence:
  - vector abundance
  - extent of human contact with vectors or infected media (water, soil, faeces)
  - disease vector habitats in proximity to human habitations (wetlands, canals, tanks, polluted waters, etc.)
  - drainage and sanitation conditions
  - influx of people serving as disease reservoirs
  - presence and abundance of animal reservoirs of infection.
- Vulnerability of community to diseases;
  - numbers of susceptible people, proximity to exposure, general health status, potential effects of immigrants, etc.
- Adequacy of health services and facilities that influence health, e.g., clean drinking water, availability of latrines, vector spraying programs, nutritional supplementation programs.

Special attention should be given to detecting trends in the above due to shifts in population density, migration, past flooding and natural hazards, as well as alterations in government health service facilities. The direction of the trend should be considered.

### 11.2.2 Existing Data Sources

The best sources of health-related data are local thana health centers and thana health officers. Hospitals located in the study area also can often provide an indication of the extent of local disease incidence and major public health concerns. Records maintained by local health centers and hospitals will usually require extensive collation, summarization, extraction and analysis to yield useful information on disease incidence, trends, etc. Many NGOs specialize in health programs and their local representatives are usually knowledgeable about local conditions. Specialist organizations such as the National Institute for Preventative and Social Medicine (NIPSOM) may have specialist knowledge of certain diseases in the study area.

Useful published material on public health concerns include the following:

FAO. 1984. Environmental management for vector control in rice fields, Irrigation and Drainage Paper 41. FAO, Rome.

Feachem, R., D.J. Bradley, H. Garelick and D.D. Mara. 1980. Health aspects of excreta and sullage management. Appropriate Technology for Water Supply and Sanitation series. World Bank, Washington, D.C.

ISPAN (Irrigation Support Project for Asia and the Near East). 1993. Nutritional consequences of biodiversity in fisheries. Dhaka.

LSTM/NIPSOM/ISPAN (Liverpool School of Tropical Medicine/National Institute for Preventative and Social Medicine/Irrigation Support Project for Asia and the Near East). 1992. Impacts of flood control and drainage on vector-borne disease incidence in Bangladesh. Flood Plan Coordination Organization, Ministry of Irrigation, Water Development and Flood Control, Dhaka.

PEEM (Joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control). 1989. Guidelines for the incorporation of health safeguards into irrigation projects through intersectoral cooperation. Report VBC/89.5. PEEM Secretariat, WHO, Geneva.

PEEM (Joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control). 1991. Guidelines for forecasting the vector-borne disease implications of water resources development. Report WHO/CWS/91.3, PEEM Secretariat, WHO, Geneva.

WHO (World Health Organization). 1989. Geographical distribution of arthropod-borne diseases and their principal vectors. WHO/VBC/89.967. Geneva.

WHO (World Health Organization). 1982. manual on environmental management for mosquito control. Publ. 66. Geneva.

### 11.2.3 Primary Data Collection

Public health concerns are best investigated by health specialists working closely with the rest of the EIA study team to ensure integration of relevant information pertaining to local hydrology, ecology and socioeconomics. Four data collection procedures are advocated.

- Literature surveys (some sources indicated in Section 11.2.2); these usually provide information on the epidemiology and dynamics of disease and public health concerns.
- Consult specialist groups at the general level (such as national institutions) and at the local level (mainly local doctors, health officials, etc.; these provide initial insight into prevailing local conditions, but may also yield useful historic data on trends, incidence, etc.
- Field reconnaissance—carried out in combination with the previous step and usually at the IEE level to familiarize the EIA team with the study area; selected homesteads and villages should be inspected for specific indications, such as proximity to contaminated water sources, signs of disease (malnutrition, goiter), etc..
- Detailed surveys to obtain quantitative information which can be used to predict and assess impacts; such surveys are best conducted as an integral part of the socioeconomic studies, which are usually based on detailed questionnaire surveys of a statistically valid sample of households or population groups.

### 11.2.4 Maps and Mapping

The extent to which maps are used to depict public health information will depend on how the data have been

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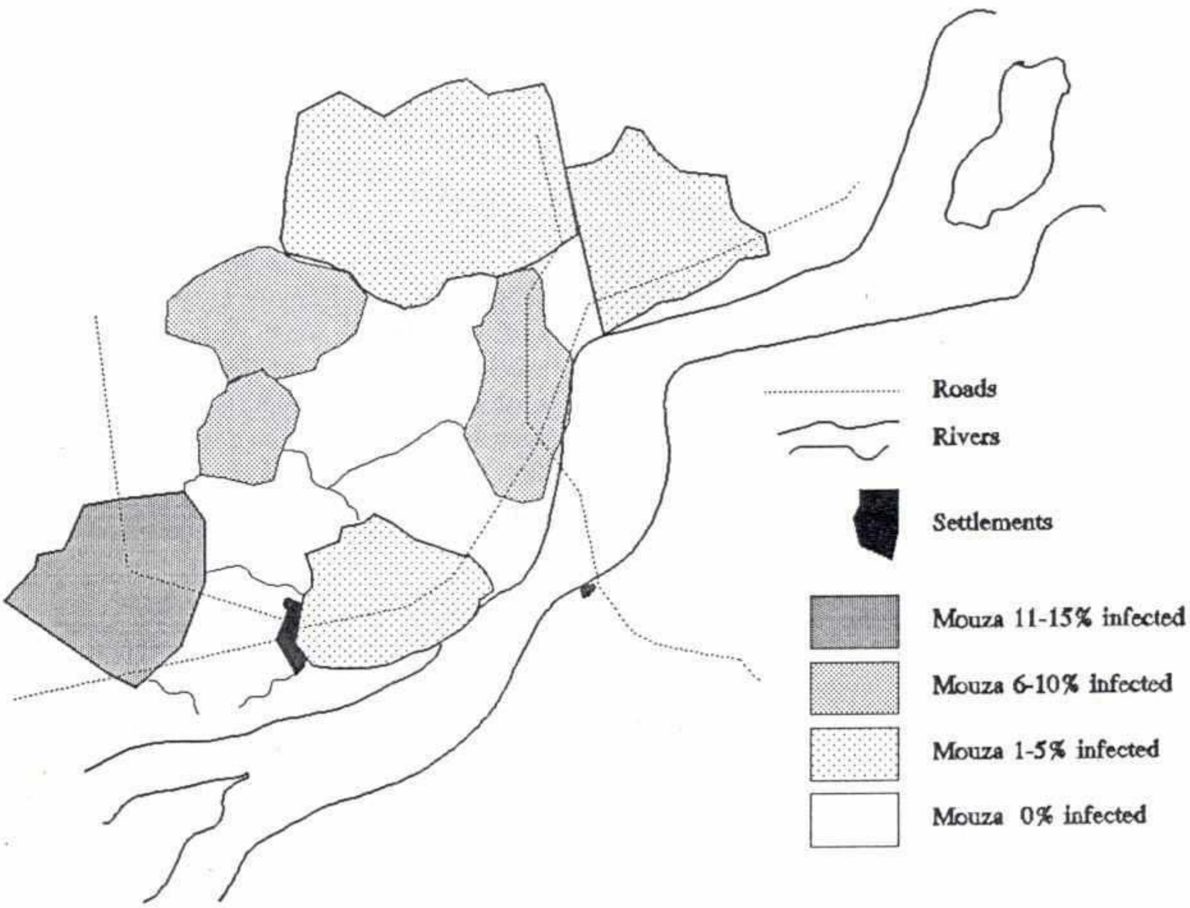


**Figure 11.1** **A GIS-based Mauza Map Showing Measured Incidence of Disease (Percentages of Kala-azar Infected Households)**

collected and categorized, and which mapping boundaries are referenced in the data. Data on disease incidence can often be referred back to the mauza in which it occurred, and the data can be mapped by mauza boundary (Figure 11.1). Other information readily displayed on maps includes the proximity of communities to health-relevant features such as proposed embankments, elevational contours, flooding frequencies (based on elevations), recorded health hazards, etc. Maps are especially effective in displaying significant long-term trends, e.g., changes in the percentages of infected people by mauza or thana over time.

### 11.2.5 Data Analysis

Health-related statistics are most useful when summarized in the form of means, ranges, indices or descriptors reflecting the incidence of the various conditions (disease incidence, malnutrition, etc.) and relating the condition to the community exposed and the underlying hydrological and ecological conditions. Following are examples of summarized statistics which meet these requirements.

- Number of disease positive cases per unit per time period (e.g., number of tuberculosis positive cases per mauza per annum)—indicates disease prevalence over time and its trend, if any.
- Number of reported cases of dysentery or diarrhoea requiring hospitalization in specific locale by month—indicates relative incidence of condition and its change in relation to annual controlling phenomenon such as flooding.

- Comparison of numbers of cases of specific condition in relation to occurrence of controlling variable (e.g., annual mortality of infants from malnutrition and diarrhoea compared to expenditures on maternal care programs to detect incidence trend.

Standard health department statistics should be used when available, e.g., annual parasite index (proportion of disease positive cases in total thana population).

### 11.2.6 Impact Analysis

The impact of water resource development on health can be predicted and assessed by correlations to key variables and/or comparisons to similar situations and appropriate forward projections. A three-stage process recommended by PEEM (1991) for assessing vector-borne diseases is applicable to most other health concerns affected by environmental changes:

*Stage 1:* Determine community vulnerability to the diseases/condition in question.

*Stage 2:* Measure the environmental receptivity to transmission of the disease or condition.

*Stage 3:* Assess the vigilance of the existing health services in dealing with the condition and any project-related change to it.

Community vulnerability is indicated by the analytical quantitative and/or qualitative statistics provided on mortalities, morbidities and spatio-temporal occurrence of the conditions.

The extent of environmental change due to project development, including changes inhydrological conditions, flooding frequency, cropping patterns, agricultural production, fish harvests, food availability, social changes due to land use changes, etc., should be available from the hydrological, agricultural, fisheries, socioeconomic and other components of the EIA. The ecology of vector populations should be related to the ecology of their habitats and any expected changes due to project, e.g., drainage congestion, water stagnation, flooding frequencies, etc.

The ability of the existing health services to deal with any negative impacts should be gauged in terms of their present (pre-project) efficiency and consideration of the constraining factors (e.g., knowledge, trained health practitioners, health facilities, etc.). Long-term changes in health conditions due to water resource alterations are usually difficult to predict with any degree of accuracy, hence it is important in the public health arena to have an effective monitoring system in place following the project to ensure early detection of any negative trends so that early corrective action can be taken.

Although it is often difficult, it is particularly important to quantify health impacts in economic terms to ensure that they are duly considered in project evaluation. Suitable economic measures of health impacts are days of labor lost due to disease and/or debilitation, costs of maintaining adequate health services to prevent disease outbreaks, costs of immunization or spraying programs, costs of social disruption due to disease, and costs of resettlement to locations where public health conditions would be improved.

Tables 11.1 through 11.6 summarize present knowledge on human vector-borne diseases in Bangladesh.

### 11.2.7 Mitigation

There are four main approaches to controlling water-related health conditions, including vector-borne diseases:

- measures aimed at the pathogen through immunization (but not available for malaria, kala-azar or filariasis, and not usually effective against cholera) or use of curative and prophylactic drugs;
- measures aimed at reducing vector densities or life spans to reduce the likelihood of transmission through the application of chemical, biological and environmental control programs;

**Table 11.1 Vector-borne Diseases Affecting Humans in Bangladesh**

| Health Hazard | Case Severity | Status in Bangladesh |
|---|---|---|
| Benign malaria | Rarely fatal, treatment available | Occurs on floodplains, prevalence low |
| Malignant malaria | Frequently fatal, drug resistant | Occurs in forests, occasionally imported to flood plains |
| Kala-azar | Frequently fatal, drug treatment expensive | Epidemic in progress (1992/3), no resources for control |
| Filariasis | Chronic and debilitating, low mortality, drugs available | Several small foci. Much less common than in India or Burma |
| Dengue | Varies from mild fever to life threatening, no treatment | No data |
| Japanese encephalitis | Frequently fatal or causes brain damage, no treatment | Very rare |
| Schistosomiasis | Chronic and debilitating, cheap drug treatments available | Does not occur in Bangladesh, nearest foci are China and Iraq |

Source: LSTM/NIPSOM/ISPAN (1992)

**Table 11.2 Disease Vectors in Bangladesh**

| Disease | Vector | Common name |
|---|---|---|
| Malaria | *Anopheles philippinensis*<br>*Anopheles aconitus*<br>*Anopheles annularis* | Anopheline mosquito |
| Kala-azar | *Phlebotomus argentipes* | Sandfly |
| Filariasis | *Culex quinquefasciatus* | Culicine mosquito |
| Japanese encephalitis | *Culex tritaeniorhynchus*, *C. gelidus* and others | Culicine mosquito |
| Dengue | *Aedes aegypti* | Aedine mosquito |

Source: LSTM/NIPSOM/ISPAN (1992)

**Table 11.3 Livestock Relationships to Human Vector-borne Diseases in Bangladesh**

| Disease | Normal Host Reservoir | Remarks |
|---|---|---|
| Malaria | Human | Cattle are diversionary hosts for the vectors |
| Kala-azar | Human | Vectors feed on cattle |
| Filariasis | Human | Vectors are peridomestic |
| Dengue | Human | |
| Japanese encephalitis | Pig, bird | Non-muslim minority keep pigs |

Source: LSTM/NIPSOM/ISPAN (1992)

Table 11.4 Communities Vulnerable to Vector-borne Diseases

| Disease | Urban/Rural | Habits | Male/female |
|---|---|---|---|
| Malaria | Rural | All | Females most vulnerable |
| Filariasis | Both | All | Male |
| Kala-azar | Rural | Cattle keepers | Male* |
| Dengue | Urban | All | All |
| Japanese encephalitis | Rural | Pig keepers | All |

Source: LSTM/NIPSOM/ISPAN (1992)
*May be due to bias in case reporting.

Table 11.5 Mortality, Treatment and Diagnosis of Vector-borne Diseases

| **Disease** | **Morbidity, Mortality** | **Treatment** | **Confirmatory Diagnosis** |
|---|---|---|---|
| Benign malaria | Fever, low mortality | Relatively cheap | Simple, poorly managed |
| Malignant malaria | Fever, high mortality | More expensive drugs required | Simple, but often poorly managed |
| Kala-azar | Fever, high mortality | Expensive | Difficult |
| Filariasis | Swelling and pain, not fatal | Cheap | Simple |
| Dengue | Fever, variable mortality | Supportive only | Difficult |
| Japanese encephalitis | Permanent disability, high mortality | Supportive only | Difficult |

Source: LSTM/NIPSOM/ISPAN (1992)

Table 11.6 Possible Effects of Flood Control, Drainage and Irrigation on Vector Breeding Sites

| Disease | **Vector Breeding Sites** | **Potential Effects of FCD/I** |
|---|---|---|
| Malaria | Mainly ponds and rice fields with algae and clear, silt free water | Reduced flushing action and silty water of floods balanced by increased water pollution, which is inimicable to breeding |
| Kala-azar | Peridomestic, organically rich soil, cowsheds | Reduced flushing action of floods |
| Filariasis | Peridomestic, foul or organically rich water, blocked drains | Reduced flushing and increased drainage obstruction |
| Dengue | Containers of clean water | No effect |
| Japanese encephalitis | Rice fields and other water bodies | No effect |

Source: LSTM/NIPSOM/ISPAN (1992)

- measures aimed at reducing man/vector or man/pathogen contact through education, personal protection measures, and vector-proofing measures.
- measures intended to improve general health and nutrition and provide greater resistance to adverse health conditions (e.g., supplementary feeding programs, distribution of food supplements such as iodized salt, etc.).

Chemical and biological control measures aimed at disease vectors include:

- use of larvicides to kill immature vectors in water;
- adulticides, which kill adult vectors through spraying, fogging or surface applications of insecticides. The best-known insecticide used for purpose in Bangladesh is DDT, which is now banned because of its ecologically toxic properties, although it is still widely used illegally.

Environmental control measures aimed at disease vectors include (PEEM 1989):

- environmental modification, which is the long-term and/or physical alteration of land, water or vegetation to make the local environment unsuitable for vector breeding or disease transmission;
- environmental manipulation, which consists of recurrent activities that temporarily make conditions unfavorable to vectors.

Other public health measures that can be applied to mitigate negative impacts include:

- health education programs;
- ensuring continuance of protein and food supplies to poorer classes through fisheries management programs;
- planned resettlements and development of project facilities to avoid unsanitary conditions that create health problems.

### 11.2.8 Monitoring

Public health monitoring in a project area is best carried out using the same institutions, survey instruments and parameters applied in the basic studies. Consistent use of the same methodologies will ensure the comparability of statistics gathered pre- and post-project. In many cases, appropriate institutions, such as the thana health center, will continue to gather routine health data that can be used to monitor the occurrence of disease, etc. However, such data may be too coarse to reflect adequately changes in a small project area, and specific data collection programs via periodic household and village surveys may be required.

## 11.3 Hazard and Risk Assessment

Note: that this section deals with environment on project impact assessment which is termed "hazard and risk assessment".

### 11.3.1 Baseline Studies

Because water management projects and other flood loss mitigation measures are designed to reduce the adverse impacts of a natural hazard there are overlaps between the hazard and risk assessment of the EIA and other components of the appraisal of water projects. Agricultural and economic analyses in typical prefeasibility and feasibility studies are usually restricted to the economic implications of reducing flood incidence and severity, while the EIA hazard and risk assessment takes a wider perspective.

The procedures summarized in this manual include:

- reviewing the hazards faced by the study area under pre-project conditions;
- assessing the risks of hazardous events and changes in the risks associated with the proposed interventions;
- assessing the consequences of hazardous events for IECs including both the human society and economy, and the natural environment;
- ensuring that risks of project failure are assessed, and where this would involve structural failure, developing a contingency and/or emergency management plan to minimize the consequences; and

- identifying major uncertainties over the impacts (benefits and disbenefits) and effectiveness of the project, as an input to the multi-criteria information presented to decision-makers.

The following definitions are used for specialized terms in this chapter:

*Hazard:* An event that causes damages and/or loss to human life, land use and/or the environment. Typical natural hazards in Bangladesh include floods, erosion and earthquakes; pollution is an anthropogenic hazard.

*Return Period:* (or exceedance probability). The average interval in years between hazardous events of the same magnitude. Thus, a 1-in-20 year flood will occur, on average, once every 20 years. This is not the same as saying that it will occur *only* once every 20 years. An alternative way of expressing return periods is to state that the exceedance probability (i.e., the risk that a hazard of given or greater magnitude will occur) in any given year is $1/20 = 0.05$. The calculable risk of this event happening in any year is independent of the occurrence in other years. Return periods are typically estimated on an annual basis through an analysis of extreme events—fitting the distribution of maximum flood levels or discharges over a number of years to a probability distribution.

*Risk:* The potential that a hazardous event will occur. In a strict sense the term is used only when a statistical probability can be estimated for events of different magnitudes (see *return period*). In common usage, the term implies the likely occurrence of a hazardous event at some time in the future.

Hazard and risk assessment in water sector projects is concerned with:

- changes in hazards and risks that arise directly from the primary objectives of a project (flood protection), e.g., reduced flood levels inside and increased levels outside a project;
- other impacts of the flood protection works or intervention for other related hazards, e.g., changes in health risks due to changed water regimes; and
- risks to the project itself from hazards, e.g., embankment failure due to earthquakes, public cuts due to social conflicts, etc.

A proposed project may alter the risk that a hazard will occur in adjacent areas, and may increase risk due to cumulative effects on existing hazards.

At the prefeasibility stage, an IEE should qualitatively screen the hazards in the study area so that the more significant ones are identified in terms of present importance and likely importance for the project options being considered. Hazards should be listed in two main groups—those that can be expected to change in terms of incidence or impacts due to the project(s), and those that would not change. Detailed analysis of the latter is usually not practical, but it is important to identify hazards that may persist with a project, and to take care in drawing conclusions without further analysis. For example, pest attacks on crops might be omitted from risk analysis since they will continue with or without any project. However, there is some evidence that if projects result in more monoculture of paddy or create refuges for rats, then the incidence and severity of pest attack may be greater. Similarly HYVs may be more prone to attack by diseases and insects, and the area may expand with a project.

At the feasibility stage, the EIA should provide background data on the nature, type, extent and frequency of natural and man-made hazards in the area affected by the project to date, including any recent trends. Those hazards identified in the IEE as potentially significant should be investigated in greater depth. Where possible, risks and impacts should be quantified for inclusion in either the project appraisal, where they can be incorporated in economic calculations (FPCO 1992), or the EIA for other environmental consequences such as health impacts. The EIA team should consult with other teams working on the feasibility study. For example, since hydrological analysis and flood loss estimation should be undertaken for the feasibility study, the EIA should ensure that the necessary analyses are carried out and, if necessary, supplement these. The EIA team should make use of these analyses in further assessment of the environmental consequences of hazards and risks.

### 11.3.2 Existing Data Sources

*BWDB (Central)*—flood stages and discharges at gauging stations for run of years; print-outs to order; analysis and modelling may also be available through WARPO, SWMC and FAP 25. Annual flood reports give narrative details and some data on flooded areas and impacts through the mid-1980s.

*BWDB (Local)*—recent flood experience, flooded areas, breaches, costs of repair work. Data not normally available for more than the past five to six years.

*Ministry of Relief*—people affected, summary data on financial losses and lives lost. Rehabilitation (and lack thereof) of local breakdowns. The methods used to obtain data are very approximate; reliability is low (data may be exaggerated to obtain relief); covers floods and cyclones.

*Ministry of Local Government*—local data on same parameters as MRR, usually at thana level; local information on flood extent may be available through local staff of LGEB.

*Bangladesh Bureau of Statistics*—same data as MRR and MLG at aggregate level for past years.

*District Gazetteers*—history of natural hazards, including floods; highlight most severe events, but may lack data on impacts. It has the advantage of a long run of years, but the amount of selectivity in determining notable disasters is uncertain, so there may be problems with the reliability of statistical analysis involving historic and recent records.

*Ministry of Agriculture*—general data on agricultural losses from flood and drought, research data on pests and pesticides and incidence of these, data on local incidence may be difficult to obtain.

*Geological Survey of Bangladesh*—earthquake history; detailed information on losses from this hazard may be lacking.

Data on the probability of hazards and the magnitude of their impacts are variable both in availability and quality. Frequently during flood impact assessment a fundamental choice arises: either estimate the return periods of different flood events separate from their impacts, or make a direct frequency analysis of past flood impacts. Both approaches have advantages and disadvantages.

When modeling flood frequencies, combined probabilities are likely to arise and cause problems. When that occurs, the direct frequency analysis of losses may be simpler, but because this method combines the influence of flood discharges with settlement and land use patterns, predicting future risks and losses is unreliable. This is because there is no way to clearly determine the underlying influences and trends in component factors. While general data on flood impacts exists in an aggregate level, empirical data is lacking to relate losses and impacts to flood characteristics for various land uses and environmental components. The same problems arise with most other hazards.

### 11.3.3 Primary Data Collection

There will be insufficient time in most EIAs for the long-term measurements and monitoring that would be needed to quantify risks and their impacts, hence it will be necessary to rely on the existing data sources and on recall by local people. Much of the information may be collected by incorporating appropriate questions in surveys that would be undertaken as part of the project appraisal or EIA. For example, frequency and magnitude of crop losses could be investigated at the same time as cropping patterns and yields. The baseline surveys should establish the recent history of hazards and their impacts in the study area, covering the major hazards identified and the land uses and IECs that might be affected. It is also important to investigate any trend in the frequency of events over time.

The survey method used will depend on the type of data. For data on the impacts of hazard events (losses) it is more appropriate to collect data from a formal sample survey—of plots for agriculture or

Table 11.7 Framework for RRA Survey of Hazard Influence at Village Level

| | Flood | Tidal Surges | Erosion | Draught | Pests, etc. |
|---|---|---|---|---|---|
| *1992*: | | | | | |
| Timing | | | | | |
| Cultivated Area Affected | | | | | |
| % Total Loss | | | | | |
| % Part Loss | | | | | |
| % Normal yield | | | | | |
| No. Households Affected | | | | | |
| *1991*: | | | | | |
| Timing | | | | | |
| Cultivated Area Affected | | | | | |
| % Total Loss | | | | | |
| % Part Loss | | | | | |
| % Normal yield | | | | | |
| No. Households Affected | | | | | |
| *1990*: | | | | | |
| Timing | | | | | |
| Cultivated Area Affected | | | | | |
| % Total Loss | | | | | |
| % Part Loss | | | | | |
| % Normal yield | | | | | |
| No. Households Affected | | | | | |
| etc. | | | | | |

homesteads for other losses, since these individual losses will differ between elevations and land uses. However RRA methods are just as useful, particularly in estimating the frequency of events of different overall magnitudes, since there will be general agreement within a village about which years had severe floods, erosion or pest attacks. Moreover, group discussions with a cross-section of people are a rapid and effective means of establishing the areas affected by different events. Village surveys should be structured to achieve coverage of all environmental zones of the study area. If only a sample can be surveyed it should still be possible from the sample to map hazard incidence and relate this with environmental, agricultural and economic parameters.

Table 11.7 is an example of an RRA checklist for hazard incidence, and Table 11.8 is an example of a table covering household losses as a result of a hazard event. The survey should establish data for the following hazards:

**Table 11.8 Household Hazard Loss Survey Format**

Hazard Event: ...........................

Year: ...........................

Date Started: ....................

Duration: ......................

| | Land Use/ Type | Water Depth | Extent of Loss | Loss of Production | Monetary Loss |
|---|---|---|---|---|---|
| *Homestead*: | | | | | |
| Household Assets | | | | | |
| Stored Food | | | | | |
| Livestock | | | | | |
| Vegetable Garden | | | | | |
| Trees | | | | | |
| Pond Fish | | | | | |
| *Business*: | | | | | |
| Farm Plot 1 | | | | | |
| Farm Plot 2 | | | | | |
| etc. | | | | | |

#### 11.3.3.1 Floods

For each of the past ten years find out, first, whether the village was affected by flooding. If it was, ask about its source, extent and depth compared with normal years, and establish the timing of the flood. This information, gathered via RRA, should be established for different land levels. Next, for each land type, determine the percentage of crops completely lost, partly damaged and undamaged; for the partly damaged crops, determine the average yield compared with normal. This can be done either with an RRA or a formal survey. The approximate number of houses flooded and/or damaged in the same events should be estimated using RRA or formal survey. Finally, the damage to the household or its assets should be valued, and detailed data on health and morbidity attributable to the floods should be collected. This is best done as part of a household survey being done for other purposes.

#### 11.3.3.2 Embankment Breaches

If there are embankments in the study area, establish through discussions with BWDB and RRAs:

- the years and locations of breaches;
- the reasons for breaches;
- the areas affected (which may differ from overall flooding in the same year);
- the impacts of the breaches; and
- the time it took to repair the breach and the cost involved.

#### 11.3.3.3 Waterlogging/Drainage Congestion

The same information as for flooding should be obtained. However, waterlogging may not be perceived as flooding, particularly when it occurs within an embanked area. In addition to the history of events and areas affected over the past ten years, local perceptions of any trend should also be recorded.

#### 11.3.3.4 Erosion

For the past ten years, where possible, establish and map (satellite imagery, aerial photos, RRA):

- the areas lost each year to erosion within the study area; and
- the type of land involved and number of houses, also where people moved to as a result of erosion.

If not covered elsewhere in the study, present market values should be established for equivalent agricultural and homestead land within the village and not threatened by erosion.

#### 11.3.3.5 Storms

For each of the past ten years identify any years when storm damage (excluding consequent waterlogging) was unusual, and estimate the crops, areas, and loss in yield involved (RRA).

#### 11.3.3.6 Drought and Irrigation

For each of the past ten years record (RRA):

- crop areas irrigated and not irrigated;
- any loss of yield or changes in cropping due to irrigation problems or drought, giving the areas involved and loss of crop production over that expected;
- reasons for irrigation problems; and
- any changes in groundwater availability over the period.

#### 11.3.3.7 Agricultural Pests and Disease

For each of the past ten years identify (RRA):

- any years with unusual crop losses due to pest or disease outbreaks;
- the pest or disease involved;
- the crops affected—areas and loss of yield; and
- any perceived trends in the incidence of pests and diseases, and any reasons that might underlie such trends.

#### 11.3.3.8 Sedimentation

This is likely to involve two processes: sand deposition, which is similar to other hazards, and general siltation, which is a longer-term process. The EIA will, in any case, investigate rates of sedimentation in water courses inside and outside the proposed project area. The predicted rate of sedimentation with a project will not only have general environmental impacts, it will also have an effect on risks—particularly risks of flooding, waterlogging, erosion and breaches. However, possible sand deposition impacts on agriculture should also be established (RRA, possibly sample surveys):

- years when land was affected by sand deposition, reasons for deposition, areas affected (size, locations and areas mapped), number of years affected, recovery pattern of cropping and yields over that period; and
- any trends in sand deposition over the past ten years.

#### 11.3.3.9 Pollution

Although trends in pollution can be expected to be investigated in the EIA, for the risk assessment it is important to establish not only the present quality of surface water and groundwater in the different environmental zones of the study area, but also:

- any trends or predictions for changed quantities of pollutants from general agricultural changes associated with the project—fertilizers, pesticides and field processing of jute, for example;
- any plans for other developments that would involve pollution risks—for example, agricultural processing industries and their probable pollutants; and
- the expected water circulation pattern with the project and extent and speed of dispersion of pollutants, also any change in infiltration into groundwater.

It is likely that local opinions on this hazard will be much less quantifiable than on most other risks, but an attempt should be made to map any current or future concentrations of pollution.

### 11.3.4 Maps and Mapping

Hazards and their risks may not be uniform throughout a project-affected area. There inevitably will be differences between protected and adjacent unprotected areas in a with-project scenario, and there are also likely to be differences within a proposed protected area. It is important to map these hazards—both the recent history, from which an estimate of without-project conditions can be made, and predictions of with-project risks in different areas. Obviously flood characteristics differ between land levels, but risks may also vary along different rivers and *khals* within a project area. Erosion risk will not be uniform along a river or embankment, and past embankment failures may also be concentrated in particular areas. The causes of this and risks for future projects should be investigated in the appraisal.

The purposes of the spatial analysis and risk maps in the EIA report are to assist in quantifying relative risks and their impacts based on the areas and land uses affected, and to assist in drawing up disaster management plans for the impacted area. For example, areas and settlements that should receive warnings of breaches can be identified, along with safe places to shelter. Some wetlands may be at greater risk of pollution than others because with-project cropping would be more intensive or involve more HYVs in some areas, or because of the proximity of industries.

### 11.3.5 Data Analysis

Analysis of the hazard risk data derived from secondary sources, RRAs and formal surveys, and other parts of the project appraisal, should result in:

- hazard risk maps for the project-affected area identifying the areas that would be affected by different magnitudes of hazard events with and without project;
- quantification of impacts associated with hazard events of different probabilities or return periods and the inclusion of these estimates in the project appraisal (economic or environmental), for example, by estimating average annual losses with and without project; and
- a checklist of project option uncertainties, which may relate to hazards, but may also relate to the physical, economic, social, and political environment and how this may affect the outcome of the project.

### 11.3.6 Impact Analysis

For general planning and prefeasibility stages the screening process is more informal, involving interactions by specialists and expert opinion. Expertise involved includes: hydrology and hydraulics, engineering, agriculture, environmental sciences and economics. At the feasibility study level the entire appraisal team should incorporate risk assessment in modelling of the impacts of project options (an example is given below).

There are likely to be uncertainties over the economic viability of the project, but these may not be quantifiable, these are best treated in a sensitivity analysis. The impact assessments used in the Project Appraisal and EIA also have probablistic components, and these risks need to be incorporated in the calculations for each category of impact (benefits and adverse impacts). In addition, the risk analysis should include an assessment of the risks of structural failure and the consequences for both economic and environmental assessments. In addition, it is important to include in these assessments maps of the areas at risk from hazards.

The following steps are involved in the hazard and risk assessment.

- Assessment of past importance of hazards in the area (based on existing data).
- Qualitative assessment of change in risks and impacts of hazards associated with a project, and of uncertainties over project implementation and impacts.

- Judgement on viability of project options with regard to risk and uncertainty, based on professional opinion of the likelihood of failure or disaster.
- Screening of hazards for detailed investigation.
- Baseline assessment and surveys to expand on existing data for "significant" hazards.
- Quantification of hazard impacts and risks associated with them:
  - identify IECs and their characteristics;
  - identify hazards that may affect an IEC and for which risks can be estimated;
  - quantify risk associated with events of different magnitudes for each hazard: a minimum of the zero- impact event and three other loss-causing events should be used to model risk impacts: the reliability of the frequency analysis will depend on the quality of the data and the number of years for which there is data, the uncertainties over the analysis should be noted to avoid analysis with spurious accuracy;
  - for each IEC, estimate and quantify impacts of the hazard events for which probabilities are estimated. The accuracy of this will depend on the amount and reliability of data that can be compiled on losses associated with events and on the database of land uses at risk (for example, on linking the digital elevation mapping with land use mapping, with land use-damage data, and with the hydrological-hydraulic and other hazard modelling);
  - estimate changes in risks of different events due to the project;
  - estimate impacts as in Step 4 but for with project risks;
  - estimate difference in IECs or in annual average economic returns between without- and with-project risk scenarios.
- Incorporation of risk assessment in economic analysis where possible.
- Mitigation plan for hazards: incorporation of hazard resistance in project design and general development programs for the area, disaster management plan for unavoidable hazards associated with the project.
- Monitoring of risks and updating of hazard and disaster management plan during the life of the project (since risks may change during the project life).

An assessment of the predicted risks with and without a given project option should be made for each major sector affected by the project, including agriculture, fisheries, property, human health, etc. Figure 11.2 is an example for crop agriculture. Although the analysis is potentially complex, more data are available to make these calculations than for other land uses. For some IECs and hazards, ranging from health status to sedimentation to ecology, there will be no chance of reducing the outcome to a single figure, unlike the annual average economic return in agriculture.

In all sectors affected by changes in risks due to the project there is a wider issue of the acceptability of changes in risk. Unfortunately, there is a lack of information to indicate the level of public and individual acceptance of risks in Bangladesh, although there is a common view that cropping patterns in flood-prone areas aim to achieve some minimum return (lower variability) and not necessarily the highest annual average return (higher variability).

#### 11.3.6.1 Checklist of Hazards and Potential Impacts

Table 11.9 is a summary of the likely consequences of water management projects to hazard risks. This is intended to be used as an initial guide for compiling data in the hazard screening and risk assessment stages of the appraisal.

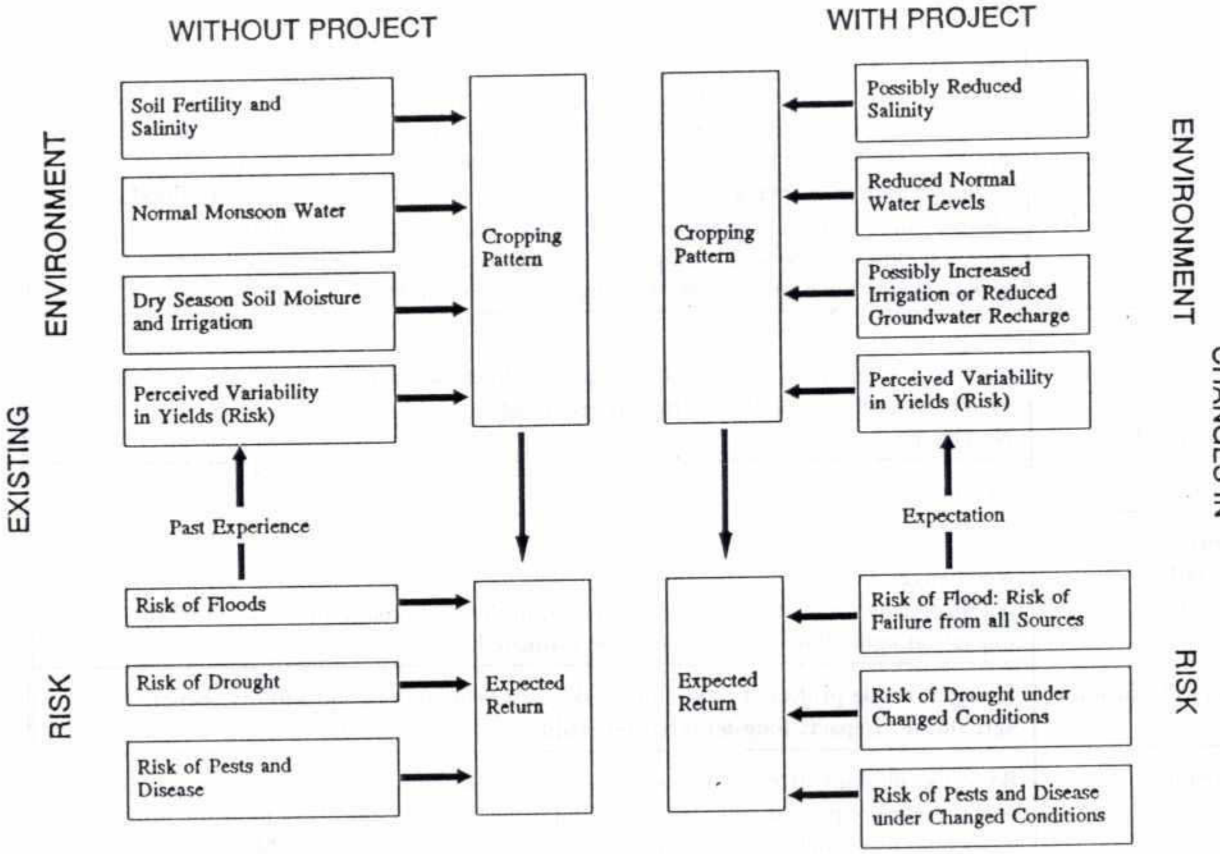


**Figure 11.2** **Changes in Risks and Environment, and Their Incorporation in Water Development Project Appraisal**

*Notes:*

1) The only environmental factors considered are those that affect risks to cultivation and that might be affected by a project.
2) Changes in the "normal" agro-environment and in perceived risks are expected to result in changes in cropping pattern.
3) Both changes in cropping pattern and changes in risks would change "expected" or annual average returns.
4) The risks shown may not all be changed by a project. It may be possible to assume that the normal environment includes variation in pests and diseases, for example, in which case risk estimates would only be needed for water-related hazards.
5) The difference in expected returns measures the per hectare impact of the project (with project minus without project), and is a function of probability estimates for different events and yield estimates for each crop for each event.
6) It may not be possible to estimate probabilities. To gauge the implications of uncertainty, those event magnitudes and frequencies that would result in a break-even project, or no change in expected returns, could be approximated.

Table 11.9 **Likely Changes Caused by Water Management Projects on Hazards for the Project Area**

| Hazard | Risk Change due to Project |
|---|---|
| Flood and Drainage | *Inside project*: reduced frequency for a given flood level, reduced duration, delay in onset, hastening of recedence. Assessment should take into account possible changes in drainage conditions that may limit this benefit. *Outside project:* confinement and sedimentation may increase flood level for a given flood event. Change in flood risk also has implications for infrastructure, homesteads, agriculture, culture fisheries, and other economic activities; ecological consequences unclear. Impacts recurrent, some processes outside a project may be long-term/irreversible. |
| Cyclones | |
| Storm Surge | Reduce frequency of floods inside project, unlikely to have impact outside; consequences similar to those for flood. Impacts recurrent. |
| High Winds | No change. |
| Tornadoes | No change. |
| Storms | |
| Hail | No change. |
| Rain | No direct change, but structures may result in drainage congestion that has short-term impact on agriculture—risk needs to be estimated. |
| Saline Intrusion | Reduced inside project, low residual risk, slow reduction in soil salinity, benefits to agriculture. Impacts long-term but reversible. |
| Erosion | Basic morphology of river may not be changed, but confinement could worsen erosion risk outside the project and for the embankment itself. Implications for agriculture, other land uses, and project failure. Impacts long-term and irreversible. |
| Sand Deposition | Prevented by embankments, but may be more concentrated if breaches occur. Implications for agriculture. Impacts long-term but reversible. |
| Drought | Reduced soil moisture on higher lands after monsoon, reduced groundwater recharge, hence higher risk of effective drought (assuming no irrigation, or increased costs of irrigation). Implications for agriculture. Impacts short-term and recurrent. |
| Crop Pests | Increased crop production and embankments that provide refuges may result in increased rat populations, hence increased percentage losses. Recurrent or general agricultural impact. |
| Crop Diseases | No direct effect, but incidence may change (increase) if increased monoculture and/or cropping intensity and/or less resistant crops are grown. General agricultural impact. |
| Human Health | Complex direct and indirect changes possible: reduced risk to life from flooding except for risk during breach events; background improved food availability from increased agricultural output, but decline in capture fish production; increased hazards from stagnant water (mosquitoes and malaria, unsanitary conditions) due to closing of waterways. Only first category a risk—recurrent impact, others are uncertain but potential general changes. |

(continued)

Table 11.9 continued

| Hazard | Risk Change due to Project |
|---|---|
| Pollution | Lack of flushing effect of floods inside project may concentrate pollution. Moreover, background agro-chemical pollution may increase if input use increases in project (as intended). Likewise, jute retting without running flood water is likely to worsen water quality. Increased potential adverse impacts from spills if sites handling hazardous materials are located inside the project. Potential long-term impacts, reversibility unclear. Secondary consequences, e.g., on health, unclear due to low general base level of toxic pollution. |
| Earthquakes | Indirect changes: risk of embankment failure and damage to other FCD/I infrastructure resulting in losses. Implications for risk to human and livestock lives, and for fresh water ecology (which may benefit). Mixture of short- and long-term impacts, events may be unlikely but consequences probably long-term. |
| Failure of Flood Protection Works | Risk depends on design standards, quality of construction, and location relative to erosion risk; implications as for flooding but consequences likely to be worse due to sudden onset of flood and lack of preparation. Short-term impact if repaired. |
| Failure of Irrigation Systems | Indirect risk from damage to surface irrigation systems due to breaching or from lowering of groundwater table due to flood protection. Short- and longer-term impacts for agriculture. |

#### 11.3.6.2 Risk of Structural Failure

The risk that a project will fail to achieve its intended objectives will depend in part on human actions to take advantage of opportunities the project creates and on the operation and maintenance performance of the project. Project planning and design should take these problems into account, so it should be sufficient in the risk analysis to analyze the risk of a structure's failure. The risk of overtopping will be obvious from the design calculations for the embankment. However, there is a lack of empirical studies of the risk of structural failure for embankments in Bangladesh even though the causes of failure are relatively well known (for example, Safiullah 1989). This risk will depend both on construction standards and subsequent maintenance practices. In addition, the risk of erosion needs to be estimated based on past trends, predictions of future river morphology, and the underlying soils. Finally, "public cuts," an added risk, quite frequently arises with projects and depend on impacts and perceived impacts among social groups. It should not be presumed that a new project will be free of this hazard even if there is public participation in its planning. Risk assessment would be aided by historic analysis of the frequencies of failures and extent of their impacts in existing projects, and by explicit engineering assessments of the risks to the structures in proposed projects.

The analysis structural failure risks has several implications. First, there are trade-offs between project costs or net benefits and failure risk. These involve: design and construction standards (higher costs result in lower risk), set-back distance (lower benefitted area results in lower risk), and mitigatory measures (compensatory measures for negative external impacts may reduce the risk of cuts). Second, it is never possible to eliminate risk of failure, so in economic terms an optimum balance should be sought between project benefits and costs that takes risk into account. This will depend on estimates of the areas that would be affected by breaches, impacts on standing crops, on other land uses and property, and on future crops (if there is sand deposition or irrigation infrastructure is damaged), compared with the additional costs of implementation. Third, it is necessary to provide for emergency repairs after a breach so that in the following year the planned benefits can again be achieved (this will need to be provided in practice). Finally, in all options the costs of emergency plans and provisions—including warnings and places of shelter—need to be included, since these will be needed even if the risk of failure in new projects is low.

Although the economic implications of these risks can be incorporated in the project appraisal, it is important to identify in non-economic terms the populations at risk and potential consequences as an input to the overall decision-making process.

In all sectors affected by changes in risks due to the project there is a wider issue of the acceptability of changes in risk. Unfortunately, there is a lack of information indicating the level of public and individual acceptance of risks in Bangladesh, although there is a common view that cropping patterns in flood-prone areas aim to achieve some minimum return (lower variability) and not necessarily the highest annual average return (higher variability).

### 11.3.7 Mitigation

An integral part of the project proposal is a plan to mitigate adverse impacts. While it may not be possible to plan to cope with uncertain environmental changes and impacts, it is important that plans and provisions be made for foreseeable risks to the project. Based on the hazards identified for the with-project assessment, and in particular on the risks to the project structure itself, a disaster management plan should be drawn up and included in the operating plan for the project. It is necessary during project planning and design to provide for proper operation and maintenance to minimize these risks, as well as to provide emergency measures that can be taken when events cannot be prevented.

The disaster management plan should include:

- public information on the risks remaining with a project, since flood control may result in a false sense of security;
- identification of safe and hazardous locations;
- provision for monitoring of embankments during the monsoon and for warning dissemination if a breach or overtopping is imminent; and
- Local administration should, as part of the plan, make provision for and authorized use of public lands by displaced people, and make provision for necessary services to support these people.

Ideally, there should be an annual rehearsal of procedures in order to strengthen awareness of the hazards and to ensure that procedures are known and work. The opportunity should be taken to modify plans in the light of monitoring of changes in the project-affected area and associated changes in risks.

## Chapter 12

## MAPS AND MAPPING

Map requirements for EIA fall under three categories:

- working maps required for, or prepared during, reconnaissance survey and field work.
- maps required for all or some of the EIA resource sections. These maps may stand on their own and may be referred to in various resource sections, but may also be used as base maps for further spatial analysis or for illustrating the results of spatial analysis.
- maps that are more specific to a particular resource chapter and generally are the result of data analysis.

Table 12.1 lists maps that may be required to be prepared by the EIA practitioner in the course of reconnaissance survey and field work. Table 12.2 lists general maps, aerial photographs and satellite imagery generally available in Bangladesh, along with other pertinent information the EIA practitioner might find useful. Table 12.3 lists maps of a general nature and which belong to the second category above. Table 12.4 lists maps of specific nature belonging to the third category above.

Selection of maps and remote sensing data from Table 12.1 will depend on the following considerations:

- the purpose for which the maps and remote sensing data are to be used;
- the information available in the various maps and remote sensing data answering those requirements; this will depend on the limitations of these sources.

Maps included in the EIA report will generally have to be accommodated either on A3, A4 or on even larger paper size. Maps with more detailed information may have to be printed on A3 paper size, while simpler maps may be printed on A4 paper. Generally, it is convenient to draw maps on A3 size and then reduce by 35 percent to A4 size.

**Table 12.1 Maps and Remote Sensing Data Required for Reconnaissance Surveys and Field Work**

| Map or Image | Scale |
|---|---|
| Project area base map | Not higher than 1:50,000 |
| Thana map | 1:63,360 |
| Topo map | 1:50,000 |
| Water development map | 1:15,840 |
| Aerial photographs | 1:50,000, 1:30,000, 1:20,000 |
| Satellite imagery | 1:50,000 or less |

Table 12.2 Maps and Remote Sensing Data Available for Bangladesh

| Title of Map or Data | Agency/ Source | Year | Scale | Major Information Available |
|---|---|---|---|---|
| **ADMINISTRATIVE** | | | | |
| 1) Bangladesh | SOB | 1986 | 1:1000,000<br>1" = 10 miles | International, divisional and district boundaries, major rivers, railways and roads, river and air transport networks, major towns, latitudes, longitudes. |
| | DLRS | 1937-44 | 1" = 8 miles | |
| | SPARRSO | Reprints 1984, 1988 | 1:250,000<br>1:500,000 | |
| 2) District | SOB | 1975-1985 | 1:250,000 | District and thana boundaries; other information as above. |
| | DLRS | 1931-37 Corrected 1944 | 1" = 4 miles | |
| 3) Thana | DLRS | 1930s | 1" = 1 mile | Thana and mauza boundaries, thana headquarter and other towns, mauza names with jurisdiction list (JL) numbers, rivers, roads, khals, latitudes, longitudes. |
| 4) Mauza | DLRS | CS:1910-1930/32 | 1:3,960 Rural Areas only. | Mauza boundary. Land plot boundary with plot number, roads, rivers, khals. |
| | | SA:1953-1962 | " | Mainly adopted from CS, new maps in alluvion/delusion areas only. |
| | | RS:1966/67 to date | " | Similar information as CS.<br>Total areas covered to date: greater districts of Rajshahi & Chittagong. Pabna and Kushtia nearly complete. |
| 5) Small Area Atlas | BBS | 1984-1990 | ~1:136,000<br>~1:182,000<br>Rural areas only. | Union and mauza boundary, geocoded. |

(continued)

Table 12.2 Maps and Remote Sensing Data (continued)

| Title of Map or Data | Agency/ Source | Year | Scale | Major Information Available |
|---|---|---|---|---|
| **TOPOGRAPHIC** | | | | |
| 1) Topo-map or Topo-sheet | SOB | 1963-1992 | 1:250,000 | Spot heights, roads, rails, rivers, khals, settlements, towns, bridges, culverts, latitudes, longitudes, benchmarks. Whole of Bangladesh. |
| | | 1965-1992 | 1:5,000 | Spot heights, roads, rails, rivers, khals, bridges, culverts, settlements, towns, contour lines, haors, beels, marshes, ponds, embankments, administrative boundaries, grids, latitudes, longitudes, ponds, benchmarks. Whole of Bangladesh. |
| | SOB | 1955-1956 | 1:25,000 | N. Bengal, part. |
| | | 1982-92 | 1:25,000 | Hill tracts |
| | | 1980 | 1:25,000 | Dhaka-Madhupur |
| | | 1978-1984/90 | 1:500,000 | Bangladesh and surrounding areas in 6 sheets. |
| 2) Water Developme nt | SOB BWDB | 1955-65 | 1:15,840 | Spot heights, contours lines at 1-foot interval, roads, rails, rivers, khals, embankments, bridges, culverts, beels, marshes, ponds, mud, haors, settlements, ponds, towns, grids, latitudes, longitudes. Whole of Bangladesh except hill areas. |
| 3) Water Developme nt | SOB BWDB | 1962-63 | 1:7,920 | Ditto. Rajshahi, Pabna, Nawabganj, Natore, part of Faridpur. |
| 4) Irrigation Planning | BWDB | 1955 | 1:40,000 | 5-feet contour line, other information as in 1:50,000 map. Part of Bangladesh. |
| **SPECIAL/THEMATIC** | | | | |
| 1) Reconnaissa nce Soil Survey | - | 1960-1970 | ---------- | Whole of Bangladesh. |
| Soil Association | - | | 1:125,000 | |

(continued)

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Table 12.2 Maps and Remote Sensing Data (continued)

| Title of Map or Data | Agency/ Source | Year | Scale | Major Information Available |
|---|---|---|---|---|
| Land Capability | FAO/UNDP | 1985 | 1:250,000 | Rivers, soil associations, thermal sub-zones, growing period sub-zones, location of groundwater monitoring wells. Whole of Bangladesh. |
| Land Use | - | | 1:250,000 | |
| 2) AEZ | | | 1:250,000 | |
| | | | 1:750,000 | Agro-ecological regions according to physiographic units. Whole of Bangladesh. |
| 3) Soil and Physiographic | SRDI | On going | 1:50,000 | Semi-detailed soil association and land level classification map. |
| **GENERAL MAPS AND REMOTE SENSING DATA** | | | | |
| 1) Thana (Upazila) Plan | LGEB | ? | 1:50,000 | Land use and infrastructure information. |
| 2) Thematic | MPO | 1985 | 1:50,000 | Land use and surface elevation. |
| 3) Forest | DOF | ? | 1:15,840 | 5-year age groupings, species composition, crown density of all forests in Bangladesh. |
| 4) Archaeological | SOB | 1988 | 1:1,000,000 | Archaeological sites, whole of Bangladesh. |
| 5) Landsat Digital Mosaic | SPARRSO | 1984 | 1:1,000,000 | Whole of Bangladesh. |
| 6) Major Cover Types | " | " | " | " |
| 10) Drainage Pattern | " | 1984 (Based on MSS) | " | " |
| | | 1988 (Based on TM) | " | " |

(continued)

Table 12.2 Maps and Remote Sensing Data (continued)

| Title of Map or Data | Agency/ Source | Year | Scale | Major Information Available |
|---|---|---|---|---|
| 11) Ponds | " | 1984 (Based on Aerial Photographs) | 1:50,000 | 40 thanas of Bangladesh. |
| 12) Large Water Bodies | " | 1984 (Based on 1984 MSS) | 1:50,000 | Whole of Bangladesh. |
| 13) Land Use | " | 1980-1988 (Based on MSS and AP) | 1:250,000<br>1:50,000 | Parts of Bangladesh. |
| **GEOLOGICAL** | | | | |
| 1) Geological | GSB | 1984 | 1:1,000,000 | Whole of Bangladesh |
| 2) Aeromagnetic Anomaly | GSB | 1984 | 1:1,000,000 | " |
| 3) Bauaer Gravity Anomaly | GSB | 1984 | 1:1,000,000 | " |
| **AERIAL PHOTOGRAPHS** | | | | |
| 1) Panchromatic | SOB FINNMAP | 1990-91 | 1:20,000 | Usual A.P. database for a 40 km-wide strip centered on the Brahmaputra-Jamuna river. |
| 2) Panchromatic and FINNMAP | SOB | 1990 | 1:30,000 | Usual A.P. database for 40,000 sq kms of the coastal area. |
| 3) Panchromatic | SOB FINNMAP | 1990-91 | 1:50,000 | Usual A.P. database for a 100 km-wide strip centered on the Brahmaputra-Jamuna river. |
| 4) Panchro-matic and Infrared | SOB SPARRSO | 1983-84 | 1:50,000 | Usual A.P. database for the whole of Bangladesh. |
| 5) Panchro-matic | SOB SRDI | 1974-75 | 1:30,000 | Usual A.P database for the whole of Bangladesh. |
| 6) Panchro-matic | SOB SRDI | 1964-65 | 1:40,000 | Usual A.P database for the whole of Bangladesh. |
| 7) Panchro-matic | SOB Japanese | 1976 | 1:30,000 | Sarishabari to Arichaghat for Jamuna bridge site selection. |

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Table 12.2 Maps and Remote Sensing Data (continued)

| Title of Map or Data | Agency/ Source | Year | Scale | Major Information Available |
|---|---|---|---|---|
| | SOB | 1955-1956 | 1:25,000 | N. Bengal, part. |
| | | 1982-92 | 1:25,000 | Hill tracts |
| | | 1980 | 1:25,000 | Dhaka-Madhupur |
| | | 1978-1984/90 | 1:500,000 | Bangladesh and surrounding areas in 6 sheets. |
| **SATELLITE IMAGERY** | | | | |
| 1) SPOT, Computer Compatible Tape (CCT) | FAP 19 | 1991 | 1:50,000 | Digital data for the FAP 3.1 North Central Region of Bangladesh. |
| 2) SPOT, Color, Hard Copy | FPCO | 1990 | 1:50,000 | Rectified photographic prints for FAP regions only. Good database for all usual information. Index map enclosed. |
| 3) SPOT, Panchromatic, Hard Copy | LGED | 1989 | 1:50,000 | Rectified photographic prints for whole of Bangladesh. Good database for all usual information. Index map as above. |
| 4) LANDSAT MSS in CCT | SPARRSO | 1984 | - | Whole of Bangladesh. Index map for MSS and T.M. enclosed. |
| 5) TM, (CCT) | " | 1990-91 | - | Whole of Bangladesh. Index map for MSS and T.M. enclosed. |
| 6) MSS Photographic prints, B/W and color | " | Pre 1986 | 1:500,000<br>1:25,000 | Whole of Bangladesh. |
| 7) TM Photographic prints, B/W and color | " | From 1986 | " | Whole of Bangladesh. |
| 8) SPOT Photographic prints, B/W and color | " | From 1986 | " | Whole of Bangladesh. |

Table 12.3 Maps Recommended for EIA Reports

| Name of Map | Information Input |
|---|---|
| Location map | Location of the project area on a map of Bangladesh in the inset.<br>Location of the project area within the region, preferably in some administrative region. |
| Project area base map | 1. Surface water distribution system including rivers, khals, beels, haors, baors, and all other lotic and lentic water bodies and wetland habitat.<br>2. Location of all climatological and surface water and groundwater hydrological data recording stations.<br>3. Roads classified, if possible, into metalled and non-metalled.<br>4. River routes with landing ghats.<br>5. Rail lines, broad and meter gauge, where applicable.<br>6. Major market centers, fair grounds, thana/administrative headquarters.<br>7. Major urban and rural settlements.<br>8. Existing FCDI infrastructures. |
| Location of problem areas | 1. Flood-affected areas with flood depths.<br>2. Erosion/breach-affected areas with length and width of erosion.<br>3. Sand deposition areas.<br>4. Drainage congestion areas.<br>5. Salinity-affected areas and/or other water quality problem areas.<br>6. Tidal flood-affected areas.<br>7. Any other specific problem areas. |
| Project map | If the project is at the feasibility stage, a project map showing the project concepts with all types of interventions and options should be available for incorporation into the EIA report. If the project is at the prefeasibility stage, a project map may be prepared on the basis of prefeasibility-level project concept. |
| Distribution of irrigation facilities | Traditional, HTWs, STWs, DSSTWs, DTWs. |
| Distribution map of irrigation change | 1. Percentage change over specified period.<br>2. Growth rate in minor irrigation.<br>3. Change in traditional irrigation. |
| Water transportation | 1. Navigable lengths of perennial waterways according to Least Available Depths (LAD) (See IWTA Master Plan Classification.)<br>2. Navigable lengths of seasonal waterways, with seasons/months/periods specified.<br>3. Landing ghats/terminals with infrastructural facilities for passengers and goods.<br>4. Constraints to navigation, i.e., embankments, roads, regulators, areas of heavy siltation. |

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**Table 12.3** Recommended Maps (continued)

| Name of Map | Information Input |
|---|---|
| General land use map | 1. Forest cover (by types if necessary).<br>2. All urban and rural settlements.<br>3. Homestead vegetation, if scale of the map permits.<br>4. Roadside and community vegetation.<br>5. Agricultural land.<br>6. Roads, rail, with bridges and culverts.<br>7. Major rivers, khals, and water bodies.<br>8. Khas land.<br>9. Jalmahal<br>10. Other Common Property Resources in the area.<br>11. Historically/culturally/archaeologically important sites. |
| Land Type Map | Land types from $F_0$ to $F_4$ |

**Table 12.4** Special Maps Required for Specific Assessments

| Resource | Map |
|---|---|
| Water & Climate | 1. AEZ thermal and moisture zones.<br>2. Isohyetal map.<br>3. Maps showing results of hydraulic analysis, both surface water and groundwater.<br>4. Location of water quality sampling sites. |
| Biological | 1. Location of sampling stations for limnological survey.<br>2. Fish migration path by species and seasons.<br>3. Critical fish habitat (e.g., important spawning, grazing areas).<br>4. Distribution of culture fish ponds.<br>5. Distribution of maximum and minimum water surface area of wetlands.<br>6. Time and volume of inflow and outflow of water to and from wetlands.<br>7. Wetlands having special/critical ecological importance.<br>8. Areas where wildlife constitutes an important resource.<br>9. Important terrestrial habitat. |
| Land | 1. Cropping pattern.<br>2. Areas having special resources, e.g., sand, boulders, etc. |
| Human | 1. Distribution of sample villages/mauzas.<br>2. Distribution of various professional groups including fishermen, weavers, bell metal makers, potters, boat builders, etc.<br>3. Distribution of fish landing centers.<br>4. Distribution of waterbodies practicing the new fisheries management policy and old short-term leasing system.<br>5. Maps showing mauza boundaries, if necessary. |

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Chapter 13

# POLICY AND LEGISLATION RELATED TO THE DEVELOPMENT OF WATER, LAND, BIOLOGICAL AND HUMAN RESOURCES IN BANGLADESH

Bangladesh has many laws dealing with water, land and human resources, laws that EIA practitioners should be aware of when preparing EIAs and EMPs. Those laws, catalogued in a separate report (ISPAN 1992), are outlined briefly below.

## 13.1 The Constitution of the Peoples' Republic of Bangladesh

The constitution is the solemn expression of the will of the people and the supreme law of the Republic. Any other law, inconsistent with the constitution shall be void to the extent of the inconsistency. All powers in the Republic belong to the people, and are exercised by the authority of the constitution.

Among the fundamental principles outlined in the constitution, the following are relevant to environmental concerns:

- economic and social justice;
- local government institutions represent peasants, workers and women;
- participation of women;
- ownership or control of the instruments and means of production and distribution take the following forms:
  - state ownership on behalf of the people;
  - cooperative ownership on behalf of their members;
  - private ownership by individuals;
- provision of basic necessities including food, clothing, shelter, education, medical care and employment;
- rural development, including the promotion of agricultural revolution, rural electrification, development of cottage and other industries, education, communications and public health;
- conservation of national cultural traditions and heritage;
- protection of national monuments, objects or places of special artistic or historic importance or interest;
- no discrimination on the basis of religion, race, caste, sex or place of birth;
- rights to acquire, hold, transfer or otherwise dispose of property.
- no property shall be compulsorily acquired, nationalized or requisitioned except by authority of law, and with compensation;
- properties of the Republic include, among others:
  - all minerals and other things of value underlying any land of Bangladesh
  - all lands, minerals and other things of value underlying the ocean within the territorial waters or over the continental shelf of Bangladesh
  - any property located in Bangladesh that has no rightful owner.

## 13.2 Environmental Policy

The chief sources of the environmental policy of the Government of Bangladesh are: the Environment Policy 1992 and Implementation Program, published by the Ministry of Environment and Forest, Government of Bangladesh, May 9, 1992 (in Bangla); and the Fourth Five Year Plan, 1990-

95; particularly chapter IX on Environment and Sustainable Development.

Following are the six general aims of the environmental policy of Bangladesh as described in the Environment Policy 1992.

- to conserve and develop the environment in order to maintain and generally improve the ecological balance.
- to protect the country from natural hazards.
- to identify and control activities leading to pollution and degradation of the environment.
- to ensure environmentally sound development in all sectors.
- to ensure environmentally sustainable, long-term development of national resources.
- to remain actively involved, as far as possible, with all international activities related to the environment.

These aims have been translated into more detailed priority objectives for different sectors. The most significant of these are summarized here.

1. *Agriculture*: Agricultural development and self-sufficiency in food are to be achieved through conserving the agriculture resource base by judicious use of appropriate development and management technology.

2. *Industries*: Appropriate pollution prevention measures should be adopted in phases; pollution-causing industries should be banned; research and development in environmentally sound industrial technology should be encouraged; before establishing any industry in the public or private sectors an EIA should be conducted.

3. *Health and Hygiene*: Public health and hygiene should be promoted; environmental thinking should be incorporated in the national health policy; environmental education should be incorporated in the health education curriculum; a healthy environment in urban and rural areas and in the labor housing areas should be developed.

4. *Fuel/Energy*: The use of pollution-causing fuels should be discouraged; precautionary measures should be taken against radioactive fuels; traditional and renewable energy sources, such as wood, should be conserved and the use of alternative sources encouraged; prior to mining for energy and minerals and EIA should be conducted.

5. *Water Development, Flood Control and Irrigation*: Development and management of water development, drainage and irrigation projects involving surface water or groundwater should be environmentally sound and sustainable; the inland waters should be maintained free from pollution; prior to implementing water development and management projects and EIA should be performed; the adverse environmental effects of previous water resources management and flood control projects should be removed or repaired.

6. *Land*: Environmentally and ecologically sound land use practices should be adopted and extended and soil fertility should be conserved; land erosion should be prevented and the land reclamation program should be strengthened; soil salinity and alkalinity should be prevented.

7. *Forest, Wildlife and Biodiversity*: Forestry conservation and afforestation program should be used in order to maintain ecological balance; wildlife and biodiversity should be conserved; a research program should be established; there should be an exchange program of knowledge and experience; the national wetlands should be conserved and migratory bird sanctuaries developed.

8. *Fish and Livestock*: Fish habitat should be protected, conserved and developed; fisheries should be developed without adversely affecting the mangrove and other ecosystems; there should be appropriate environment for livestock development; those FCD/I projects found to cause adverse

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effects on fisheries resources should be re-evaluated.

9. *Food*: Food production, processing, and distribution practices and waste food disposal practices should be environmentally sound; the importation of food injurious to public health and environment should be prevented.

10. *Coastal and Marine Environment*: The coastal and marine ecosystem and fisheries resources should be conserved and developed; pollution from domestic and foreign activities should be prevented; the research program on coastal and marine environment should be strengthened; the coastal and marine fish catch should be maintained at the maximum sustainable level.

11. *Transportation and Communication*: Resource degradation and pollution by ports, dockyards and carriers and by their passengers should be controlled; road, rail, air and inland navigation systems should not pollute or degrade the environment; prior to implementing any project related to transportation and communication and EIA should be conducted.

12. *Housing and Urbanization*: Environmental ideas and concepts should be integrated into all planning and research regarding housing and urbanization; environmentally sound physical facilities should be extended into urban and rural housing areas in phases; housing and urbanization that is creating both local and general adverse effects on the environment should be controlled; the role of water bodies in the beautification of urban areas should be emphasized.

13. *Population*: The environment should be conserved and developed with the participation of women and the jobless and through human resource development; the concept of protection and conservation of the environment should be incorporated in the population control policy and program.

14. *Education and Public Awareness*: Mass education, both formal and informal, should be provided to create public awareness and to ensure the voluntary participation of people in the conservation and long-term sustainable use of resources and the environment; environmental education materials should be included in the training of government and non-government officers, employees, industrial and business workers.

15. *Science, Technology and Research*: The National Science and Technology Policy (1986) includes provisions for supervising and controlling environmental pollution. It also provides for environmental consideration in the priority sectors for research and development.

16. *Legislative Framework*: The Environmental Policy also includes provisions for updating and amendment of existing laws, particularly in the light of international laws, conventions and protocols which Bangladesh should consider approving; new laws should be enacted in whatever sector necessary, and laws for the conservation of environment and resources and control of environmental degradation and pollution should be enforced.

17. *Institutional Framework*: The policy also emphasizes the necessity of an appropriate institutional framework with a defined role. A National Environment Committee, chaired by the head of the government is to provide general guidance toward implementing the Environmental Policy. The Ministry of Environment and Forest is to coordinate the implementation of the policies and take necessary timely steps to amend and extend the scope of the policies to answer to the future requirements of the changed socioeconomic and environmental

conditions of the country. The Department of Environment is to give final review of and approval to all EIAs.

*Implementation Program Related to Environment*: In order to achieve the aims and objectives of the national environmental policy, a list of definite sectoral action programs and relevant implementation authorities has been incorporated as an addendum to the policy. The sectors are the same as described in the policy section above. The implementation authorities are too numerous to mention but include relevant ministries, departments, corporations, institutes, boards, organizations, offices and bureaus, authorities and administrators. The EIA practitioner will be well advised to consult this list of sectoral programs and implementation authorities while identifying, for example, mitigation and management programs.

### 13.3 Environmental Legislation

Legislation of environmental concern related to water, land and human resources development comprises acts, ordinances, rules and regulations, which may be used by the EIA practitioner for the following purposes:

- to determine whether a project proposal conforms with the existing policies, laws and the rules of the land;
- to identify if any part of a project proposal is in contravention of the existing policies, laws and rules of the land;
- if certain policies, laws and rules appear to be contradictory with regard to a particular project proposals, to advise on a course of action that would best be in the long-term environmental interest of the nation;
- to learn whether any proposed action may infringe on the fundamental or traditional rights of the people;
- to establish whether relevant legislation that may be used profitably for the benefit of the environment, is or has become inoperative due to prevailing socioeconomic conditions,
- to determine whether there are gaps in the existing legislation for which new enactments may be necessary;
- to find out whether and where existing legislation needs strengthening or updating to take into account the prevailing conditions/state of the environment or environmental awareness.

The acts, ordinances and rules listed here are not exhaustive, and only the most important ones have been included. The EIA practitioner would be well advised to read the original version of the texts of the legislation, generally to be found in the government gazette notification, the Bangladesh Code, and the publications of the relevant ministries and departments published by the government press.

Many of the laws now on the books, although subsequently amended and adapted, date back to 1836. Since the independence of Bangladesh there has been extensive amendment, adaptation, and repeal of existing laws and enactment of new laws to meet the changed and changing political, social and economic needs of the new state. The EIA practitioner, when trying to apply a particular legislation in a particular situation would need to check on the latest amendments.

There are some acts/ordinances whose provisions cut across several fields. For example the Pourashava Ordinance provides for health and sanitation as well as parks. The East Bengal Embankment and Drainage Act also provides for compensation and land acquisition under the Acquisition Act, 1894. Similarly, the Cattle Trespass Act may also be placed under the Livestock section. The Agricultural and Sanitary Improvement Act, 1920, deals both with agriculture and sanitation. Legislation relating to land tenancy and other related issues are many and scattered throughout various other legislation.

Legislation has been grouped into sections according to the important environmental components considered in the EIA Guidelines. Within each section legislation has been arranged chronologically as far as possible, without disturbing the context. The title in the parentheses is the short title of the legislation. In law literature the short title is generally used for easy reference. The date following each act is the date it was enacted.

*Agriculture*

- The Agricultural and Sanitary Improvement Act, 1920 (Bengal Act VI of 1920)
- The Agricultural Pesticides Ordinance 1971 (Ordinance No. II of 1971)
- The Agricultural Pesticides (Amendment) Act (Act V of 1980)
- The Seeds Ordinance, 1977 (Ordinance No. XXXIII of 1977)
- The Pesticide Rules, 1985

*Betterment*

- East Bengal Betterment Fees Act, 1953 (E.B. Act XII of 1953)

*Cultural and National Heritage*

- Antiquities Act, 1968

*Energy*

- Brick Burning (Control) Act, 1989 (Act No. VIII of 1989) (In Bangla)

*Fisheries*

- Private Fisheries Protection Act, 1889 (Bengal Act II of 1889)
- Tanks Improvement Act, 1939
- East Bengal Protection and Conservation of Fish Act, 1950 (East Bengal Act XVIII of 1950)
- East Bengal Protection and Conservation of Fish (Amendment) Act, 1963 (E.P. Act 11 of 1964)
- Protection and Conservation of Fish Rules, 1985
- Protection and Conservation of Fish (Amendment) Ordinance, 1982
- Marine Fisheries Ordinance, 1983
- East Pakistan Fisheries Development Act.
- Corporation Ordinance, 1964 (E.P. Ordinance No. IV of 1964)

*Forestry*

- The Cattle Trespass Act, 1871 (Act No. I of 1871)
- The Forest Act, 1927
- The Sylhet Forest Transit Rules, 1951
- The Chittagong and Chittagong Hill Tracts Reserved Forest Fire Protection Rules, 1958
- The Attia Forest (Protection) Ordinance, 1982

*Gender Issues*

- Muslim Family Laws Ordinance, 1961 (Ordinance No. VIII of 1961)
- Dowry Prohibition Act. 1980 (Act No. XXXX of 1980)
- Dowry Prohibition (Amendment) Ordinance, 1984 (Ordinance No. LXIV of 1984
- Cruelty to Women (Deterrent Punishment) Ordinance, 1983 (Ordinance No. LX of 1983)

*Health, Sanitation and Water Supply*

- East Pakistan Water Supply and Sewerage Authority Ordinance, 1963 (E.P. Ordinance No. XIX of 1963)

*Lands and Soils*

- Bengal Alluvion and Diluvion Act, 1847 (Act IX of 1847)
- Bengal Alluvion (Amendment) Act, 1868 (Bengal Act IV of 1868)
- Bengal Alluvial Lands Act, 1920 (Bengal Act V of 1920)
- East Bengal Building Construction (Amendment) Act, 1952 (E.B. Act II of 1953)
- Building Construction (Amendment) Act, 1990.

*Livestock*

- The Livestock Importation Act, 1898 (Act No. IX of 1898)
- The Glanders and Farcy Act, 1899 (Act No. XIII of 1899)
- The Cruelty to Animals Act, 1920 (Bengal Act I of 1920)

*Local Government*

- Local Government Ordinance, 1976 (Ordinance No. XL of 1976)

- Pourashava Ordinance, 1977 (Ordinance No. XXVI of 1977)
- Local Government (Upazila Parishad and Upazila Administration Reorganization) Ordinance, 1982 (Ordinance No. LIX of 1982)

*Navigation/Water Transportation*

- Canals Act, 1864 (Bengal Act V of 1964)
- Ferries Act, 1885 (Bengal Act I of 1885)
- Water Hyacinth Act, 1936 (Bengal Act XII of 1936)
- East Pakistan Inland Water Transport Authority Ordinance, 1958 (E.P. Ordinance No. LXXV of 1958)

*Pollution*

- Smoke-Nuisances Act, 1905 (Bengal Act III of 1905)
- Environment Pollution Control Ordinance, 1977 (Ordinance No. XIII of 1977)

*Population*

- Births and Deaths Registration Act, 1873

*Recreation and Parks*

- Public Parks Act, 1904 (Bengal Act No. II of 1904)

*Tenancy and Land Administration*

- Transfer of Property Act, 1882
- Easements Act, 1882
- Land Acquisition Act, 1894 (Act I of 1894)
- East Bengal Non-Agricultural Tenancy Act, 1949 (E.B. Act XXII of 1949)
- East Bengal Acquisition of Waste Land Act, 1950
- State Acquisition and Tenancy Act, 1950 (East Bengal Act XXVIII of 1951)
- Land Administration Manual, 1982
- Land Reforms Ordinance, 1984 (Ordinance No. X of 1984)
- Laws of Inheritance
  - The Muslim Law of inheritance
  - The Hindu Law of inheritance
  - The Buddhist Law of inheritance
  - The Christian law of inheritance

*Voluntary Organization*

- Voluntary Social Welfare Agenciės (Registration and Control) Ordinance, 1961 (Ordinance No. XLVI of 1961)

*Water Resources*

- The Panel Code, 1860 (Act No. XLV of 1860)
- Bengal Irrigation Act, 1876 (Bengal Act III of 1876)
- The East Bengal Embankment and Drainage Act, 1952 (E.B. Act I of 1953)
- The East Pakistan Water and Power Development Authority Ordinance 1958 (E.P. Ordinance I of 1959)
- The Bangladesh Water and Power Development Boards Order, 1972 (Presidents Order No. 59 of 1972)
- The Bangladesh Irrigation Water Rate (Amendment) Act, 1990.

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Chapter 14

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