

# **Environmental Aspects of Water Resources Development**

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## **1.0 NATIONAL SYSTEM AND ENVIRONMENTAL QUALITY**

Natural System and Environmental Quality (NS & EQ) generally refer to the physical-chemical-biological environment. The term Natural System refers to ecosystems of various types – aquatic and terrestrial – in various types of uses – agricultural, fisheries, forestry, grazing, and water resource. The objectives of natural systems management are the maintenance of the renewable resources base and of ecosystem productivity, and preservation of species and habitats. The term Environmental Quality refers to the state of air, water, land, and human artifacts, as affected by human activities. Since economic growth is often accompanied by increasing stress on natural systems and significant effects on environmental quality, India should try to conduct development activities in a fashion that preserves the long-run productivity of natural systems for sustained development and that minimized deterioration in environmental quality. This is, by and large, in line with the policy enunciated in the Fourth Five Year Plan document and which is being adhered to at present. Of course these cardinal principles or policy statements can be implemented only when the objectives are well-defined and the procedure laid down is capable of identifying, analyzing, and evaluating the implication, effects and after-effects of various activities involved in the plan.

## **2.0 CONSTITUTIONAL PROVISION**

THE Indian Constitution gives explicit recognition to the need for environmental protection by incorporating it in the Directive Principles of State Policy. Article 48 states that “the State shall Endeavour to protect and improve the environment and to safeguard the forests and wild-life of the country”. Further, Article 51 (4) states that “it shall be the duty of every citizen of India to protect and improve the national environment including forests, lakes, rivers, and wildlife, and to have compassion actions taken by the Union and state Governments under the aforesaid provision in the constitution, there is a full-filled mechanism for integrating environmental aspects

Policy decisions to introduce environmental aspects into water resources development planning were taken during the Fourth Plan Period and since then there has been continuous increase in the level of importance attached to such aspects during presanction appraisal of projects. All major and medium-size irrigation projects of the country are required to be cleared by the department of environment (provisionally, Department of Science and Technology) before being accepted for approval by the Planning Commission. The departmental consideration in project planning.

In India's Fourth Five Year Plan document (1969-74), the need to integrate environmental consideration from the early stages of planning for economic development was addressed. It was laid down that along with effective conservation and rational use of natural resources, protection and improvement of human environment is vital for national well-being. The document also under issues, particularly economic and ecological, to evolve harmonious development plan, recognizing the unity of nature and men. India must go a long way in development of its agriculture, which in turn, largely depends upon water resources development; and water resources development involve many activities effecting the natural systems, including activities for construction of more dams and canals, for supply of water for irrigation in areas which have hitherto depended on scanty and erratic rainfalls; for augmenting supply for industrial expansion and domestic water supply system, both in urban and rural areas. The present status of conservation storage in India is such that the storage capacities have to be at least double during the next two to three decades in order to provide adequate water required for about one hundred million hectares of irrigated agriculture for achieving self-sufficiency in food; and, obviously there will be interference with the natural systems. So, the problem is to evolve criteria's and guidelines for harmonious planning for economic development with adequate attention to preservation of the natural system to the extent feasible and improvement in the environmental quality to the desired standard. The physical environment is a dynamic, complex, and inter-connected system in which any action in one part affects the others. There is also the inter-dependence of living things and their relationships with land, air, and water. Obviously it is a complex problem and deserves rational approach in planning, implementation and operation of water resources system by a multidisciplinary group of experts.

#### 4.0 ECONOMIC DEVELOPMENT AND ENVIRONMENTAL ASPECTS OF WATER RESOURCES DEVELOPMENT

Economic aspects of multi-purpose reservoir project are shown in table-1. The direct project outputs are shown on the left and the indirect effects (benefits) of economic development are shown on the right side. The likely consequences of the project on the Natural Systems and Environmental Quality (NS & RQ) are shown in Table-2. These effected or impacts have to be carefully identified, analyzed and evaluated before they are incorporated in the overall benefits-cost analysis of the project or the plan. The objective should be to incorporate measures required to reduce the likely adverse effects on ambient environmental quality, both on-site and off-site in formulation of the development projects; and the cost of such measures required to either eliminate or to reduce the adverse effects plus any damage costs from the remaining adverse environmental effects should be added to the normal project cost to arrive at the total project cost. Similarly, the total benefits should consist of the benefits of improvements in ambient environmental quality arising from the project. Acknowledging that one of the objectives of water resources development is to enhance the quality of environment by the management, conservation, preservation, creation, moderation or improvement of the quality of certain natural and cultural resources and ecological systems, it is necessary that the beneficial and adverse effects of the alternative plans on the environmental characteristics of the project areas, the region, and the nation as a whole should be evaluated and displayed in terms of relevant physical and ecological criteria or dimensions, including the appropriate qualitative and quantities (to the extent feasible) effects of the plan on the NS & EQ aspects broadly identified in Table – 2

## 5.0 NS & EQ ASPECTS ON PROJECT PLANNING AND DECISION-MAKING PROCESS

A simplified version of an idealized project or program planning and decision-making process is shown in Table-3 (Hufschmidt, etal, 1983).

The objective of incorporating the NS & EQ aspect in the project can be achieved by adopting the method and procedure suggested in Table-3 because

- i. NS & EQ aspects get incorporated in the beside process from the very beginning;

- ii. Benefit-cost analysis, including valuation of environmental quality and natural system effects, enters the process early in plan formulation (step 3) and executive (stapes 4,5 and 6);
- iii. An essential feature of the alternative plan formulation in step 3 is the inclusion of “implimentation incentives” – the means of obtaining or achieving the installation and operation of the physical and other measures of the management plan; and
- iv. The process involves frequent feed back of information from the later steps to earlier ones.

In the context of water resources development planning in India, the first two suggestions are of urgent importance, in spite of growing importance and increasing emphasis on environmental aspects, the fact, by and large, remains that these aspects are considered only at the level of Union Government and that too only at the presanction appraisal stage. The result is that the clearance of the project is delayed on account of issues raised

**T A B L E S – 1**  
**ECONOMIC ASPECTS OF A MULTIPUPOSE RESERVOIR PROJECT**  
**ECONOMIC DEVELOPMENTS**

<b>INCCREASE IN</b>	<b>DECREASE IN</b>	<b>INDIRECT</b>
<b>DIRECT PROJECT OUTPUTS</b>		<b>EFFECTS</b>
1. Agricultural Production	1. Agricultural production from land falling in reservoir in canal net work.	1. Increase in employment
2. Fisheries in reservoirs		2. Stabilization of economic
3. Flood control benefits	2. Forest produce to the extent it is affected	3. Self-sufficiency and self-reliance
4. Hydro-power	3. Mines & minerals to the extent it is affected.	4. Income redistribution
5. Inland navigation		5. Economic development induced by or steaming from the project including inputs and outputs.
6. Recreation & Tourism		
Industrial and domestic water supply		

## TABLE – 2

### NS & EQ CONSEQUENCES OF A MULTIPURPOSE RESERVOIR PROJECT

NS & EQ CONSEQUENCES	
1. May submerge forest with rare varieties of tree/plants.	1. Effects of changes in the state of environment on receptors, including humans, plants, animals and materials.
2. May adversely affect wildlife habitat of rare species and of special importance.	2. Rising population and industrial growth along the river and canal banks may aggravate water pollution.
3. May submerge or adversely affect sites/monuments of archaeological & historical importance.	3. Construction and Maintenance activities particularly use of heavy plant and machinery and a large contingent of worker may lead to immigration of wild habitat to other forests, if available.
4. May submerge wild and scenic beauty spot of rare value.	4. A large-size irrigation project may affect the weather conditions in the long-run due to change in soil-moisture balance, ground water table and agricultural precautions.
5. May adversely affect the river regime in the long run impairing the carrying capacity, leading to braiding of the channel, and causing stagnation not conducive to pollution control.	
6. Decrease in river-flow below a certain minimum may aggravate water pollution.	
7. May adversely affect fish and wildlife in the river below the dam.	
8. Irrigation may lead to water logging and salinity in the command areas.	
9. Over-use of nutrients, fertilizers, pesticides, etc. may pollute water in wells, canals and/or rivers.	
10. May affect irreversible/irreplaceable environmental assets.	
11. May cause damage to forest/trees through tempted use of forest wood for fuel by construction staff.	
12. May affect human health and sanitation due to large storage of water and large scale year-round irrigation.	

### TABLE – 3

#### **SIMPLIFIED VERSION OF PROJECT PLANNING PROCESS SHOWING ENVIRONMENTAL QUALITY AND NATURAL SYSTEM ASPECTS**

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1. Environmental quality and natural-systems problems and	1. Perception and definition of a problem, need, or opportunity.
2. Environmental quality and natural-systems objectives and criteria developed	1. Specifications of basic social objectives, and development of associated planning economic criteria; specification of analysis conditions
3. Basic analysis of Natural systems and environmental quality aspects, and formulation of appropriate plans including implementation incentives and institutional arrangements	3. Conduct of basic physical, economic and social analyses and formulation of alternative plan  Plans include implementation incentives, physical measures, and institutional arrangements economic analyses including benefit-cost analysis are important
4. Environmental quality and natural-systems aspects weighed in relation to other objectives	4. Review and evaluation of alternative plans and selection of preferred plan for execution Benefit-cost analysis plays a key role
5. Environmental quality and natural-systems; execution and monitoring	5. Execution of selected plan; monitoring of progress and results of execution
6. Ex-post Evaluation of environmental quality and natural-systems aspect of execution of the plan.	6. Ex-post evaluation of execution of the plan Benefit-cost analysis plays key role.

Hufschmidt, et al, 1983. Environmental, natural Systems, and Development: Valuation Guide.

at this late stage by the members representing the Department of environment on the Advisory Committee of the Planning Commission. In the process, there is also an attempt by project proponents to hustle through the project on place of prosing public demand for execution of the project which was formulated and found technically as well as economically viable on the basis of normal criteria. As a matter of fact, this is the case with economic appraisal also. Seldom have there been attempts to formulate alternative plans with information as to their relative economic worth, from which the best available plan could be selected. This situation exists because there is either a complete absence of or grossly inadequate type of institutional arrangement in state in state government irrigation department (which have the primary responsibility of identifying, formulation and processing for sanction of such projects) for incorporating environmental quality aspects in projects formulation. In some cases, when such aspects are identified due to efforts of some individuals connected with projects; the difficulties of valuation crop up and there

being hardly any worthwhile assessment and valuation methodologies available to project engineers, the prospect of meaningful and objective assessment of the situation turns out to be bleak. The National Environmental Quality guidelines, which as a matter of fact, are merely a check-list, do not serve the purpose. The short-comings can be overcome and improvement brought about if:

- i. River Basin Commissions and/or River Boards are set up with adequate arrangement for preparation of comprehensive plans addressing problems in multi-disciplinary;
- ii. Along with an Economics and Statistics Cell, there should be NS & EQ Cells in River Basin Commissions, the Central Water Commission, and in State Governments (Irrigation and Agriculture Departments);
- iii. The department of environment should set up regional units. Throughout the Nation identify environmental quality and natural systems problems and needs, to develop criteria and to guide, from time to time, the project planners in charge of water resources development in different regions;
- iv. The Department of environment should set standards for environmental quality and issue guidelines on valuation of the various effects of water resources development projects on environmental quality and natural systems;
- v. The Department of Environment should have separate committee for different sectors, such as water resources development, energy and transport, with experts drawn from related fields to take a final view on the project, taking into consideration the cherished goals and objectives of development or agency of the Government should exercise the right of the veto in the complex nature of things associated with planning in a developing country such as India, with enormous problems of poverty, unemployment and shortage of food. Instead, coordinated efforts should be made by all concerned to evolve an acceptable plan – economically viable and environmentally desirable;
- vi. The appropriate are scope of analysis to be done by different agencies and at different levels, must be determined taking into consideration the fact that the planners of a specific project may fail to appreciate to overall impacts of this plan, especially the

long-run effects on the environment, because a wide range exists both for time-rate of change in environmental quality and for the geographical area of influence of residual discharges on environmental quality.

## **1.0 SOME POINTS OF RELEVANCE FOR NS & EQ ANALYSIS**

In the case of water resources development plans, the specification of natural systems and environmental quality as a planning objective and the development of associated planning guides, criteria's, and conditions for analysis should, inter-alia, take into account the following:

- i. Conservation, diversion, or utilization of water will necessarily affect the status-quo of natural systems in the hills and forest where the reservoir are build, and the natural state of the river-flow and river-regimes downstream of the points of conservation or diversion. Such human interference or action with respect to natural systems need not necessarily be construed as a hostile attack on natural system without weighing carefully and rationally the NS & EQ aspects in relation to other objectives of development planning;
- ii. Planning guide, criteria and conditions for analyses in water-abundant regions or river systems should be different from those in the water-scarcity ones, especially when and where higher priorities are warranted for domestic water supply and agriculture;
- iii. Where in-stream flows in prescribed quantities and time patterns are not provided for purposes of navigation and/or fisheries, the in-stream recruitments from the view-point of water pollution control will have to be assessed and provided for separately. In doing so, however, it would be prudent to examine to what extent the objective of pollution control could be achieved by modifications or improvements in the industrial production processes and purification of municipal wastes from cities and villages which are the major sources of water pollution;
- iv. Many effects on environmental quality occur in a regional rather than a site-specific context, and hence a correct selection of the boundaries of analysis is



essential for assessing the ambient environmental quality and valuation of natural systems and environmental quality effects;

- v. Whether watershed management, including soil conservation, should or not form an integral part of a water resources development project (involving reservoir storage) in terms of project costs and benefits should be considered on a case by case basis. Watershed management can not be treated in the same manner as the land and water management in the irrigation-command areas lower down which had direct bearing on the agricultural productivity envisaged in the project. If the soil conservation measures in the catchment area are effective enough to reduce siltation in the reservoir and, thus, in increasing the life of the reservoir, or if watershed management leads to moderation of the flood peak thus effecting the design of flood spillways and downstream flood hazards, there is good ground for incorporating the catchment control measures, to the extent relevant to the particular plan, in the ambit of the project. Of course, while doing so, both costs and benefits will have to be taken into account. Difficulties in incorporating the watershed management costs in an irrigation project arise because (a) the life of the reservoir (generally one hundred years) is determined assuming that the silt-entry to the reservoir will continue to be at the rates observed in the past; (b) the minimum draw-down levels may be higher than the required sediment-storage level, in which case the need for watershed management leading to reduction in siltation gets further downgraded; (c) the effect of catchment control measures on moderation of flood-peak is still not well-established; and (d) the planning implementation and maintenance of watershed in generally a long-term plan, that can possibly be justified on its own merits, i.e. technical feasibility, economic viability, and incorporating maintenance of natural systems and environmental quality at desirable standard, of course, the necessity of planning for watershed or catchment control while planning for water resources development project can hardly be over-emphasized. In India, it is going by default are present, primarily because there are no effective institutions for river basin planning. Once the river-basin or major sub-basin becomes the unit of planning, the whole basin gets attention – catchment and command area alike.
- vi. As is recommended for valuation of benefits from economic development, the principle of “with and without” should be substituted for the principle of “before and after” which is currently in practice. As a matter of fact, the ‘with and without’ principle is continuous process of change in human artifacts and natural systems that are not limited to effects of water resources development activities.
- vii. For protection of forests and wildlife, the government of India has established 19 national parks and 202 wildlife sentries covering an area of 76,000 sq. kms. A proposal

for establishment of Biosphere reserve as a matter of high priority is also under consideration. Such plans are formulated by the forest department in consultation with department of informant, obviously the locations are chosen without any consideration of positional natural sites. Needed for economic development this on of the major cause of conflict, at a later stage, between the water resources project planners and the environmentalists. Hence, there is need for better coordination. The engineers should consider the issues pertaining to natural systems and environmental quality in selecting the site, in determining the scope and size of the project, and in construction an operation of the project. Similarly, the environmentalists should realize the compulsions of economic development, irrigations on availability of auditable sites for exploitation of natural resources, and constraints of resources, region-wise and for the nation as a whole.

## **2.0 NEED FOR ECONOMIC VALUATION**

A comprehensive appraisal of environmental issues, particularly economic and ecological, can be done by only if the whole a problem is analyzed objectively and the effect of the project as planned are value in monetary terms to the effect of the project as planned are valued in monetary terms to the extent possible, more so when cost are likely to be incurred to safeguard the environment and the natural systems.

### **2.1 ENVIRONMENTAL QUALITY OBJECTIVES**

There is inadequate or accent regard for protecting and improving environmental quality in the process of planning, execution and maintenance of water resources development and utilization system this leads to long-term economic losses, danger to forests and wildlife, and general deterioration of natural systems and environmental quality. Failure to incorporate this aspect right from the identification and formulation stage of projects is causing ling delays in clearance of the projects and in evolving suitable measures an integral part of project or separately.

The water resources management system has not so far succeeded in creating adequate awareness among the project planners of the imperative need for identification of environmental issues specific to the project areas and for a pragmatic approach to measures needed for projection of natural systems, to the extent desired and found feasible.

The present system of scrutinizing the project from the environmental quality angle only at the presanction appraisal stage by the union Government agencies

is not perceived by project planners as a useful approach. A superior alternative is to take account of environmental aspects from the very start of the project planning. Environmental impacts of alternative plans should be studied, valued and displayed before selecting a plan to be recommended for approval.

## **2.2 Assessment and valuation**

Inadequate efforts to identify specific effects of proposed projects on natural systems and environmental quality; and to assess and evaluate them in qualitative as well as in quantitative terms lead to needless losses in environmental and natural systems values.

Subjectivity in the decision-making process generally does not impress the project planners and the people likely to be benefitted by water resources development projects.

Many of the likely adverse effects of water resources projects on natural systems could be averted by taking up preventive or remedial measures. Most of the direct consequences on natural systems could be prevented and/or remedied if due care is taken during plan formulation and appraisal. For instance, loss of forest products could be compensated by forestation and control on forest denudation which is going on unabated lately; submergence of forests with rare varieties of trees and plants could, in many cases, be avoided by judicious planning of storage capacities; disturbance to wild-life and habitat or rare species in forests outside the reservoir could be minimized, if not altogether done away with, by proper choice of the structure, the construction equipments required for it and location of the construction and maintenance camps; could be compensated by developing spots of recreation value around the reservoir; likely adverse effects on river-regime, fish and wild-life, and waste-assimilation capacity could be adequately obviated by proper planning of water utilization and reservoir management practices; and, the problem of water-logging and salinity, pollution caused by use or over-use of chemical fertilizers and pesticides etc., human health and sanitation in the irrigation command areas could be taken care of by scientific planning of the irrigation system and proper water management practices during the operation of the project.

If these are quantified and properly valued, it will facilitate the decision-making process by providing greater credibility and confidence.

The department of Environment, the Planning Commission and the Ministry of Irrigation should try to evolve guidelines for assessment and for economic valuation of effects on natural systems and environmental quality, with a pragmatic approach to achieving harmonious development.

## **8.0 GENERAL EVALUATION CONSIDERATION**

According to “Principles, Standards and Procedures for Planning Water and Related Land Resources” issued in 1980 by U.S. Water Resources Council, environmental quality (EQ) evaluation comprises a set of activities necessary to identify, assess, and value the effects of alternative plans on significant natural and cultural resources. Its purpose is to identify the beneficial and adverse effects of alternative EQ resources so that decision-makers can appraise the net effects of the plans on environmental quality. The interaction of EQ evaluation with the planning process is intended to emphasize enhancement and to avoid degradation of EQ resources. However, in EQ evaluation, significance is attributable to both resources and effect with focus on issues that are significant, that is, that are likely to have a material bearing on the decision-making process.

Before taking up evaluation, it is necessary to identify the specific natural and cultural resources that are likely to be affected by the proposed project. Quantitative measurement in physical terms can be attempted with indicators or units of the types shown Table-4. The quantity of EQ resources is to be measured in terms of its ecological, aesthetic historic, educational, scientific, and pristine values. Suggested indicators and units for measurement or estimation of EQ value changes are shown in Table-4. These may be considered as suggestive of one of the ways in which the problem could be approached in a general way. This is a sphere in which value judgment counts and the indicators will vary according to the professional judgment of experts with training and experience relevant to each resources and value.

**T A B L E – 4**

**ENVIRONMENTAL QUALITY RESOURCES AND THEIR MEASUREMENT UNITS**

**Types of EQ resources required to be evaluated**

**Quantitative Measurement of Resources**

	Indicator	Unit	Guideline
1. Fish and Wild-life habitat	Area of each habit type		
	Area of each critical habitat	Hectares	Preservation and enhancement
2. Endangered species critical habitat	Importance attached by Union and State Govt. their places in the national and State registers	Hectares	Preservation and enhancement
		Present/absent in list	
3. Cultural resources (archaeological, architectural and scientific resources)	Length of wild, scenic and recreational river	River kilometers	Preservation and enhancement
		Cumecs or Hectares or hectare-meters	Preservation
	Flow in water courses, or areas or volume of water body.	Sq. km. Hectares	Preservation or improvement in flow/area with respect to applicable water quality standard
4. Wild and Science Rivers	Area		Preservation or improvement in area with respect to applicable air quality standards.
	Area or each parcel of particular concern		
5. Wter (Quality)			
6. Air (Quality)			
7. Area of particular concern			Preservation and enhancement.