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IDENTIFICATION OF HYDRO-ENVIRONMENTAL INDICES

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ABSTRACT

Water resources development projects represent an integral part of the entire complex of development aimed at the remarking of nature useful for man. These projects may be taken up for a variety of purposes including supply of drinking water, irrigation of crops, extraction of energy, transportation of goods and carrying away the wastes. While these water resources projects provide for various useful purposes, they may have indirect or inadvertent effects which are undesirable. These undesirable effects may be reflected in the physical, chemical, biological, social and economic components of the total environmental system. Such effects can be minimised if not eliminated, if certain indices to be referred to as hydro environmental, to characterise various components of environment likely to be affected, can be defined during the planning and decision making stages of these projects.

The present report classifies various types of water resources development projects, their impacts on environmental components, and identifies possible hydro environmental indices which would characterise the environmental system. Generally an environmental assessment must address all the quantitative and qualitative changes which would result from a water project and to these identified changes some values must be assigned. These values must be somehow balanced or weighted in relationship to the overall goals of a society and must also be described in

simple and understandable terminology. Therefore, the need to develop such characteristic indices which may provide comparative information to aid in the evaluation and selection of a water project to meet a particular water related need, is greatly felt.

These indices once developed can be used for evaluation of water projects for environmental impact assessment studies. Proper evaluation of the various impacts would lead to having assessment of the net gain of the projects on public welfare. Identification of such indices is of greater importance for developing countries like ours and needs to be introduced in the planning process of future water resources development projects.

1.0 INTRODUCTION

1.1 General

Due to acute crisis of energy and depleting raw material resources, the development plans are taking up a major step forward. As a consequence of this the environmental concern has also got a big boost. There is a day to day tussle between the environment protectors and the people responsible for future development. However, several studies by sober environmentalists have shown that development and protection are not only compatible but can also be mutually reinforcing. These studies have reduced the fears to some extent, but the motto is still not "Development without Destruction".

Sustainable development and environmental protection are two mutually related aspects for an optimized management of resources. There should nothing be against taking up large water resources projects for generation of energy or for the purpose of irrigation but before such a multi-dimensional scheme is taken up a thorough analysis of the effect of the project on the environment must be made. This would give the designer many ideas by which the design of the projects could be greatly altered so that the negative effects of the project on the environment are minimized, without much affecting the cost criteria.

Because of the uneven distribution of rainfall in space and time, steep slopes of rivers and water pollution problems in the midstream and downstream segments

of water course, water resources development e.g. building of dams, reservoirs etc. are essential for industrialization and economic growth of India. However, as mentioned above, this development can also induces significant impacts on the environment. Water is needed to achieve water needs, but one has also to worry about the adverse effects on the environment. Hence the environmental impact assessment (EIA) has two important roles to play, one is to assist the engineers and policy makers to choose a proper alternative and another is to decrease environmental impact due to such development. Because, EIA is still a relatively new concept in India, the ability to evaluate environmental impact has not kept pace with the ability of engineering part of water resources development projects (WRDP) Thus there are many difficulties in establishing a sound and generally acceptable EIA system for impact evaluation of WRDP. However, before any such procedure is used, it would be necessary and informative to list out some important definitions (UNESCO,1984).

1.2 Definitions

The most commonly used definitions in this report and relevant literature are given:

1.2.1 Environmental system

The creation of the circumstances of life for human beings or society by the surrounding objects, region and conditions can be described by a system referred to as environmental system. This system is composed of various

components including physical, chemical, biological and/or man made nature. The complete knowledge of an environment system is still under investigation and can not be described completely at this stage.

1.2.2 Indicators

In order to describe the components of an environment system in quantitative form certain measurements or observations are necessary which can be formed as indicators of the environmental system. Thus, the status of various components of environmental system can be described quantitatively or qualitatively by indicators.

1.2.3 Standards

The values of indicators of various components of the environmental system should be upto certain limits within which the occurrence of the selected component should lie so as not to be detrimental to man or his environment. Based on the ideal conditions of living. The values of standard may be selected to which indicators are compared to know the status of environmental system.

1.2.4 Index

In order to find the status of various components of environment or the environmental system, it may be possible to define an index which relates to observed value of indicator to the standard, both corresponding to the component in respect of which the environmental status is to be assessed.

1.3 Need for Environmental Indices

Development of water resources has been practiced since the dawn of civilisations for varied purposes including drinking water, irrigation, extraction of energy, transportation of goods and carrying away of wastes. While these projects have on one hand provided for a number of beneficial purposes, there have also been incidents when these have led to certain undesirable effects on the various social, biological, physical and chemical components of the environment. The adverse impacts may perhaps be due to inadequate assessment during planning and decision making stages of these projects. In order to have proper development of the resources to meet basic human needs without destroying the ecological basis on which the sustainable development depends, an environmentally sound management approach is required. For this purpose, some hydro-environmental indices for the evaluation of water projects may need to be defined. These could be used for environmental impact assessment studies of these projects which are necessary because of non-uniform distribution of rainfall over space and time, steep slopes in rivers and pollution of water downstream segments of many rivers. The methods for evaluating a water project and all its potential impacts are still largely in the development stage. The problems of analysis, interpretation, and presentation are immensely complex when a project must be evaluated for several objectives and numerous impacts. The evaluation processes may include consideration of items like national

economic development, environmental quality, regional development and social impact etc. (Bhatia, 1983 and 1986).

The environmental impact assessment (EIA) is a relatively new concept in India and the techniques of EIA have not been developed independently whereas, the engineering aspects of the planning, executing, construction and operating of water projects are very well advanced. The environmental assessment should generally address all the quantitative and qualitative changes which would result from a water project, and to these identified changes some values must be assigned. These values need to be compared with the standard values corresponding to the identified changes for achieving overall goals of the society. In other words, there is need to develop indices corresponding to each component of the environment which will provide comparative information to aid in the evaluation and selection among project alternatives to meet a particular water related need. The present report discusses the basic philosophy of development of hydro-environmental indices, their types and use in EIA study of water projects.

2.0 WATER RESOURCES DEVELOPMENT AND ITS IMPACTS

2.1 Types of Water Resources Projects

Generally water resources projects are classified based on their intended functions and purpose. However, for assessing the environmental impacts of the projects these may be classified as per the physical nature of the projects. Basically, there are five broad categories of water projects (Haber, 1979: UNESCO, 1984) as below:

i) Impoundment of water

a) reservoirs

b) artificial control of lake outflows

ii) Channelization

a) irrigation canals

b) navigation canals

c) drainage works

d) dyking for flood protection

e) erosion control measures

iii) Diversion of water

a) between natural basins

b) for consumptive use in home or industry

iv) Waste dilution and assimilation

v) Ground water extraction and recharge

vi) Vegetation management for increased water yield

The last category of water project is of recent origin and is still under experimentation stage. The basic principle on which such a project is designed is that of manipulating the vegetation in upland watersheds, the yield of water for downstream users can be increased and this increase in yield is attributed to variation in evapotranspiration losses associated with manipulation of vegetation or change in land use. As the evaporation/ evapotranspiration process accounts for significant portion of the annual precipitation input on must watersheds, the potential of increasing water yield by vegetation manipulation becomes quite attaractive.

The water projects may consist of several components which fall into several of above given classifications. However, for environmental impact assessment, developing indices, fixing standards and indicators, a clear understanding of the nature of each component in the project is required.

2.2 Hydropower Development and Its Environmental Impacts

There has been considerable development in hydropower production owing to increasing requirements of growing population and the quality of life. This section focusses the discussion on all the main environmental aspects of water projects. Since there are always gaps between recognition of a problem, finding solutions and implementing relevant measures, this part concentrates on the status of each aspect rather than on the details of the problem. Other than the effects as caused by irrigation projects on environment, additional effects may also be there due to hydropower projects because of their relatively large dimension (Goodland, 1985). To present a comprehensive picture and to make the report readable as a interdisciplinary information source the various impacts are being presented hereunder.

(a) Health

It is recognised from olden times that water resources development projects can adversely affect the habitates around the project area and downstream of the project. However, it has been recognised recently that these adverse

effects can be greatly minimised if due care is taken during the planning, design, construction and operation of Project. Maleria is a glaring example of the case in point. Nowadays, material vector control by destruction of habitat, encouragement of mosquito larvae eating fish, transmission reduction (nets), prophylaxis and chematherapy, together with some larviciding and adulticiding is well known and our country is a leader in malaria control. However, there are certain disease vectors which can be controlled at the initial stages only and if preventive measures are not taken at appropriate time such vectors are impossible to eradicate. This again stresses the need for taking precaution at the time of design of the project. As an example Schistosomiasis is such a vector which can be kept out of a new water project if careful preventive measurs are implemented, but the snail once arrived is almost impossible to eliminate (Mandgal, 1985).

(b) Resettlement

The resettlement of people is expensive and time consuming when done acceptably. The cost of rehabilitating the people as a cost of the water project has been taken seriously only recently and the record is improving. The people can and should be better off after the project is completed. All resettlement costs such as employment creation. purchase of compensatory house lots, and agriculture lands are to be fully internalised in the project analysis. The situation is not easy as the number of persons displaced is large, their cultures differ greatly

from main stream society and compensatory land is not readily available. The hydro projects should become regional development activity which integrates rural development for people. Resettlement of vulnerable ethenic, unacculturated minority should be avoided and if unavoidable special precuation should be taken (Mistry & Purohit, 1985).

c) Wilde life

This is receiving greater importance nowadays as this impact falls into the irreversible category of environmental effects. The main losses could be of wild lands, wild life, extinct species etc. Extinction should be minimised by proper siting. Loss of wild life can be mitigated by including or wild land management equavalent to the inundated tract unit in the watershed. It would be advisible to undertake a biotic inventory of the tract to be flooded in order to identify rare or endangered species and to scope out the magnitude of wild life resources. Measures can thus be incorporated for wild life salvage or rescue or their transfer to protect areas (Dinesh Mohan, 1986).

(d) Fisheries

Most fish do not migrate and hence a dam does not impede them. However, mitigation if any will be impaired without passage facilities if a dam is constructed as an obstruction. The main measure seems to be the development of fishery potential within the new reservoir. With due attention reservoirs can and should become significant

sources of protein, employment and economic profit. Realisation of the full fish potential of impoundments is not yet achieved in projects and more attention is warranted in this regard. Here it would be appropriate to stress the importance of estuaries in this regard. The anormous biological productivity and importance of estuaries is becoming quantified, but much remains to be done in order to conserve their values.

(e) Biomass removal

This relates to removal of biomass which is needed downstream for fisheries and navigation. Valuable timbers and fuel should be salvaged. Opportunity cost of lost timber and foregone use of inundated land should be internalised.

(f) Water quality

The construction of a water resources project affects the water quality within the reservoir and in the downstream. The effects of such constructions may be clearly visible in typical structures with salinity intrusion, loss of flushing, decrease in mutrients etc.

(g) Erosion

Erosion in the upstream will lead to sedimentation which in turn will affect the dead in the beginning, and live storage at later stages. This particular impact could be countered by adopting to judicious watershed management practices. However, below the dam, the erosivity definitively increases.

(h) Water weeds

The growth of weeds can increase disease vectors and transpiration also increases which in turn in responsible for water loss, adversely affecting the water quality and fish culture. The increase in weed growth clogs the navigation channels and affects irrigation and recreation. However, the weeds can be put to considerable usage.Suffice to say that the problems of weed growth are well recognised. Solution exist to convert weeds into resources (Lohani, 1982).

(i) Archeological sites

In a country like ours where lot of importance is given to religious values, this is a very important aspect to be considered. Only recently has the relationship between water projects and loss of cultural property been great enough to call for action, however. It is proper to conduct a reconnaissance survey of the prospective reservoir area before construction of a dam is taken up. If important cultural property is found, the project should be relocated or else stayed, while archeological measures are conducted.

(j) Navigation

This may need special provisions such as docks, cleared shipping lanes etc. In some cases lake transport may become economically advantageous. However, construction of water resources project definitely points to a relook at the navigation system.

An excellent presentation of possible consequences of a multipurposes dam and reservoir project are presented by Carpenter (1985) as given in figure 1.

2.3 Irrigation Development and Its Environmental Impact

For the last several decades major stress has been directed towards exponential growth of irrigation. Sub conciously or conciously mankind has always been concerned about the impact of irrigation development on the environment. However, for the last one and a half decade the environmental concern has been a major issue in our country also. the plausible reasons could be advances made in the environmental sciences, rapidly changing technology and agriculture in general and irrigation in particular, and the most important being the phenomenal grwoth in the demand of agricultural products.

The effects of irrigation development are mostly confined to the project sites while in some cases the effects are concernsly spread on the other endeavours and the life outside the project. In some rare cases the effects may be spread across the international boundaries also. It is conceivable that difficulties and mishandling of impacts having a wider dimension requiring policy decisions at national and international levels have been allowed to hinder progress in developmental efforts. Such impacts are very vital and have to be tackled at the appropriate levels by suitable remedial measures. For example, at the project level, issues like soil degradation, primary

health, social issues etc. would be relevant whereas at wider levels water quality, hydrological impacts, regional droughts etc. may be relevant and at global level protection of wild life, conservation of forest, long range economic impacts etc. could be the pertinent issues to be considered (Framji, 1986).

The concern about environment with the development of irrigation can be broadly addressed to:

a. Water pollution

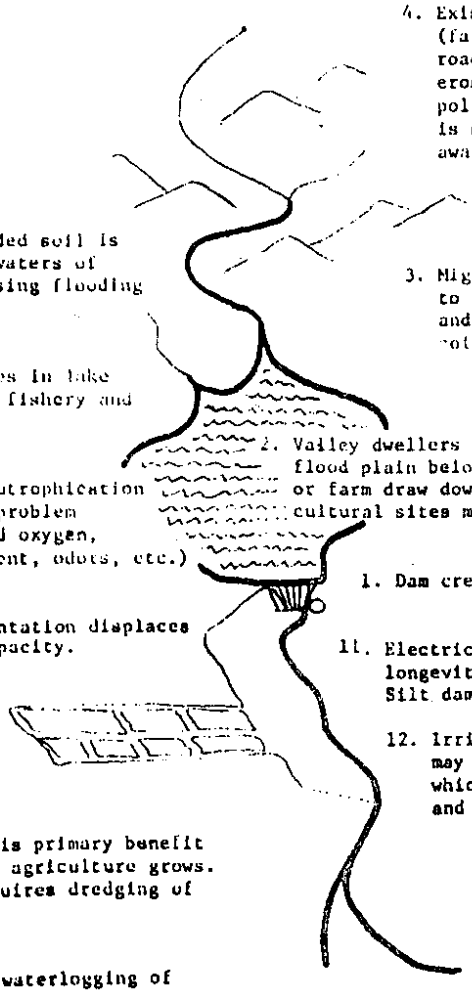
b. land degradation and

c. ecosystem imbalance

Over or under irrigation or the use of low quality water may result into pollution by dissolved solids, sediments, mal-nutrients, organic and pesticides which in turn may affect the environment. Sediment inflicts a loss of top soil which is almost impossible to recover and replacement value involves huge sum of national money. Sediments act as transporting vehicle of pesticides and malnutrients in surface water and aquifers and cause toxic and/or concinogenic hazards to fish, wild life and human health. Settlement of sediments in reservoirs affects the reservoir capacity and reduces their life. The influx of sediments into river channels involves expensive dredging Leaching of pollutants into ground water results into complex reactions and is currently not understood and is one of the premier areas of research in irrigation water use.

The construction and operation of irrigation systems also presen-

Figure 1. Some Possible Consequences of a Multipurpose Dam and Reservoir Project.



4. Existing upland activities (farming, forestry, agroforestry, roads and settlements) cause soil erosion, silt and chemical pollution of streams. Sediment is stored in delivery system awaiting storm events.

5. Sediment from eroded soil is deposited in headwaters of lake at first causing flooding of adjacent land.

3. Migrants from reservoir site add to population pressure on marginal and steep sloping lands causing soil erosion.

6. Turbidity increases in lake interferring with fishery and recreation.

2. Valley dwellers displaced to uplands or to flood plain below dam or begin fishery in lake or farm draw down area. Wildlife habitat and cultural sites may be inundated.

7. Nutrients cause eutrophication and aquatic weed problem (lowered dissolved oxygen, fouling of equipment, odors, etc.)

1. Dam creates multipurpose reservoir.

8. Eventually sedimentation displaces active storage capacity.

11. Electric generating capacity and longevity lost through sedimentation. Silt damage to turbines increases O & M.

12. Irrigation return flow to river may carry toxic chemicals and salts which affect downstream fisheries and other water uses.

9. Irrigation water is primary benefit and dependence of agriculture grows. Silt in water requires dredging of feeder canals.

13. Severe storms require water release and flood plain damage.

10. Salinization and waterlogging of soils may occur from improper control of irrigation.

14. Many dependencies develop on a water management system which may be rather short-lived.

ts several environmental concerns:

a) destruction of river and adjacent terrotrial habitate

b) destruction of productive form and forest land by reservoir inundation

c) raising of water table

d) water logging and salt accretion

e) detrimental effects of storage and diversion projects on water quality

f) loss of recreational amenities

Moudgal(1985) has given a schematic representation showing the various environmental aspects (Figure 2) of irrigation projects.

In summary, it can be inferred that at current stage of knowledge of the state of environment it may be appropriate to say that environmental issues relating to irrigation development projects are quite evident in gross terms i.e. as cause and effect. However, it is not always simple and feasible to identity and quantify intermediate controllable parameters for the designer to cater for future environmental changes. This again stresses the need for taking up immediate research considering actual irrigation projects and their impact on the environment. The evaluation of environmental hazards and the cost involved in their alleviation will enable identification of those aspects of irrigation which are in the greatest need of amelioration. Increasing the efficiency of water use and scienti-

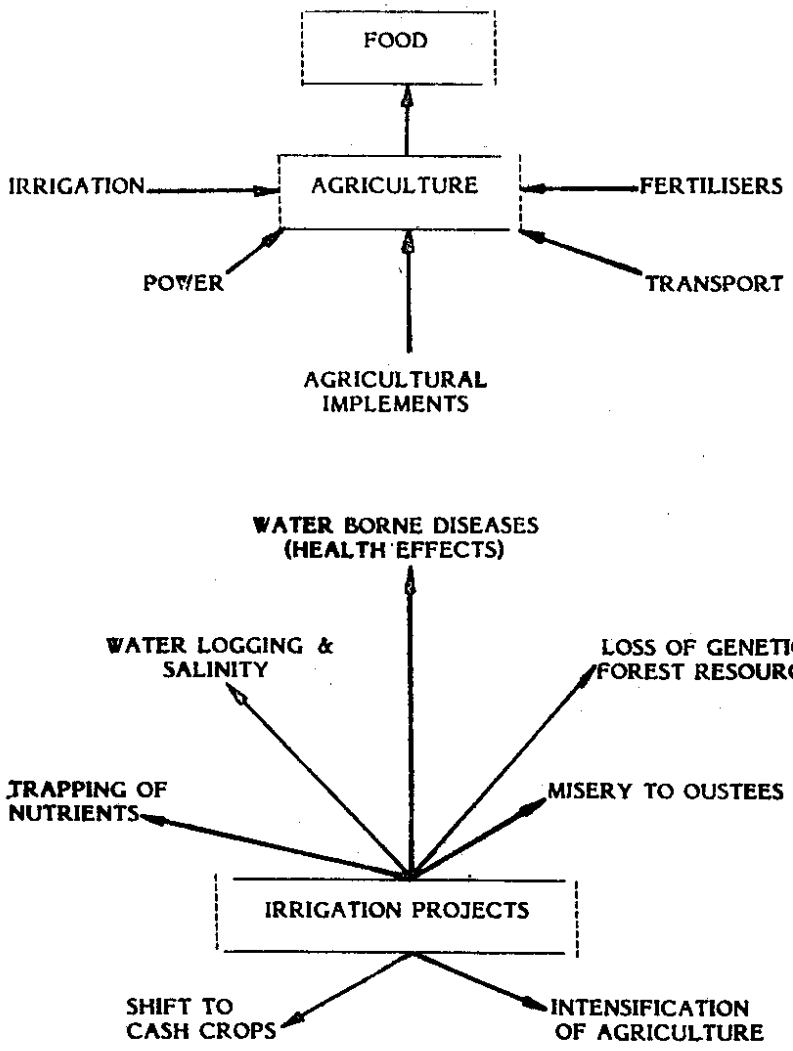


Fig. 2 Related Environmental Aspects

fic allocation and conveyance of existing developed water supplies irrigation network systems will ensure, as far as can be foreseen, the widest extent of environmental benefits. Scientific management of irrigation is thus now an absolute essential.

3.0 ENVIRONMENTAL IMPACT ASSESSMENT AND TECHNIQUES

3.1 General

Any national policy for environment protection aims at encouraging a productive harmony between man and his environment such that while essential developmental activity is not stopped and lasting damage to the biosphere is prevented. The purpose of an Environmental Impact Assessment (EIA) is to determine before implementation the environmental effects of a proposed action. It defines and assesses a proposed action's physical, biological and socio-economic effects, bringing together all aspects of a project in a form that permits a decision to be made logically and rationally. Negative environmental impacts are exposed, thus allowing their alleviation through the identification of possible site and construction/process alternative.

In many countries, the EIA has been incorporated in legislation. The Indian policy regarding the environment has been enunciated in the approach to the Seventh plan (1985-90)as follows:

" All future development programmes must take environmental considerations fully into account. Towards this end, environmental factors and ecological imperatives will have to be incorporated into the design of all developmental projects from the very commencement of planning. All activities which might cause loss of environmental quality or unacceptable damage to ecosystems will have

to be carefully regulated. Planning and implementation of projects should minimise environmental degradation such as the loss of genetic diversity, air and water pollution and other environmental hazards which might threaten health and well being. Environmental planning must how be projected to achieve both sustainable development as well as to ensure quality of life".

Rees (1981) has suggested to include following details in an impact assessment:

- a description of the nature and characteristics of the proposed development;
- a description of the existing bio-physical and socio-economic environment;
- an assessment of significant types of environmental impacts during site preparation, construction and operation;
- integration of the expected bio-physical impact with the indirect socio-economic consequences and community response;
- review of the compatability of the proposed development with approved land and water management objectives, and environmental standards and quality criteria for the area(s) likely to be impacted;
- reasons for choosing the particular location and project specification and operation from among possible alternative, adverse impacts which can not be avoided; and

a summary suitable for decision makers and other interested parties;

In order to have above details available and for their proper analysis multi-disciplinary approach is a must. The main aspects to be dealt with the personnel required for such a job are as shown in figure 3 (Rees, 1981).

3.2 Environmental Impact Assessment Procedure

A comprehensive impact assessment procedure may involve carrying out the evaluation in two stages i.e., preliminary assessment procedure and detailed assessment procedure. The idea of having the preliminary assessment is to have an early judgement of severe or important impacts upon the existing environment. The priliminary assessment will be based on the initially available data such as maps, reports, photographs, plans, siting & operation alternatives of the project and competence of the staff available. By systematically relating the characteristics of the proposed development to the site chosen and its surroundings, an information matrix can be developed which will contain the characteristics of the proposed development in columns and characteristics of the site and its environs in rows. Based on such matrix the critical components of environment which are likely to be affected severely can be identified. Such identification will indicate whether there is any need for detailed impact assessment.

If no adverse impacts are confirmed, or when after

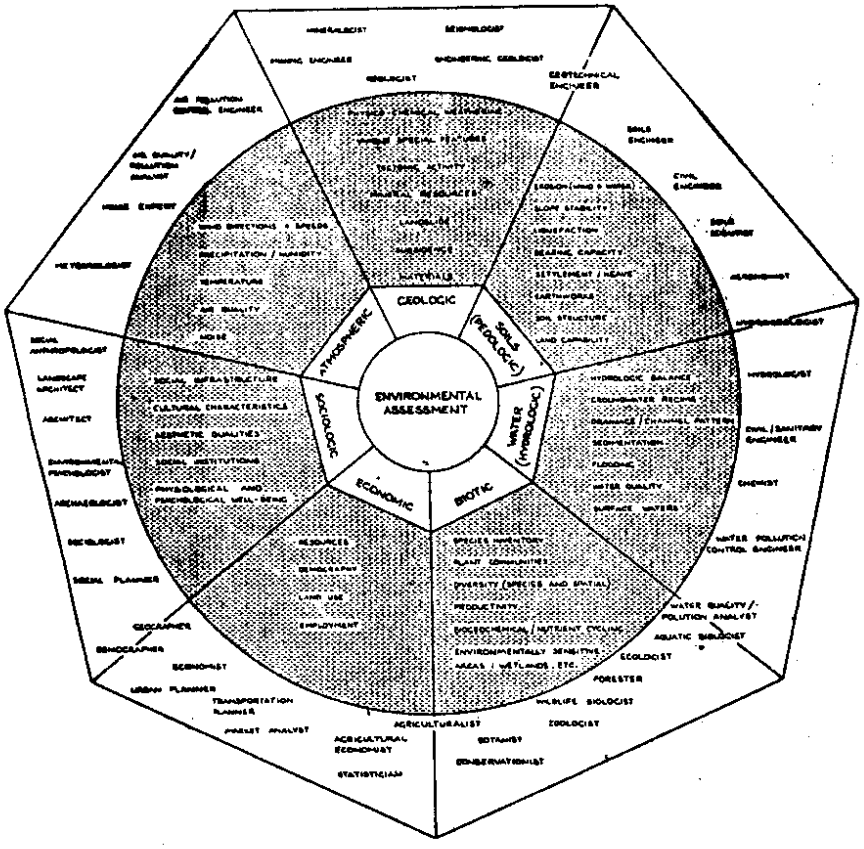


Figure 3. Major components and subcomponents of environmental impact assessment and relevant specialists.

preliminary assessment the problem sites are eliminated from further consideration, then there is no need to carry out detailed impact assessment. In case it is confirmed that certain components of the environmental system is being seriously affected, the particular components are subjected to greater scrutiny. The impacts are then examined in more details, generally through the increased analytical precision of detailed baseline and process studies. More expert opinions are taken on the impacts in terms of their duration, reversibility, directness and cumulative and synergistic effects. Finally a summary of the assessment is prepared which contains determination of the cost/benefits of the proposed project, an explanation of how adverse impacts have been minimised, offset or compensated for and details of follow up surveillance/monitoring. The summary is prepared for the decision makers and other interested parties to expose the environmental consequences of the proposed developmental projects so that adverse compaign regarding the projects could be logically countered.

While assessing the impacts of proposed development it is required to know the nature and characteristics of the proposed development. Sufficient details should be available to give a clear picture in respect of the following aspects of the proposed projects as included in the feasibility report:

general location,specific siting and project layout

. size/magnitude of operation

. site preparation and construction

. transportation/communications requirement

. accidents/hazards

. waste disposal and control

. monitoring and surveillance systems

Also, before attempting to analyse the effects on environmental system as caused by proposed development, it may be worthwhile to assess the nature and characteristics of the existing environment. For this matter the existing environment will need to be described in terms of its present characteristics, especially the ones which are likely to prevail for the entire duration of the proposed development. Such evaluation of existing environmental system may require initiation of large scale surveys and/or long term monitoring programmes, and therefore, needs sufficient time for completion. The effects on environmental system may be evaluated by having known the effects on various elements which may consist of the following:

3.2.1 Physical and Biological Resources

1. Climate
2. Water
3. Geology
4. Soils
5. Noise and Vibration
6. Ecology
7. Environmentally sensitive areas

3.2.2 Human and Economic Development

1. Wate supply
2. Flood control
3. Navigation
4. Transportation
5. Land use and capability
6. Fisheries/wild life management

3.2.3 Quality of Life values

1. Socio and economics
2. Resettlement
3. Public health
4. Nutrition/diet
5. Recreationa and aesthetics
6. Archaeological, historic and cultural sites

Once the existing conditions of the environmental system are ascertained in terms of above listed elements, then attempts are made to outline impacts of the project on all or some of these elements as a result of likely utilisation, alteration and impairement of natural resources affected by the project. Some typical examples in case of water projects which need to be seen are as given below:

(A) Physical and Biological Resources:

Climate:

It may be worthwhile to check whether the micro-climate is being affected as a result of project implementation e.g.changes in meteorological phenomena.

Water:

The hydrologic regime of streams or river systems may get modifed alongwith changes in water quality. Similarly, the ground water quality and quantity in the vicnity of reservoir, changes in water table conditions may take place. the rate of erosion and sedimentation may get increased which may reduce the life of reservoir alongwith deteriorating water quality. The yield of water may get influenced.

Geology:

The geological aspects like effects on tectonic/ seismic activity; mineral resources, physical and chemical weathering; land slides and subsidence characteristics are potential impact assessment issues.

Soils:

The related matters on which the project development may have impacts as far as soils are concerned may include erosion of soild from watershed, slope stability, bearing capacity and soil structure.

Ecology:

The effects on flora and faunal resources of watershed is another vital issue to be investigated for impacts of development projects. The fauna and flora resources in the inundated area and their regeneration and rehabilitation aspects need careful

investigation. Other major effects may include anticipated physical, chemical and biological characteristics of the reservoir, nutrient trapping in the reservoir, effects on marine/estuarine zones, changes in fish population due to possible change in quantity and quality of flow and expected conditions of fisheries in reservoir and in the altered downstream zone(s), and potential for growth of water weeds in the reservoir.

(B) Human and Economic Development

Water supply:

The effects of proposed development on quantity and quality of water available for downstream users.

Flood control:

The likely impacts due to flood control including potential reduction in flood damage and reclamation of lands for agricultural use are to be considered.

Navigation:

Likely effects of the project on navigation above and below the project and augmentation of other facilities such as transhipment and landing facilities.

Transportation:

The effect due to likely requirement of transportation as a result of proposed development and alterations in highway and railroad routes are

needed to be considered.

Land use and Capability:

The impacts on land use pattern and land capability types after proposed development is needed considered.

Agriculture:

The improvement in agriculture due to augmentation of downstream flow needs to be assessed.

(c) Standard of Living

The effects of development on the living standard of the people affected by the project may be required. This may be in the form of finding how the newly constructed roads, industries coming up after development, electrification etc. affected the life of people. The assessment should also include effects as caused by conditions after resettlement of population, changes in agriculture practices. The chances of having water borne diseases should be studied the effects of proposed sanitation facilities for the new habitation around the project should be studied. The recreation potential of the proposed development and plans for its effective development should be assessed. Similarly, the effects on archeological, historic and cultural sites which will be inundated after development should be highlighted and schemes for preservation should be suggested.

Once the assessment report on various aspects is available it should be possible to say whether the

proposed site is alright for development or alternative site needs to be chosen where relatively the impacts (the negative ones) will be less. After studying the assessment reports of all possible alternatives, the one causing acceptable environmental impacts should be the one chosen for development. Department of Environment has also formulated guidelines for this purpose (Moudgal, 1985). A step-wise procedure for preliminary and detailed assessment for a proposed development is shown in Figure,4.

3.3 Techniques of Environmental Impact Assessment

After a careful study of the beneficial effect and negative impacts of a WRDP, one can draw a significant conclusion that ther is a great necessity of thoroughly analysing the environmental impacts of WRPS before they are actually taken up for construction. An indepth study of the expected outcome may lead to many considerations which may significantly alter the design of WRPS but may also ensure environmental protection. Some of the methodologies which are being used in developed countries are:

3.3.1 Adhoc techniques

This technique of EIA is quantitative by nature and gives information in comparative statement for different development schemes or for different options of sites for a WRP. This method is very simple and can be easily understood by decision makers as well as laymen (Raw and Wooten.1980). It is not based on expert opinion and thus can be prepared quite fast. For example, it could give the extent of area

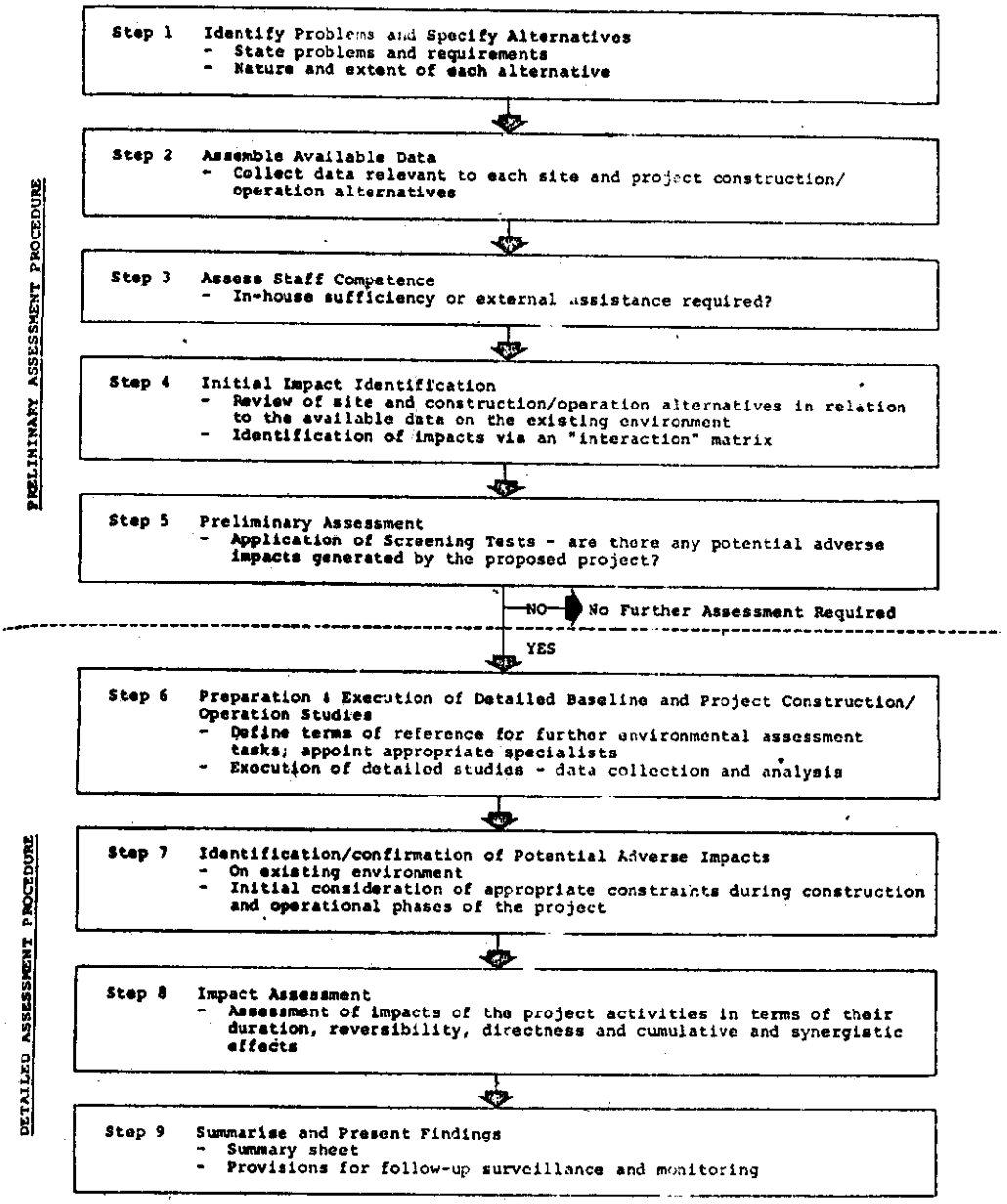


Figure 4. Preliminary and detailed assessment procedures for proposed developments.

submerged by a reservoir, if alternate sites are chosen or earth work to be done if two designs are adopted. Table 1 gives a hypothetical example to illustrate this method.

TABLE 1 : Example of Adhoc Technique

Sr.No.	Item	Various Alternative/sites A	B	C	D	E
1.	Submerged Area	10000	2000	5000	1000	15000
2.	Irrigation potential	50000	10000	20000	5000	30000
3.	Power Generation	11000	10000	7000	3000	13000
4.	Soil Erosion	4a	2a	3a	a	5a
5.	Displacement	25000	15000	10000	5000	20000
6.	Weed Growth	Yes	No	Yes	No	Yes
7.	Fish Culture	No	Yes	Yes	Yes	No
8.	Water Quality	Yes	Yes	No	No	No

3.3.2 Environmental indices

Index is a quantified limit of a specific environmental element. Quantification in this case can be a simple 'yes'or 'no'. Depending on the project, a certain number of indices must be incorporated into the impact stury. Indices can be divided as:

a. Resources indices: These types of indices show the change of the potential of the system or its subsystem.

b. Ecological indices: These types of indices show the change of abiotic and biotic environmental component.

c. Socio-economic indices & cultural indices: These types of indices show the changes toward

the improvement of living conditions.

The use of such indices can be seen in the Adhoc method explained earlier. The indices can form the matrix column of the table. The identification, selection and classification of environmental indices is essential for a successful impact assessment (Singh, et al., 1985). Most EIA studies contain a list of indices ranging between 50 to 1000 with the majority having 50 to 100 indices (Canter, 1985). The number of indices would depend upon the length of data, size of data and the type of data. While developing or identifying indices for new WRP, the baseline data of an existing project in the vicinity may be very useful. However, the adhoc method and indices method derive a lost from each other.

3.3.3 Matrix assessment

This method is based on the action-response relation and is expressed by matrix notation (Leopold et al., 1971). On the one side of the matrix, the charactreristics of existing situation are displayed while on the other side, the environmental factors effected by construction and operation of the project are listed. Sometimes the construction effects may prove to be more damaging than the operational effects. Expected impacts are noted on the interaction points of the matrix and are focussed for their importance. Table 2 gives an example of matrix methods. Whenever a detailed appraisal of certain aspects included in the initial matrix is needed, an expended matrix

is developed (Clark et al., 1981, Pendse 1985;1987).

TABLE 2 : Matrices Method

Characteristics of existing situation	Characteristics of proposed development* 1	2	3	4	5	6	7	8	9	...
1. Water quality										
2. Land use										
3. Climate		⊗								
4. Employment										
5. Water supply			⊗							
6. Displacement										
7. Health	⊗			⊗						
8. Flora & fauna					⊗					
9. --	--									
10. --	--									
11. --	--									

*Noise, 2.Pollution, 3.Dust, 4.Vibration, 5.Solid wastes 6.Odors, 7.Water demand, 8.Employment, 9...., 10.....

3.3.4 Checklist method

This is another quantitative method which facilitates to rapidly assess the environmental impact. Checklist methodologies range from simple listing of environmental elements to sophisticated techniques where a weighing factor is assigned to each element according to its importance, and then sealing techniques evaluate the impact from each alternate, solution. A large number of checklist have been formulated. For water resources there are checklists of the Environmental Impact Centre (1973) and of Battelle Columbus Laboratory (1974). A checklist of 62 environmental

factors related to environmental quality was developed by Canter and Hill (1979). A simple example of the check-list method is given in table 3.

3.3.5 Network method

The environmental components are dealing with human phenomena and hence are very complicated and complex. These represent the impact causes and consequences through an integrated network system. The network is generally shown as a tree which is sometimes known as 'impact tree'. To arrive at the tree structure, one has to answer a series of questions related to each of the project activity, such as activity, such as primary impact area, secondary impact areas, etc. The main limitation of the network approach is that this provides inadequate information on the technological treatment of the problem (US.SC.S, 1977).

TABLE:3 Checklist Method

Item	Likely Impact					
	Beneficial			Harming		
	Short long	Riversible irreversible	Local wide	Short long	Significant normal	Local wide
1.Atmospheric						
a.Air pollution.						
b.Climate						
c.Temperature						
2.Land use						
a.Forests						
b.Grazing						
c.Residentia						
d.Industrial						
e.Agriculture						
3.Water						
a. Lakes						
b. Rivers						

3.3.6 Overlay method

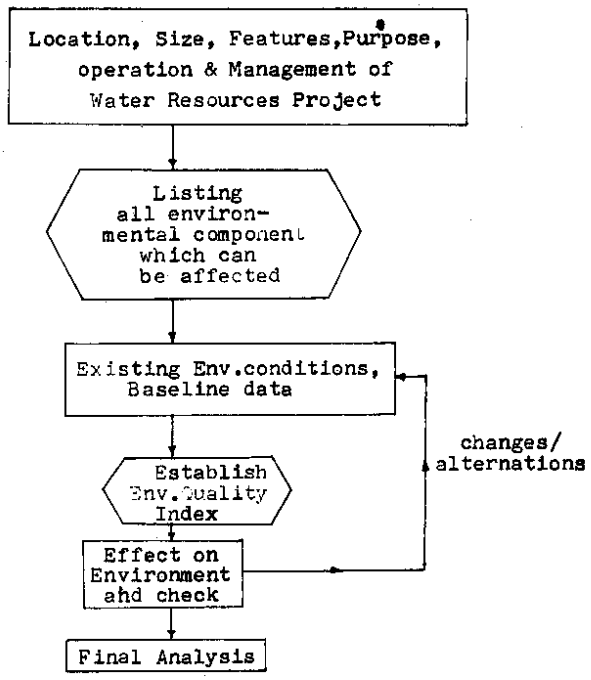
In this procedure, the assessment of environmental impact is done by using the cartographic techniques. Here, the project area is depicted by physical, social, ecological characteristics of the environment. The maps are superimposed on each other to assess the environmental characteristics laying within the project boundary (Lohani, 1982). This method is very useful for selecting a site among alternative sites. The non-availability of baseline data is a serious short coming of the method.

3.3.7 Energetic method

In this method, the relationship between man and ecology is described using energy concept. Energy flows and storage are incorporated, with systems analysis and ecology, for environmental impact assessment (Odum, 1971). The shortcoming of this method is requirement of high degree of technical information and resources. Application of this technique for environmental, economic and hydrologic impacts of palm Bay Area in USA was presented by Barile (1977).

3.4 Flow Chart for EIA

Based on the preceeding sections, it can be summarized that for developing environmental indices to evaluate the impact assessment, various steps would be required (Bhatia, 1986).



Simple Flow Chart for EIA

Though water resources impact assessment is very crucial for protection and conservation of the existing environment yet in India, till date systematic studies are very limited and sporadic. A number of WRPS are delayed, abandoned or are not taken up because of lack of EIA studies. As EIA is a very positive step towards healthier life, it should be throughly studied and used before WPRS in India are designed.

4.0 HYDRO-ENVIRONMENTAL INDICES

After the previous given on the types of water resources projects their probable impact on the environment and the various techniques for evaluating impact of the development on the environment, it would be in order to discuss the various basic units on which these assessment procedures depend. A close look at the various procedures described in the earlier chapter clearly brings out that one may select any procedure/methodology but he has to definitely understand the various environmental indicators, their relationships and the indices developed.

4.1 Indicators

In this chapter, it is intended to bring out various indicators such as:

a) Physical indicators

b) Hydrological indicators

c) Physico-chemical indicators

d) Biological indicators

e) Socio-economic indicators

f) Socio-economic indicators

f) Health and nutrition indicator

g) Cultural indicator

As these indicators are crutial for the chosen EIA procedure it would be imperative to go into each category in some details.

4.1.1 Physical indicators

These are the indicators relating to geomorphology,

climate conditions and may also include the relationship between physical, geological, morphological and human system components. A detailed list of physical indicators (UNESCO, 1984),;Voorhees and Asso., 1975, U.S. Deptt. of Agri, 1975) has been compiled. Some of the indicators collected from available literature are as below:

The physical indicators can be grouped under the following categories:

(a) Geology:

This would include unique features, mineral resources, slopes stability, depth of impermeable layers, subsidence, consolidation, weathering and tectonic activity.

(b) Geomorphology:

These may include altitude, slope, network of rivers and water courses; erosion and sedimentation and if applicable, glaciation.

(c) Soils:

These may include soild types, variety, slope stability, foundation support, strink and swell property, liquifaction, erodibility, compactibility permeability, hydrogen ion concentration, frost suscetibility.

(d) Climate & Air:

This is an important type of indicator and may include macro-climatic hazards, heat balances, radiation input, temperature of atmosphere, yearly precipitation,evaporation,air humidity,shadow effects, generation and dispersion of contaminants etc

(e) Human and Economic Geography:

These are indicators which are significantly different from social indicators,nevertheless their importance can not be overlooked. These may include roads, sites of agricultural use, sites of special use as per settlements, mining or for water power potential.

(f) Special land features:

These may be typical to certain situation. However, for a particular site they may play vital role. Some of the examples of such indicators could be sanitary land fills, wet lands, coastal zones, mine dumps, spoil areas etc.

4.1.2 Hydrological indicators

These indicators describe the water quantities, types of water and all other aspects related with water The main hydrological indicators could be:

(a) Hydrological balance:

This is important indicator and well comprise of inputs in the form of precipitation and outputs in the form of runoff,recharge, inter-basin flows etc. The detailed components under this category could be the fate of the input (precipitation) which may lead to snow field and glacier storage, surface runoff, evaporation, transpiration and ground water enhancement.

(b) Groundwater:

This is a long term varying indicator and depends upon the time since the environmental change has taken place. This would include vertical and horizontal ground water movement and the time dependent variation of the ground water.

(c) Runoff:

This would include fluctuation, storage, discharge and the frequency of the annual runoff and the average of the number of years of discharges,peak-duration and size of high water characteristics, flood wave characteristics incorporating their frequency during different years, and low water characteristics such as duration, stability,minimum runoff and drying up.

(d) Flow characteristics:

This would include the flow conditions like velocity,balnce,flow path and longitudinal water profile.

(e) River configuration:

This indicator would take into account morphological characteristics of the river cross-sections, longitudinal slope of the river bed, plan of the river section and may also take care of characteristics of the suspended and bed sediments.

(f) Flood plains:

Such indicators may account for flood plains, relation of river area to flood area. Frequency of flood and its duration will also be included

here.

(g) Drainage and channel forms:

This is an important characteristics as it is easily dissernible. The drainage in the area and the various channel forms directly affect the environmental system.

(h) Estuary conditions:

This indicator would take into account salt water intrusion, littoral drift and sediment deposition in the mouth of estuary. However, this indicator is a type which shall be prevailing only is specific conditions.

4.1.3 Physical chemical indicators

Such indicators shall provide relevant information on qualitative aspects of water or the potentials to change physical and chemical characteristics of water by reactions between physical, chemical and biological components and to certain degree, human components. These may be categorized as:

(a) Physical:

For standing waters, such indicators could be light energy, transparency, absorption of light, temperature and temperature stratification, mixing characteristics and sedimentation characteristics. In the case of flowing water, such indicators could be character of flow, depicting turbulence, sedimentation, sediment transport and erosion.

This would also have the important aspect of temperature and its changes over time. In case of rivers and reservoirs,thermal and chemical stratification due to difference between inflowing water and still water is of immense importance. For ground water only the seasonal variation of temperature and its age are important.

(b) Chemical:

Here a complete set of chemical characteristics can be identified such as:

i) total dissolved solids
ii) total suspended solids
iii) total organic carbon
iv) pH value
v) redox value
vi) conductivity
vii) dissolved oxygen
viii) total dissolved gas
ix) total salinity
x) alkalinity
xi) acidity
xii) hardness
xiii) chemical oxygen demand
xiv) total dissolved organics
xv) biochemical oxygen demand
xvi) cations
xvii) anions
xviii) specific organic components

Resulting from interactions or integrations

for specific purpose

Radioactive

xix) alpha,beta, and gamma particles

xx) stratification

Table No. 4 gives a listing of environmental attributes.

4.1.4 Biotic indicators

These are very important indicators and are also not very easy to take into account. These are the living expression of the quantity, quality and interaction of,and between, the physical, chemical and biological components on one side and their composite interaction with the biological components on the other side. These may be classified as:

(a) Terrestrial fauna and flora:

In case of catchment area, the type of plant community, production of biomass and turnover, export of plant nutrients, cation exchange capacity of soils are very important. Whereas in case case of flowing waters the import of nutrients through ground water, trophic potential and actual production along the water course, standing crop, composition of bottom flora & fauna along the water course, indicator organisms, self purification, fish population are of vital importance. However, some consideration should also be given to specific organisms along the river course, DO-BOD relation and disease vectors. While it comes to the case of natural lakes, ponds and

TABLE 4: Environmental Attributed Listing
(US DA, 1975 Modified)

Category	No.	Attribute	Category	No.	Attribute
Air	1.	Diffusion factor	Ecology	27.	Large animal (Wild & domestic)
	2.	Particulates		28.	Predatory birds
	3.	Sulphur oxides		29.	Small game
	4.	Hydrocarbons		30.	Fishc, shell fish, and water fowl
	5.	Nitrogen oxide		31.	Field crops
	6.	Carbon monoxide		32.	Threatned species
	7.	Photochemical oxidants		33.	Natural land vegetaion
	8.	Hazardous toxicants		34.	Aquatic plants
	9.	Odor	Sound	35.	Physiological effects
Water	10.	Aquifer safe yield		36.	Psychological effects
	11.	Flow variations		37.	Communication effects
	12.	Oil		38.	Performance effe-ects.
	13.	Radioactivity		39.	Social behaviour effects
	14.	Suspended Solids			
	15.	Thermal pollution			
	16.	Acid and alkali			
	17.	Biochemical oxygen demand			
	18.	Dissolved oxygen (DO)	Human	40.	Life styles
	19.	Dissolved solids		41.	Psychologieal needs
	20.	Nutrients		42.	Physiological systems
	21.	Toxic compounds		43.	Community needs
	22.	Aquatic life			
	23.	Fecal coliform			
			Economic	44.	Regional economic stability
Land	24.	Erosion		45.	Public sector revenue
	25.	Natural hazard		46.	Per capital consumption
	26.	Land use patterns			

reservoirs primary production and production potential along with the crop type and flora and fauna become more important. In addition chemical components such as phosphorus and nitrogen and their seasonal changes in different strata along with the specific organisms can provide vital information. Another important aspect of the hydrologic cycle is ground water which has got the indicators like fecal pollution, biomass production etc. as good indicators.

(b) Aquatic biology:

Normally this would exclude fisheries and they would be of immense importance as indicators as in the case of still waters, lakes, ponds and remaining waters. Interaction with biologists is necessary for assessing the impact of the changing environment on the aquatic culture which in turn would act an indicator. The anticipated impact on the upstream and downstream including the effect of nutrient trapping in the reservoir.

(c) Fisheries:

The anticipated losses in the existing fisheries due to inundation, changes in the quantity and quality of downstream flow due to storage and interference with migration behaviour may act as a sound indicator. Determination of expected fisheries conditions in the reservoir and in the altered downstream zone could also be effective indicator

4.1.5 Socio-economic indicators

This category could be broadly classified under the following heads:

a) Indicator for pressure on the environment which can be represented by population density, economical requirement like desired GNP.

b) Indicator on the degree of success like age distribution of population, their diversity, size, source and income of the family, living conditions, savings etc.

c) Their could be additional indicators like energy consumption, land holdings, irrigation, urbanisation, working conditions and recreational facilities.

4.1.6 Health and nutrition indicators

The ultimate aim of any development is to improve the living conditions of the mankind so that the quality of life gets improved. Sufficient high quality food and water are the prime requirement for an improvement in the quality of life. Quality of life upto some extent is responsible for the health and nutrition of the people. There has been an increase in the life span of the man, to some extent the development of water resources has also contributed to this aspect. Components of health care, health dangers and nutrition, therefore reveal to what degree man's technical pressure on the environment has been successful to have a healthy population within a healthy environment. These indicators could include the following:

(a) General health situation indicators:

Birth rate, death rate, infant mortality, average life span and age distribution, population growth and population density are some of the basic aspects to be included here.

(b) Degree of health care indicator:

This could include the doctor/population ratio, hospital beds/population ratio and other characteristics indicating the quantum of facilities available to the population in the area.

(c) Public hygiene indicator:

Such indicators could be the housing conditions, safety of water supply, disposal of wastes, degree of vaccination, and intensity of various diseases etc.

(d) Specific indicators:

There could be specific indicators for health situation such as percentage of T.B. patients, intenstinal infections etc. The specific indicators for potential health hazards could be presence of disease vectors, presence of parasites etc.

(e) Nutritional status indicators:

There could be general indicators like available, calories per man, available protein per man, uptake of vitamin 'A' and 'C'. Specific indicators under this category could be high/weight ratio of the children, and anaemia problem in the children.

4.1.7 Cultural indicators

During the growth of mankind be has been fascinated with the ideal of preserving his cultural inheritance through the constructior of unique manuments which have a long lasting value. As such these cultural preservation do not add to the wealth of the society,however, their mere presence becomes a vital necessity for the social pursuits of the people living in that area. Certainly some of these monuments have lost their importance with further development and others have lost their meaning, but many of them are still present, and rapid changes or neglecting them could result in heavy negative feed back on system development. Definitely while water resouces development programme is taken up such monuments or similar cultural inheritance could be endangered because of the development and in this way such cultural components could prove to be good indicators. These indicators could be subdivided into the following:

(a) Indicators of social importance:

These indicators may include ethenic background, family structure, land ownership practice, sexual preference, tribal politics etc.

(b) Indicators of social and cultural importance:

This would take into account taboos, religious practices, existence of holigrounds, and archeological sites.

(c) Indicators of cultural & ecological importance:

This would include holi grounds (as a land feature),

wild life reserves and potential for establishing reserves etc.

4.2 Interrelationship Among Indicators

After getting an insight into various indicators, their importance and categorisation, it would be imperative to dabble into the interrelationship existing among various indicators. Such interrelationships are highly complicated and delicate balances are maintained. A note of caution is warranted here. A particular situation necessitating impact analysis need not necessarily require defining all the indicators. However, if the interrelationships are knwon intelligent interpretations may lead to proper indices value. It would be useful to study the following interrelationships:

a) General relationship between ecological and human components.

b) Interaction between living components

c) Selft restoring potential of living communities

d) Interrelationships between physico-chemical and biological components in still water and some qualitative consequencies for human use.

e) Interaction within, and probable positive and negative results creats by a multipurpose system.

4.3 Indices

The quantified limits for indicators are indices. Quantification in this context means, but is not restricted to, a certain amount or concentration which can be the uppermost or the lowest value permitted. Hence a 'Yes'

or 'No'' answer would also fall under this quantification. Indices are intended to be protective measures for man or for man's direct sources for food and water. No indices have been developed for the long term protection of nature. Another school of thought considers nature as a human resource. Therefore, if seen in near future, limits have to be set as to what degree existing nature should be and must be protected. But as nature is a composite whole, standards have to be found for selected indicators, thus defining and transforming the selected indicators into indices. Some of the indices are being discussed as below. (for details one may refer to UNESCO, 1985, Cater, 1979).

4.3.1 Resource indices

The potential use of a system or a component within a system may be referred a resources and the index showing status of resource's potential as it is developed is referred to as resource index. This index regulates the human health requirements by setting limits to usable potential of the resource or its components. These resources may include potable and industrial water supply, food production resources, energy creation resources, mineral resources and resources for recreation.

Indices for resources for water supply may cover the hydrological background, the natural chemical back ground, and the pollution. These indices would depend upon the water supply source, the usage to which the water is put like potable water, water for industrial use and

water for irrigation purposes. The indices for food supply sources may depnd upon soil pollution with heavy metals, because of using muncipal wastes or in agricultural areas along the highways. Hence, limits have to be specified for metal concentrations in sludge to be used for agriculture. However, while using these limits one has to consider the soil type and the climiate conditions. The indices for air resources may also be significant in certain typical environments. Air pollution as is the fact, endangers mankind directly and indirectly. Direct effect is through the oxygen intake and indirect effect can be seen on the buildings and various other structures and by attacks on forest and crops by acid rain. Limits are set for this in developed countries at present.

4.3.2 Ecological indices

These are rare indices and a thorough review of literature in the area may not yield much. Much basic scientific work is needed to understand the ecological system and to identify indicators which could prove to be significant for protecting the ecological system. Some experience has been gained in protection of sub-system such as rivers, lakes and wet lands and limits have been set for import of organic and inorganic pollutants as well as for plant nutrient specially phosphorus. Some attempts have also been made to fore cast the phosphorus concentration in the rivers (Bhatia, 1985;1986). However, for large and complex ecological systems experience for protection hardly exists. However, UNESCO(1984) suggests the following

ways to develop the indices:

(a) Changes of abiotic components:

The hydrological components to be used could be percentage of surface runoff, percentage of ground water supply, evaporation over the course of the year etc. The climate component to be used could be changed of wind velocity and direction, and change of mean temperature over the years. The physical components to be used could be change of flow, change of temperature stratification etc. The chemical components to be used could be the quality of water.

(b) Changes of biotic components:

The pattern of natural and cultivated land or water bodies, diversity and variety of species, food web chain, metabolsium of the system, vulnerability to eco-system, toxic effects of components in the system, probity, and tropic status are some of the biotic components.

To briefly summarise the biological indices, all man made changes and man induced stress on an eco-system, the total amount of energy import could be used as a general index. As all management needs energy import to change nature into cultivated land or to counteract nature's self healing efforts. For the use of indicators and indices it is important to emphasize the need for knowing the aim of their application.

4.3.3 Other indices

All the man made and man induced changes have to measured and quantified with respect to social or economical or cultural or bombining one or more of these goals. However, the time frame is of great importance in such goal setting. The benefits should pass on to future generations rather than limiting to the present generations. Hortman (1984 in UNESCO 1984) has schamtically given the criteria for selection and hierarchy of indicators to be used, as indices for man made systems which is given in figure 5. The figure shows first order indices and the other indices can be derived from the indicators given in sub-sections 4.1.5 and 4.1.6.

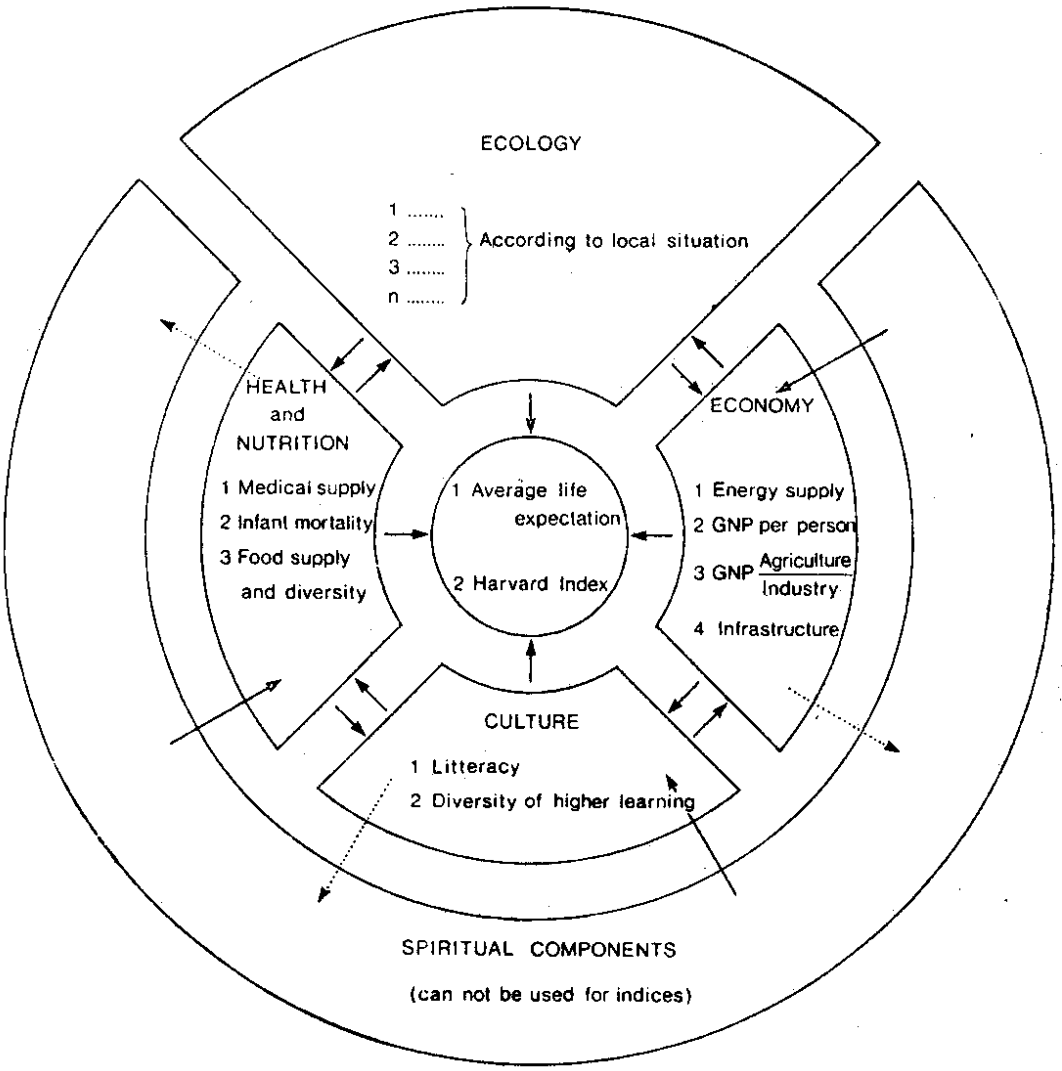


Figure 5. Selection and hierarchy of indicators to be used as indices for man managed systems. (L. Hartmann)

5.0 CONCLUSIONS

After a detailed review of the three main components of the cause-effect relationship i.e., standards, indicators and indices, it would be useful to look at them in the perspective of development of water resources in the country. There is no doubt that these indicators shall always be existing in Indian conditions and their may be some standards and very few indices to work upon but the main crux of the problem is of fixing the standards and identification of indices. One sould be very carefull while choosing the indices to work with because while evaluating an existing project or a proposed project some of the indices may not be important and some of the indices which are important may not have any data to support that. In the case of standards, setting up of very stringent standards may make a technically feasible site environmentally unsafe and keeping very relaxed standards may, in later stages endanger the environment. Hence, one can not work with the standards and indices developed by the advanced countries. For developing indices and standards for an optimal development of water resources a multidisciplinary group consiting of environment protectors and the people responsible for future development have to sit together and formulate the required indices keeping in view the national interest. An important purpose which has been served by the review is that such groups would have the complete information with them and then the priorities can be defined.

As brought out by the detailed discussions the evaluation of water projects must not be limited to hydro-ecological factors alone. All water projects must be reviewed as a part of total environmental system encompassing physical, chemical, biological, economical, social and cultural components. A combination of all these should form the basis for development.

No matter how detailed environmental assessments may be, problems are prevented only by conscientions implementation of precautionary measures. Conscientions implementation can occur only if there exists a mutual trust and will to look for the best solution (Padhye, 1987).

A review of all the available indices submits the case that environmental precautions are available, affordable, feasible and tested (in developed countries) and that their implementation can prevent damage and mitigate environmental cause. The only necessary remaining requirement is the social and political will to insist on 'Development with out Destruction'.

The report pinpoints the scientific fact that this is only a beginning in an important direction and considerable development remains to be done to make the use of indices an effective tool for the evaluation of water projects in the country.

The next step in this direction should be to develop the identified hydro-environmental indices for a completed water resource project. A note of caution is warranted

here because the water data situation in our country merits a relooking. One should not get disheartened because the data available on various components specially biological and social indicators may not be easy to obtain. However, some judicious assumptions would definitely steer over the problem. As is evident, for successful completion of such a study a team of multi-disciplinary experts working in the areas of engineering, economics, social sciences, life sciences, pure sciences, applied sciences, mathematics etc. are required to sit together for working out the suitable strategy. To substantiate this hypothesis, a tentative list of data required for an environment impact assessment study is given in Appendix-I.

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APPENDIX-I

DATA REQUIRED FOR EIA STUDIES

Following data will be required for carrying out the study:

(A) Basic Information

i) Existing land use in the catchment

a) Agricultural land
b) Forests
- Reserved
-Unreserved
c) Barren land
d) Other land use

ii) Land use data of pre-construction period

iii) Submerged area

a) Culturated land
b) forests
c) shrubs and fallow
d) area under ponds and lakes
e) residential area
f) other uses

iv) Forest types incatchment area and submerged area

a) forest density
b) Other vegetation
c) Rare species if any
d) Forest area cleared for construction of roads,colonies and other uses of project

v) Total duration of construction and progress of various works during this period

vi) Data regarding faunal resources of the region

a) type of wild animals
b) endangered species
c) any wild life sanctuary in the region
d) information regarding migration routes of animals
e) Hunting practices data, if any
f) measures proposed to salvage/rehabilitate

vii) Data regarding aquatic life

a) status of fisheries
b) effects on fish culture
c) measures to protect fisheries and other aquatic life

viii) Data regarding industrial development of the area
   a) present status of industries
   b) type of industries
   c) sources of raw material
   d) effects of construction on availability of raw material for industries
   e) status of polution to industries

ix) Population density (per sq.km.)
   a) catchment
   b) submerged area
   c) command

x) Population affected by construction
   a) Number of villages
   b) population
      -scheduled caste
      -scheduled tribes
      -others
   c) Occupation details
      -Agriculturists
      -Agricultural labour
      -industrial labour
      -forest labour
      -artisans
      -any other
   d) Land ownership
      -marginal farmers
      -small farmers
      -medium farmers
      -big farmers
   e) Social status
      -income per family
      -details of schooling facilities
      -availability of market facilities
      -religious sentiments attached with specific areas
      -any other pecular characteristics

xi) Resettlement details
   a) details of rehabilitation committee if any
   b) guidelines laid for rehabilitation, providing compensation in cash/kind
   c) resettlement plans
      -in existing villages
      -at new village sites
      - facilities being provided (school,post office,bank,police station, roads, drai n - age, water supply etc.

xii) Details of developmental activities in affected areas
   a) small farmer development agency
   b) drought prone area programme
   c) integrated rural development programme
   d) tribal development programme

xiii) Information regarding tourisum
   a) was the area a tourist resort
   b) details of relegions, archeological and recreational centre, wild life sanctuaries national parks afected by the project.

xiv) Diseases/Health problems
   a) details of endemic health problems due to soil water borne diseases
   b) remedial measures taken

B. Hydrological and other data

i) Rainfall data over years

ii) Streamflow values

iii) Sediment data/rate of siltation

iv) Water quality data

v) data relating to floods

vi) Ground water data including depth and seasonal variations, quality, status of use

vii) Proposed soil conservation

viii) Problems of slips and slides on the periphery of the reservoir and remedial measures

C. Impact Assessment Data

i) Increases in irrigation facilities/irrigated area

ii) Crop yield values and improvements recorded

iii) Power generation and its impacts

iv) Flood protection activities and impacts

v) Water supply

vi) Ground water recharge

vii) Employment generated

viii) Tourism attraction generated

ix) Alteraction of weather and changes in micro climate

x) expected changes in groundwater quality and proposed remedies

xi) expected waterlogging problems and remedies

xii) proposals for fisheries development and crocodile farming

xiii) mines, minerals, commercial timber and other natural resources coming under submergence

xiv) injurious minerals coming under submergence

xv) likely impact of reservoir loading of seismicity.

xvi) Broad details regarding growth of weeds (Salvinia, water hyacinth).

D. Any other relevant data including name of agencies already involved in carrying our impact studies of the project.