IMPACT OF DAMS ON BIODIVERSITY IN INDIA

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EXECUTIVE SUMMARY

IMPACT OF DAMS ON BIODIVERSITY IN INDIA[1]

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Introduction, Objectives and Scope:

It is recognized that large dams directly or indirectly transform the nature and productivity of riparian, estuarine and coastal ecosystems. This will have a direct bearing on the biological diversity that is encompassed in these ecosystems. The ecosystems, the reservoirs of biodiversity, not only provide the biomass, food and economic sustenance to the local communities, but also play crucial roles of carbon sequestration, water regime management, soil erosion prevention and regional ecological balance. In this light, an attempt is made to prepare a review paper that will try to assess impact of dams on biodiversity in India.

The major objectives of this review paper are to: Analyse dam distribution; summarize trends and statistics in environmental impacts of dams and their consequential impact on biodiversity; characterize the nature of impacts of dams on ecosystem structure and functions and services; review existing EIA framework to assess its capability and adequacy to address issues related to biodiversity; examine Indian EIA process vis-à-vis international conventions and guidelines like CBD; and suggest policy responses and institutional mechanisms that are needed to internalise the biodiversity impact externalities caused by large dams in India.

Biodiversity is the totality of genes, species, and ecosystems in a region. Depending on the scale, dam building has the potential to alter the characteristics of riparian, terrestrial and estuarine ecosystems at local, regional and landscape levels. An ideal impact assessment study should attempt to capture all these elements in real time and should have the capability to predict the future scenarios.

Major results and conclusions

The three states of Maharashtra, Madhya Pradesh and Gujarat have 3159 large dams (2641 commissioned and 518 under construction), which is 74% of the total large dams (4291) in India. By 1980, India had lost about 500,000 hectares of forest due to 2178 dams that were constructed and an estimated 9157883 ha to 4504800 ha forest is lost due to dams after 1980. Even if we consider the lower estimate, a staggering 5 million hectares of forestland could have been lost due to dam construction. A biogeograpic zone approach indicates that Deccan Peninsula biogeographic zone has maximum dams - 3268 (76% of the total). Gangetic Plains has 266 (6%) and North-East (0.4%) of dams.

[1] Sub-thematic review paper prepared under the "National Biodiversity Strategy and Action Plan" for the Ministry of Environment and Forests, Government of India

Apart from forests, the reservoirs and the dams also impact floral and faunal diversity encompassed in other ecosystems like agriculture, pastures etc. Unfortunately, there was little effort to assess the impact on biodiversity in non-forest ecosystems. Even the studies that have been conducted on the impact on fauna and flora have been inadequate on many counts:

- ✓ There is almost no study of the cumulative impact of any dam on the full range of biodiversity values at genetic, species and ecosystems level.
- ✓ There is no mention of agricultural biodiversity in any of the dams that were studied. This might mean that many genetic strains of endemic crop varieties might have been lost due to dams.
- ✓ Similarly, many species of lesser-known taxa like invertebrates, algae, fungi, bacteria would have been lost, even before their ecological and economic values are recorded and realized.
- ✓ In none of the dams studied were there any efforts to monitor the status of wildlife after the construction of the dam, to assess the impact of the mitigative strategies and to check the validity of the impact assessment done prior to construction.
- ✓ There is a tendency to consider only large mammals as 'wildlife' and a stress on 'valuable' species, which often means the more prominent or visible species. However, some of the less visible species might actually be even more important to conserve.
- ✓ There is also a tendency to focus only on endangered species. Being concerned only about endangered species results in other species also becoming, over time, endangered.

In India, impacts on biodiversity are not adequately addressed in impact statements. Usually, traditional EIAs did not address biodiversity impacts. Where ecological impacts are included, these are often restricted to the results of brief habitat surveys and species lists. EIAs have focused on impacts upon protected species and habitats. They are less likely to address other aspects of biodiversity such as diversity between species and habitats, trends over time, species abundance and distribution, and the functional components of biodiversity. Positive conservation measures such as the rehabilitation of degraded ecosystems have not received explicit attention. Components of biodiversity which are already protected, either by established protected areas or by a listed status, are more likely to be included in an EIA study than components which have been given less attention but may be important to the long term productivity of ecosystems and maintenance of biodiversity.

Therefore the Indian EIA should be made more sophisticated with through investigation and analysis of potential impacts on an ecological unit and the species and communities within it. A more ecosystem approach is needed, which looks at potential impacts on the ecosystem as a whole, particularly its functions (for example forests

provide "carbon sequestration" function and wetlands providing a 'storage function' to help avoid flooding), and the potential knock-on effects of impacts.

Expand the scope of EIA

The general feeling about the environmental statements found in India is that in many cases the ecological information provided was so limited in quantity, or of such poor quality, that it was not possible to assess the ecological implications of proposed schemes. Even without the obligations of the CBD (Convention on Biological Diversity), the requirements of existing EIA legislation such as the EIA notification of 1994, which requires the assessment of impacts on flora and fauna, were not fully met.

On the other hand, the CBD provides a strong international platform for applying impact assessment techniques to biodiversity conservation. It specifically calls for impact assessment measures to ensure that biodiversity is addressed in projects, plans and policy decisions (Article 14). This paper argues that the CBD provides a mandate and an opportunity to identify opportunities for enhancing the biological resource of habitats and species through EIA. IUCN proposed a new impact assessment tool - Biodiversity Impact Assessment (BIA) as an extension of EIA, which would ensure that biodiversity issues are explicitly considered in impact assessments. Although a new tool may not be necessary, a serious review of existing tools is needed to ensure that the obligations of the CBD are met by Indian EIA process.

Biodiversity impact assessment should therefore be seen as and extension of existing impact assessment systems, and not promoted as a separate entity. There is an impetus behind the biodiversity agenda, and so the term 'biodiversity impact assessment' can be used to raise awareness of these issues within the impact assessment community. This will enable us to focus on the more positive aspects of biodiversity, looking at the ecosystem approach, dealing with fragmentation issues and so on, and not just the traditional EIA approach of mitigating impacts. Biodiversity is not just about rare species and habitats, but about enhancing degraded areas, reversing species declines, and creating new habitats.

The Challenges and the path ahead

There are two main challenges that biodiversity conservation raises for impact assessment: (1) Existing impact assessment tools must be improved to address biodiversity impacts, and (2) The tools need to be expanded to provide more positive benefits for biodiversity.

There exists an opportunity to integrate the provisions of CBD at every stage in EIA process and achieve the above two objectives. For example, it is important to ensure that screening procedures include biodiversity criteria, so that projects with potentially detrimental effects on biodiversity are subject to EIA. The scoping stage is vital, to identify the impacts which will be fully addressed. Four principles can be considered at the scoping stage for biodiversity: spatial context, cumulative effects, public participation and biodiversity criterion. The EIA study itself must consider potential biodiversity impacts, determine their significance, and recommend measures

to mitigate adverse impacts and maximise positive impacts. Finally, the post-project monitoring and review stages are essential to determine whether impacts were predicted accurately, to assess if mitigation measures are effective, and to address any unexpected impacts. This feedback loop is crucial to maximize the effectiveness of EIA, and is sorely left out of the present process chain.

Achieving the objectives of the CBD requires more than just mitigating impacts on biodiversity. A proactive approach is required, which seeks first to avoid impacts, and identifies opportunities to enhance biodiversity. For example, opportunities to create wildlife corridors or links between habitats could be highlighted, or the potential for management practices to enhance the biodiversity interest of existing features.

- ✓ EIA has traditionally been a reactive tool, because it responds to impacts through mitigation rather than examining the potential to design out impacts through the consideration of alternatives. However, examining alternatives may not exactly fit into the scope of Indian EIA procedures. But a strong case exists for careful examination of alternatives at a Strategic Environmental Assessment (SEA) level. This also enables a more positive approach to be taken to biodiversity conservation, particularly through identifying opportunities for enhancement.
- ✓ Changes are needed at all levels of impact assessment. At national level, changes to impact assessment notification and guidelines are necessary to introduce formal requirements for biodiversity issues to be addressed. India has already signed up to the obligations in the CBD, and these need to be transferred into existing impact assessment requirements.
- ✓ The word "BIODIVERSITY" does not appear anywhere in the EIA notification or the EIA manual prepared by the MoEF. There is no direct reference to ECOSYSTEM or ECOSYSTEM SERVICE LOSSES.
- ✓ Create an independent autonomous institution to conduct biodiversity impacts of various projects and policies. This institutions should have a broad expert base that is capable of addressing all aspects of biodiversity (genetic, species and ecosystem levels and experts who can address the complete spectrum of biodiversity ranging from micro organisms to large mammals). The funds to create such an institution could come from the project proponents and MoEF. This will introduce the transparency into decision making and will also ensure a broader, more ecosystems based, perspective of impact assessments.
- ✓ Broaden and expand the scope of benefit cost analysis of dams to incorporate monetized biodiversity and ecosystem value losses in an integrated economic and environmental accounts framework
- ✓ Ensure representation to local NGOs, / stakeholders at the draft EIA report preparation stage to capture their perceptions and indigenous knowledge.
- ✓ Disseminate 'best practice' EIAs that explicitly addressed biodiversity issues to bench mark standards and practices.

- ✓ Prepare and disseminate guidelines on how to explicitly incorporate biodiversity issues into impact assessments on a priority basis.
- ✓ Finally, ensure transparency of decision-making and right to information to stakeholders, so that it can be clearly seen how biodiversity impacts have been taken into consideration.

The challenge ahead is enormous, but very exciting. It is time that we take advantage of the CBD mandate to strengthen existing methodologies and techniques and advocate stronger application of those techniques to protect biodiversity. In addition, we need to make the most of opportunities to expand impact assessment into a more positive, proactive tool, in order to reverse some of the damage and declines of the past, rather than just mitigating the impacts of current activity. In this way, impact assessment can help to deliver the objectives of sustainable development, to meet the needs of the present without compromising the ability of future generations to meet their needs.

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1. INTRODUCTION

At the turn of the 20th century there were about 630 dams in the world. By 1949 about 5000 dams were constructed, mostly in the developed countries. By the end of 20th century, there were over 45000 large dams in over 140 countries. World over, a great majority of large dams have been completed only in the last thirty years. India is a major dam builder among the developing countries. India has 4,291 large dams, counting the 695 that are under construction. Of these, 2,256 dams were built between 1971-1990. About three-quarters (73%) of the 3,596 completed dams are situated in three western states of Gujarat, Maharashtra and Madhya Pradesh. In India majority (93%) of the dams are constructed for the purpose of irrigation and 7% are constructed for other purposes (3% multipurpose, 2% hydro power, 1% water supply and 1% miscellaneous).

Large Dam

There are various definitions of large dams. The International Commission of Large Dams (ICOLD) defines a large dam as one with a height of 15 meters or more from the foundation. If the dams are between 5 to 15 m in height and have a reservoir volume of more than 3 mm^3 (million cubic meter), they are also classified as large dams.

Dam construction has a long tradition in India. With the development of modern engineering, the construction of dams took a quantum leap. As early as 1897 the Periyar Dam was constructed in South India, 54 m above the foundation level. Other high dams were the Wilson Dam (82m, 1926) and Mettur Dam (70m, 1934). After Independence, there was rapid growth in dam building. The Koyna (103m) completed in 1961, was the first dam above 100 m in height. 226m high Bakra Dam was commissioned in 1963. From fewer than 300 large dams existing at the time of

Independence, the number of dams constructed and under construction has risen to 4291 in 2000.

It is recognized that large dams directly or indirectly transform the nature and productivity of riparian, estuarine and coastal ecosystems. This will have a direct bearing on the biological diversity that is encompassed in these ecosystems. The ecosystems, the reservoirs of biodiversity, not only provide the biomass, food and economic sustenance to the local communities, but also play crucial roles of carbon sequestration, water regime management, soil erosion prevention and regional ecological balance.

In this light, an attempt is made to prepare a review paper that will try to assess **impact of dams on biodiversity in India**.

2 WHAT IS BIODIVERSITY

The United Nations Convention on Biological Diversity (UNEP, 1992) defines biodiversity as "*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*" (Article 2). Biodiversity is the totality of genes, species, and ecosystems in a region. The wealth of life on earth today is the product of hundreds of millions of years of evolutionary history. Over the course of time, human cultures have emerged and adapted to the local environment, discovering, using, and altering local biological resources. Biodiversity can be divided into three hierarchical categories that describe quite different aspects of living systems that scientists measure in different ways.

2.1 Genetic diversity

Genetic diversity refers to the variation of genes within species. Roughly speaking, genetic diversity concerns the information represented by genes in the DNA of individual plants and animals. This covers distinct populations of the same species (such as the thousands of traditional rice varieties in India) or genetic variation within a population (which is very high among Indian rhinos, for example, and low among Asiatic Lion).

2.2 Species diversity

Species diversity refers to the variety of species within a region. The number of species in a region -- its "species richness" -- is one often-used measure, but a more

precise measurement, "taxonomic diversity," also considers the relationship of species to each other. For example, an island with two species of birds and one species of lizard has greater taxonomic diversity than an island with three species of birds but no lizards. Thus, even though there may be more species of beetles on earth than all other species combined, they do not account for the greater part of species diversity because they are so closely related. Similarly, many more species live on land than in the sea, but terrestrial species are more closely related to each other than ocean species are, so diversity is higher in marine ecosystems than a strict count of species would suggest.

Species diversity and classification

Species diversity refers to the variety of living organisms on earth and has been variously estimated to be between 5 and 50 million or more, though only about 1.4 million have actually been described. Biologists classify life on earth into a widely accepted hierarchical system that reflects evolutionary relationships among organisms. In ascending order, the main categories or taxa, of living things are:

1. Species
2. Genus
3. Family
4. Order
5. Class
6. Phylum
7. Kingdom

Humans, for example, are classified as follows: Animalia (Kingdom), Chordata (Phylum), Mammalia (Class), Primates (Order), Hominidae (Family), Homo (Genus), sapiens (Species). These last two designations, together referred to as the Latin binomial, are used to identify an organism, and distinguish it from any other.

In general, the higher the category ranking of an organism, the more ancient the evolutionary divergence. Thus, with *Homo sapiens*, it was more recently that the species became established than the genus, and more recently that the genus evolved than did the family (Hominidae), and so on up to the Kingdom level.

Most biologists recognize five kingdoms of organisms:

Prokaryotae (bacteria)
Protoctista (includes algae and protozoans)
Fungi (mushrooms, molds, and lichens)
Animalia (animals), and
Plantae (plants)

2.3 Ecosystem diversity

Ecosystem diversity refers to diversity at a supra-species level, namely, at the community level. This covers the variety of communities' of organisms within particular habitats as well as the physical conditions under which they live. Ecosystem diversity is harder to measure than species or genetic diversity because

the "boundaries" of communities -- associations of species -- and ecosystems are elusive. Nevertheless, as long as a consistent set of criteria is used to define communities and ecosystems, their number and distribution can be measured. Until now, such schemes have been applied mainly at national and sub-national levels, though some coarse global classifications have been made. Besides ecosystem diversity, many other expressions of biodiversity can be important. These include:

- The relative abundance of species,
- The age structure of populations,
- The pattern of communities in a region,
- Changes in community composition and structure over time, and ecological processes as predation, parasitism, and mutualism.

More generally, to meet specific management or policy goals, it is often important to examine not only compositional diversity -- genes, species, and ecosystems -- but also diversity in ecosystem structure and function.

3. NEED AND SCOPE

When dams are built, water is impounded on the upstream. This often leads to submergence of fertile agricultural land, forests, and riparian areas. As dams alter the water flow regimes, upstream and downstream riparian ecology is altered. On the upstream, lentic (free flowing) aquatic ecosystems are converted to lotic (static) reservoirs altering the physico-chemical and ecological characteristics. On the downstream, restricted and reduced water flows effect the riparian ecosystem characteristics. Dams limit freshwater flows into the river mouth that will have an impact on the estuarine ecosystem composition and characteristics. All these changes have an impact (either positive or negative) on the biodiversity present in these ecosystems.

Depending on the scale, dam building has the potential to alter the characteristics of riparian, terrestrial and estuarine ecosystems at local, regional and landscape levels. As biodiversity is crucial for sustenance and development of human race, it is imperative to understand the impacts of dams on biodiversity at genetic, species and ecosystem levels. An ideal impact assessment study should attempt to capture all these elements in real time and should have the capability to predict the future scenarios.

In this review paper an attempt is made to address the following issues:

1. Analysis of dam distribution by major biotypes to identify where dams have had most impact on significant biodiversity and endangered species.
2. Summarize trends and statistics in environmental impacts of dams and their consequential impact on biodiversity.
3. Characterize the nature of impacts of dams on ecosystem structure and functions and services
4. Review existing EIA framework to assess its capability and adequacy to address issues related to biodiversity. Examine Indian EIA process vis-à-vis international conventions and guidelines like Convention on Biological Diversity.
5. Suggest policy responses and institutional mechanisms that are needed to internalize the biodiversity impact externalities of large dams in India.

4. METHODOLOGY

This paper depends on the secondary sources of information and on the information contained in the *"Environmental and Social Impacts of Large Dams: The Indian Experience"* prepared for the World Commission on Dams (Singh et.al, 2000). Singh *et.al* (2000) analyzed 22 EIA reports in India and reported impacts on biodiversity.
Further, specific case studies related to 6 dam projects are analyzed for methodology, scope and level of coverage, impact identification, prediction capabilities and suggested mitigation strategies.

5. CHARACTERISTICS AND NATURE OF IMPACTS OF DAMS

The environmental impacts of dams vary considerably depending on the size of the dam, the characteristics of the reservoir, and site specificity such as topography, river flow, climate, ecology and land use. The objective of this review paper is not to review the range of environmental impacts associated with large dam projects but is limited to the impacts on biodiversity.

The creation of a reservoir (impoundment area), as well as the existence of a large body of water, affects the local environment. The most important impacts are outlined in the **Box** below.

Impacts of Large Dams on the Environment

I*mpacts due to the presence of a dam and reservoir:*

1. Creation of static water body that replaces a free flowing river
2. Inundation of valleys that submerge agricultural land, forests, habitations
3. Accelerated sedimentation due to altered land use pattern
4. Changes in downstream morphology of riverbed and banks, delta, estuary and coastline due to altered sediment load.
5. Changes in downstream water quality: effects on river temperature, nutrient load, dissolved gases, concentration of metals and minerals.
6. Reduction of biodiversity due to the blocking of the movement of organisms and because of changes 1, 2, 3, 4, 5 and 6.

impacts due to the pattern of dam operation:

1. Changes in downstream hydrology – change in total flows; change in seasonal timing of flows; short-term fluctuations in flow; and change in extreme high and low flows.
2. Changes in downstream morphology caused by altered flow pattern.
3. Changes in downstream water quality caused by altered flow pattern.
4. Reduction in riverine/riparian/floodplain habitat diversity, especially, because of elimination of floods.

When reservoirs are created, large areas of forests and land, including agricultural lands, are flooded. Such areas often include wetlands, which are important wildlife habitats, and low-lying flood plains, which are often fertile croplands. Flooding of forestland also means the loss of species and habitat diversity. The biodiversity impacts of dams can be broadly classified into 5 categories:

- ✓ Impact on aquatic ecosystems
- ✓ Impact on terrestrial ecosystems
- ✓ Impact on agricultural biodiversity
- ✓ Impact on micro climate; and
- ✓ Impact on ecosystem services

5.1 Impact on aquatic ecosystems and biodiversity

Reservoir creation will have many effects on water quality, including:

- Reduction in oxygen content and gas release (methane, sulphuretted hydrogen). Anaerobic decomposition of inundated vegetation consumes large amounts of oxygen and produces noxious gases that are toxic to aquatic life.
- Slow water flow can lead to thermal stratification, with warm water on top and cold water underneath. Since the cold water is not exposed to the surface, it loses oxygen and becomes uninhabitable for fish.

- Habitats for fish that feed / spawn in the river bottom, and for invertebrates such as insects, mollusks and crustaceans, are reduced or destroyed by intense flooding and depletion of riverbed gravel.
- Construction activities, including the diversion of the river through a tunnel, cause major disturbances and have adverse impacts on the aquatic ecosystem. In many cases, vulnerable species, with either limited distribution or low tolerance, become extinct even before the dam is completed.

One rapid EIA study reported only one fish species in a Ravi river stretch of 18.5 km (3.5 km submergence + 15 km downstream). This looks highly improbable and might be due to the "rapid" nature of the study. The local villagers reportedly have seen otters in 1992-93. The report says, "Otters appear to have become locally extinct" by 1998. A more systemic analysis would have ascertained the reasons for local extinction viz. is it due to pre-dam construction activities that altered the habitat characteristics?

Source: EIA technical report no. 23 (1998). Wildlife Institute of India, Dehra Dun.

Even after the construction of the dam, there can be various adverse impacts of the dam on aquatic ecosystems. The blocking of a river and the formation of a lake significantly alters the ecological conditions of the river, adversely impacting on the species and ecosystem. There are changes in pressure, temperature, and oxygen levels and even in the chemical and physical characteristics of the water. Besides, by interrupting the flow of water, ecological continuity is broken. This is most obvious in the case of those species of fish whose passage up to their breeding grounds is blocked by the dam. However, all other species get affected, though not always so dramatically.

5.2 Impact on terrestrial ecosystems and biodiversity

India has a total of 89,451 animal species accounting for 7.31% of the faunal species in the world (MoEF 1997) and the flora accounts for 10.78% of the global total. The endemism of Indian biodiversity is high - about 33% of the country's recorded flora are endemic to the country and are concentrated mainly in the North-East, Western Ghats, North-West Himalayas and the Andaman and Nicobar islands.

Dams impact terrestrial biodiversity in three basic ways a) Habitat loss b) Habitat fragmentation c) Cumulative impacts.

The major proximate causes of species extinction are habitat loss and degradation affecting 89 percent of all threatened birds, 83 percent of mammals and 91 percent of all threatened plants assessed globally (IUCN 2000). The main causes of habitat loss are agricultural activities, extraction (including mining, fishing, logging and harvesting) and development (human settlements, industry and associated infrastructure). The construction of a storage dam and subsequent inundation of the reservoir area effectively leads to irrevocable loss of habitat. Large-scale impoundments may eliminate unique wildlife habitats and affect populations of all species. Along with the ecosystems, the biodiversity in them is most often wiped out or in some cases may displace few species. Habitat loss and fragmentation leads to the formation of isolated, small, scattered populations. These small populations are increasingly vulnerable to inbreeding depression, high infant mortality and susceptible to environmental stochasticity, and consequently, in the end, possible extinction. Changes in forest composition and quality, and the resultant habitat type lead to declines in primary food species for wildlife.

The underlying causes of biodiversity loss, however, are poverty, macroeconomic policies, international trade factors, policy failures, poor environmental law/weak enforcement, unsustainable development projects and lack of local control over resources (Wood et al 2001). Population pressures and concomitant increases in the collection of fuelwood and fodder, and grazing in forests by local communities too take their toll on the forests, and consequently its biodiversity.

Most often when a river valley development is planned, it involves construction of a series of dams. For example, the Narmada valley development envisages construction of 30 major dams, 135 medium dams and over 3000 minor schemes along the course of the main river and its tributaries. This water management plan of mammoth proportions will alter the river valley ecology, land use and economy irrevocably. However, as the impact assessments and mitigation strategies are conducted for a single project at a time, most often, the interlinkages and the cumulative impacts at macro landscape level are missed out. The mitigations planned at a project level are ultimately ineffectual at a macro level.

There are secondary impacts associated with dams, which also get rarely quantified and reported. For example, the disturbance caused by the pre dam construction

activities, including the noise and vehicular movement, building of roads, extraction of stone and soil, construction of buildings, etc. negatively impact on biodiversity at and around the project site. Similarly, construction of irrigation infrastructure may have many secondary impacts. Land use changes provoked by dams not only have direct negative impact in terms of habitat loss, elimination of flora and fauna and, in many cases, land degradation, but also feedback effects on the reservoir through alterations in hydrologic function. The loss of vegetative cover leads to increases in sedimentation, storm flow, and annual water yield; decreases in water quality; and variable changes in the seasonal timing of water yield.

Secondary impact identification and mitigation is most often out side the preview and scope of the current EIA reports.

5.3 Impacts on agricultural biodiversity

Reservoirs often submerge productive agricultural land. This will have an associated social and economic cost but will also adversely affect agricultural biodiversity. Endemic species of cultivable plants, domestic fauna and gene pools might be irrevocably lost, before their full potential is realized. A host of birds, insects, mammals and reptiles that are dependent on agricultural ecosystems also are negatively impacted in the process. In many cases, traditional crop varieties and methods of cultivation might disappear because of the submergence of agricultural lands. The EIA reports in India have so far ignored this component of biodiversity and concentrated more on the “wild” biodiversity – that too in a narrow sense of larger and charismatic wildlife forms.

5.4 Impacts on micro climate

The existence of a reservoir and the resultant changes in temperature and humidity can negatively impact the biodiversity of a region, which otherwise might be naturally adapted to a warmer and dryer climate. This aspect has also not been looked at in any of the dams studied.

5.5 Impact on ecosystem services

There is a growing awareness about the importance of maintaining a high level of biodiversity in ecosystems in the context of the ecosystem services that they provide. Ecosystem services are the services generated as a result of interaction and exchange between biotic and abiotic components of ecosystems. The ecosystem

services include numerous invisible but essential services viz., soil formation and fertility generation, reduction of soil salinity, decomposition and waste dissipation, biomass productivity, carbon sequestration and atmospheric gases balance, stabilization of climate and mitigation of climate change, nutrient cycling, maintenance and raising of water table, enhancement of water and air quality, food and drought control. It is realized that it is the poor and the marginalized stakeholders that benefit most from these ecosystem services.

The economic value of ecosystem services and components of biodiversity is estimated at US $ 33 trillion, which is around 1.8 times more than the global gross national product.

When dams are built, along with the ecosystems, the silent services the ecosystems provide are irrevocably lost. While the benefits of dams flow to a small segment of the society, it is the society at large that bears the losses of these ecosystem services – raising the issue of equity and benefit sharing.

None of the EIA studies in India have addressed the issue of “ecosystem services” and none of the studies tried to value (in economic terms) the ecosystem services loss due to dam building. The economic value of ecosystem services loss / or the costs of alternates provision is not taken in to account while computing the benefit cost analysis of dams. This is a major gap in conceptual and methodological aspect of current EIA process.

6 TRENDS AND STATISTICS IN BIODIVERSITY IMPACTS OF DAMS

The decadal construction rate of large dam in India and their state wise distribution is shown in **Figure 1 & 2**. The three states of Maharashtra, Madhya Pradesh and Gujarat have 3159 large dams (2641 commissioned and 518 under construction), which is 74% of the total large dams (4291) in India **(Figure 2)**.

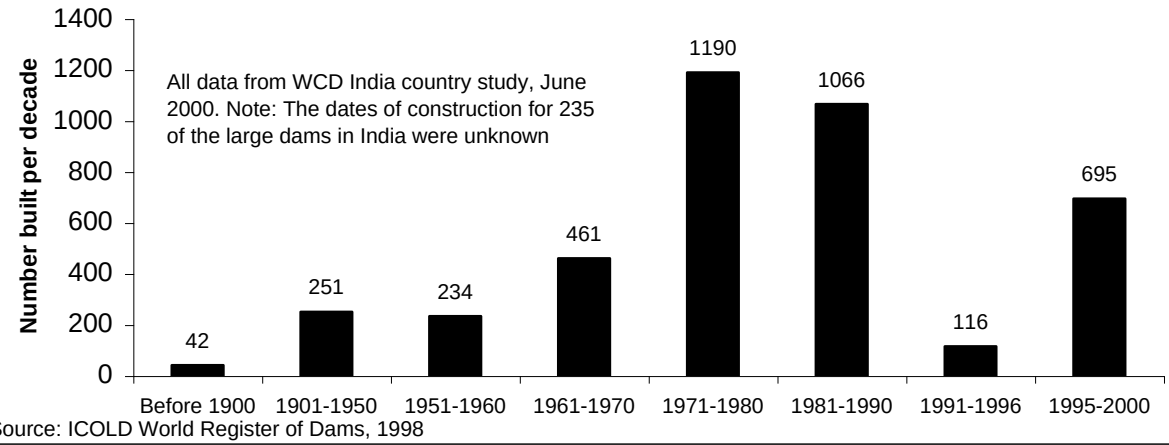
Exact figures on forest loss due to dam construction are not available. It is reported that by 1980, India had lost about 500,000 hectares of forest due to construction of 2178 dams. Singh et.al (2000) have estimated that the forest loss due to dams (completed or under construction after 1980) to be any where between 4.5 to 9.1 million hectares. Even if we consider the lower estimate, a staggering 5 million hectares of forestland could have been lost due to dam construction.

All the existing and under construction dams in India are roughly classified to determine the biogeographic zones that they represent **(Table 1).** This is a crude

classification as coordinates of dams are not available. Deccan Peninsula biogeographic zone has maximum dams, 3268 of them (76% of the total). Gangetic Plains has 266 (6%) and North-East (0.4%) of dams.

The 61 dams (**Table 2**) for which land submergence and rough coordinates are available, are classified into the broad biogeographic zones that they fall under after Rodgers *et.al.,* 2000. 32 of the 61 dams fall under Deccan Peninsula biogeographic zone, 10 are in Semi arid/arid zone, 7 in Gangetic plains and 4 in North East biogeographic zone. About 2 million hectares of land was submerged due to creation of reservoirs by these 61 dams. 5,81,912 hectares (29%) of this submerged land was forest area. 27 Dams in Gujarat, Maharashtra and Madhya Pradesh out of the 61 dams, accounted for 22% (4,38,099 ha) of the total submergence area and 25% of the total forest area. Dams in Deccan Peninsula account for 32% of the total submergence area and 32% of the forest submergence area as well.

Figure 1: Dams Commissioned by Decade in India



Source: ICOLD World Register of Dams, 1998

Figure 2: State wise distribution of Dams in India

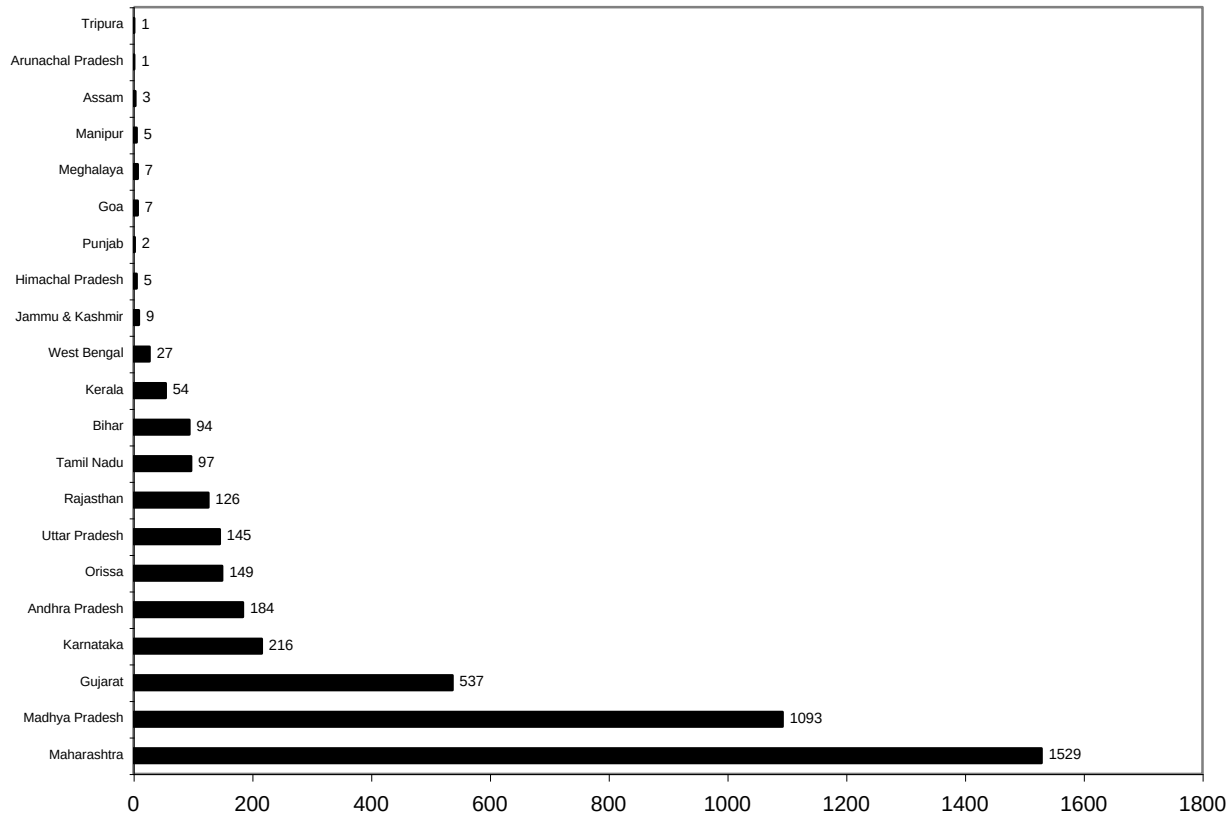


Table2: Forest area submerged by 61 dams

State	Biogeographic zone	Number of dams for which data is available	Total submergence area	Forest area Submerged	Forest area as % of total submergence area	Forest area diverted for dam related activities
Indeterminate		3	51,890	37,450	72.17	0
	Indeterminate	**3**	**51890**	**37450**	**72**	
Andhra Pradesh	Deccan Peninsula	4	161,111	14,754	9.15	29116
Karnataka	Deccan Peninsula	4	97,416	14711	15.10	0
Madhya Pradesh	Deccan Peninsula	9	250,223	81,212	32.45	319
Maharahtra	Deccan Peninsula	11	43,097	8869	20.57	457
Orissa	Deccan Peninsula	4	97,388	29,798	30.59	46122
	Deccan Peninsula	**32**	**649235**	**186794**	**29**	**76014**
Bihar	Gangetic plain	1	17,409	1,060	6.08	-
Uttar Pradesh	Gangetic Plain	6	39,500	13536	34.27	2442
	Gangetic Plain	**7**	**56909**	**14596**	**26**	**2442**
Himachal	Himalaya	4	18,246	6,821	37.38	36
	Himalaya	**4**	**18246**	**6821**	**37**	**36**
North-East (Manipur, Mizoram, Sikkim)	North East	4	52,979	21,630	40.82	1646
	North East	**4**	**52979**	**21630**	**41**	**1646**
Gujarat	Semi arid	7	144,779	55,615	38.41	-
Rajasthan	Semi arid/Arid	3	45,286	7268	16.05	-
	Semi arid/Arid	**10**	**190065**	**62883**	**33**	
Kerala	Western Ghats	1	5,000	5,000	100	-
	Western Ghats	**1**	**5000**	**5000**	**100**	
Total		**61**	**20,09,148**	**5,81,912**	**28.96**	**80,138**

Table 1 Biogeographic zone wise distribution of dams in India

State	Biogiographic zone *	Completed	Under Construction	Total Existing
India		**3596**	**695**	**4291**
Maharashtra	Deccan Peninsula	1229	300	1529
Madhya Pradesh	Deccan Peninsula	946	147	1093
Karnataka	Deccan Peninsula	188	28	216
Andhra Pradesh	Deccan Peninsula	158	26	184
Orissa	Deccan Peninsula	131	18	149
Tamil Nadu	Deccan Peninsula	84	13	97
Deccan Peninsula		**2736**	**532**	**3268**
West Bengal	Gangetic plains	22	5	27
Uttar Pradesh	Gangetic Plans	123	22	145
Bihar	Gengetic Plains	61	33	94
Gangetic Plains		**206**	**60**	**266**
Himachal Pradesh	Himalaya	4	1	5
Punjab	Himalaya	1	1	2
Himalaya		**5**	**2**	**7**
Assam	North –East	2	1	3
Arunachal Pradesh	North –East	0	1	1
Meghalaya	North-East	6	1	7
Manipur	North-east	2	3	5
Tripura	North-East	1	0	1
North-East		**11**	**6**	**17**
Gujarat	Semi Arid/Arid	466	71	537
Rajasthan	Semi Arid/Arid	122	4	126
Semi - Arid		588	75	663
Jammu & Kashmir	Trans Himalaya	7	2	9
Trans Himalaya		**7**	**2**	**9**
Kerala	Western Ghats	38	16	54
Goa	Western Ghats	5	2	7
Western Ghats		**43**	**18**	**61**

* This classification is tentative as data on coordinates of the dams are not available.

Apart from forests, the reservoir and the dams also affect other ecosystems and various fauna and flora species. Unfortunately, till recently, there was little effort to assess the impact on flora and fauna and on non-forest ecosystems.

After analyzing data from 60 dams, Singh et.al (2000) reported that information on the impact on flora and fauna was available in 22 cases. Of these 22, 10 stated that there was no adverse impact on the flora and fauna, primarily because there were no 'valuable wildlife' in the submergence area. In 12 cases it was stated that important forestland will be destroyed and important species or ecosystems will suffer damage.

The 6 case studies that were analyzed for this paper, 4 reported that considerable wildlife values exist in the impact areas, but none of them is valuable enough to stop dam construction. The common reason cited in the four reports is that "no threatened or endangered or endemic" species are found in the impact zones, so it is fine to construct the dams. Two of the studies said "NO" to the dam because of the highly endangered and endemic species found in the impact area (Bodhghat dam where wild buffalo is found and Puyankutty dam where a large number of endemic and threatened species of plants and mammals are found.

The Puyankutty Hydroelectric Project Stage I

The project

The project envisages construction of two dams in Idukki district of kerala, with a total submergence (reservoir) area of 2800 ha (1900 ha forest land (68%), 670 ha shrubs, fallow and grassland (24%), 30 ha wetland (1%), and 30 ha of cultivated land).

Scope of the study

Threatened plants and animals of the area and their endemicity; population studies of economic plants of the area and adequacy of mitigatory measures; elephant population in the study area, their corridors and likely impact on them.

Study area

Constitute the project location and an area within 10 km radius from it (@314 km^2).

Methodology

Over a one-year period (summer, monsoon, winter) the study used the following standard methods to study different taxa as under:

- ✓ *Plant: Quadrat sampling and enumeration*
- ✓ *Butterfly: Transect counting*
- ✓ *Fish: Cast net, gill net, traps*
- ✓ *Amphibians: Visual encounter survey (search)*
- ✓ *Reptile: Visual encounter survey (search)*
- ✓ *Bird: Line transects, ramdom walk*
- ✓ *Mammal: quadrat smapling, tracks and signs, and visual encounter survery.*

Findings

The study reports that the area is rich with 289 vertebrates (34 fish; 22 amphibians, 43 reptiles, 168 birds, 22 mammals) and has high levels of endemism (2 fish, 11 amphibian, 10

reptile, 11 birds and 2 mammals. The study also reports 61 plants endemic to the Western Ghats and Peninsular India (35 trees; 8 herbs, 11 shrubs; 6 epiphytes and 1 climber).

Impact identification and recommendation

The study concludes that mitigation of the impacts on endemic plants and vertebrates is not feasible and says NO to the dam. Further, the study recommends that the entire area have to be preserved for posterity at all costs.

Source: PA Azeez, Bhupathy S, A Rajasekaran, PR Arun, D Stephen and P Kannan (1999). **"Comprehensive Environmental Impact Assessment (Botanical and Zoological aspects) of the Proposed Puyankutty Hydroelectric Project, Kerala".** Salim Ali Centre for Ornithology & Natural History, Coimbatore.

Bodhghat Hydel Project

The project

The project envisages construction of a composite 1720 m long hydroelectric dam on Indravati river in Bastar district of Madhya Pradesh State (now in Chattisgarh). Total submergence area is 13783.14 ha of which 5704.3 ha is forest land.

Scope of the study

Vegetation components, status of wildlife, dependence of local communities on submergence area forests were studied.

Study area

The study area constituted the project location, submergence area, downstream areas, access sites and areas immediately outside the submergence area.

Methodology

Over a one-year period (summer, monsoon, winter) the study used the following standard methods to study different taxa as under:

- ✓ *Vegetation: Line transects, quadrat sampling and enumeration*
- ✓ *Wildlife: Line transects, tracks and signs, and visual encounter survery.*

Findings

The study reports 181 plants (98 trees, 40 shrubs, 24 herbs, 17 climbers). 13 species of mammals, 7 species of reptiles, 12 species of fish and 127 species of birds are reported.

Impact identification and recommendation

The study concludes that impacts on flora and fauna are substantial and any amount of compensatory afforestation cannot offset the loss of biological values. The study says NO to the dam on 3 counts: destruction of genetically pure central Indian wild buffalo habitat; social concerns for the PAPs; and landscape ecology.

Comment:

The study goes beyond project specific impact assessment and takes other proposed downstrem dams (Kutru I&II, Nugur I&II and Bhopalapatnam) into consideration while giving its recommendation. This is a good example of a EIA study at a landscape level. However, the inferences are qualitative in nature.

Source: Panwar H.S., Rajavanshi A, Gautam P, Muraleedharan V.V and Rastogi A (1990). **"A study of impacts of Bodhghat hydel project upon wildlife and related human aspects with special reference to wild buffalo conservation in Bastar".** Wildlfie Institute of India, Dehra Dun.

The EIA studies on fauna and flora have been inadequate on many counts:

1. There is almost no study on the cumulative impact of any dam on the full range of biodiversity values at genetic, species and ecosystems level.
2. The studies are project specific, where as the impacts occur at landscape level.

3. The ecosystem services loss due to dam construction is not quantified in any of the EIA reports.
4. There is no mention of agricultural biodiversity in any of the dams that were studied. This might mean that many genetic strains of endemic crop varieties might have been lost due to dams.
5. Similarly, many species of lesser-known taxa like invertebrates, algae, fungi, bacteria, insects would have been lost, even before their ecological and economic values are recorded and realized. The Tehri Dam studies conducted by Zoological Survery of India and Botanical Survey of India, to some extent address the complete range of taxonomic spectrum. This could be due to the inherent strength of these two institutions. However, their impact identification, prediction and mitigation planning strengths are poor.

Tehri Dam: Environmental Impact Assessment Study – Faunal Analysis

The project

The project envisages construction of a earth and rock filled dam across the river Bhagirathi. Reservoir area of the dam is 42 km^2.

Scope of the study

status of fauna in the submergence area, action plan for conservation of rare species, detail adverse impacts on the wildlife habitats.

Study area

The study area constituted the project location, and submergence and above submergence areas.

Methodology

Five faunal surveys of 10 days duration each between May-October 1992. Road transects were used to collect evidence / specimens. The different groups covered are as under:

- ✓ *Mammals*
- ✓ *Aves*
- ✓ *Reptiles*
- ✓ *Amphibia*
- ✓ *Pisces*
- ✓ *Insects belonging to Lepidoptera (butterflies), odonata (dragonflies), hymenoptera (wasps and bees)*
- ✓ *Arthropods (Arachnida – spiders and scorpions), and (myriapoda – centipedes).*

Findings

The study reports 18 species of mammals (16 from submergence area); 73 birds (54 from submergence); 10 species of reptiles (8 from submergence); 9 species of amphibians; 10 species of fish (6 in submergence); 81 species of lepidopeterans, 29 species belonging to odonata; 24 hymenopterans; 23 arachnids; and 4 species of myriapods (2 confirmed, 2 assumed to be present).

Impact identification and recommendation

The study concludes most of the species found in the submergence area are widely distributed in the region. No noticeable adverse impacts are predicted. Fish ladders are suggested to facilitate fish migration.

Comments:

The study prepared, by far, the widest checklist of both vertebrate and invertebrate fauna.

This indicates the intricate strength of the study team interms of taxonomy. However, the report lacks in depth discussion on impact prediction and mitigation planning.

Source: Arora G.S, Kumar A, Husain A. **Environmental Imapct Assessment Study: Faunal Analysis. (not dated)** . Zoological Suvery of India, Northern Regional Station, Dehra Dun.

Vegetation of the Tehri Dam Submersible Area: An Environmental Impact Assessment

The project

The project envisages construction of a earth and rock filled dam across the river Bhagirathi. Reservoir area of the dam is 42 km^2.

Scope of the study

Status of vegetation in the submergence area

Study area

The study area constituted the project location, and submergence area.

Methodology

✓ *Three plant collection tours and earlier surveys of BSI.*

Findings

The study reports 672 plant species of phanorogams (116 families and 474 genera); 34 taxa of pteridophytes; 19 taxa of bryophytes; 7 taxa of lichens; 11 taxa of fungi and 21 taxa of algae.

Impact identification and recommendation

The study concludes most of the species found in the submergence area are widely distributed in the region. No noticeable adverse impacts are predicted. Afforestation programme for local species is suggested.

Comments:

The study prepared, by far, the widest checklist of flora. This indicates the intricate strength of the study team interms of taxonomy. However, the report lacks in depth discussion on impact prediction and mitigation planning.

Source: Uniyal B.P. and Singh S (1993). Vegetation of the Tehri Dam Submersible Area: An Environmental Impact assessment. Zoological Suvery of India, Northern Circle, Dehra Dun.

6. Post project monitoring on the status of wildlife, to assess the effectiveness of mitigation strategies and to check the veracity of the estimates of impact done prior to construction is missing.
7. There is a tendency to consider only large mammals as ‘wildlife’, despite the fact that the Wildlife (Protection) Act of 1972 includes all wild fauna and flora into the meaning of wildlife.
8. There has been a stress on ‘valuable’ or charismatic species, which often means the more prominent or visible species. However, some of the less visible species might actually be even more important to conserve.
9. There is also a tendency to focus only on endangered species. Being concerned only about endangered species results in other species also becoming, over time, endangered. Besides, the endangered status is usually applied to species that

are nationally or globally endangered. If a proper survey is not carried out it can never be determined which of them were locally endangered and, therefore, requiring protection.

Mitigation planning:

Some large dam projects have tried to mitigate terrestrial impacts on biodiversity by physically rescuing animals from the area to be flooded or by anticipating that mobile species will simply move to neighboring areas. This latter model is proposed for the ongoing Indira Sagar Dam on Narmada in Madhya Pradesh. A National Park and two Sanctuaries in the immediate catchment were proposed. Creation of forest-protected areas in the immediate catchment has the potential to benefit the lifespan of the dam through reduced sedimentation. These protected areas can also be justified on the basis that they help in *in-situ* conservation of representative biodiversity that is impacted by the dam. However, creation of such protected areas cannot be justified on the premise that they will provide refuge to the wildlife displaced from the reservoir created by the dam. At the most, few big and mobile species (mammals, birds) might ultimately migrate to these refuge areas, provided, the distances are small and an undisturbed corridor connects these two. But it is to be realized that a greater percentage of biodiversity, representing amphibians, reptiles, insects, and microorganisms, is not equipped by nature to undertake such migration, and the impacts on them are irreversibly negative when dams submerge habitats.

Narmada Sagar and Omkareshwar Hydroelectric Projects

The project

The project envisages construction of two dams (Narmada Sagar and Omkareshwar) on Narmada river in Khandwa district of Madhya Pradesh. Total submergence area is 100741 ha of which 45609 ha is forest land.

Scope of the study

The scope of the study is: baseline status of biological and socioeconomic values, ethnobotanical values, habitat use by bird communities, identify impacts on flora and fauna, identify areas for designation as protected areas, devise special measures for rare and endangered flora and fauna and suggest ameliorative measures.

Study area

The study area constituted the project location, submergence area, 1.5 km stretch around the submergence area (called impact zone), and contiguous forests around the impact zone. In all an area of around 80000 ha is studied.

Methodology

Over a three and half years, the study used the following standard methods to study different taxa as under:

- ✓ *Vegetation: Line transects, quadrat sampling and enumeration*
- ✓ *Large mammals: Line transects, vehicle census, tracks and signs, and visual encounter*

survey.

- ✓ *Birds: Line transects, visual encounter survey.*
- ✓ *Habitat quality: Line transects, quadrat sampling, Habitat Suitability Index (HSI) models,*

Findings

The study reports 369 plants (66 monocots, 300 dicots, and 3 pteridophytes). 30 species of mammals, 209 birds, 5 species of reptiles, and 30 species of fish.

Impact identification and recommendation

The study details primary and secondary impacts of the two dams on vegetation, terrestrial and aquatic mammals, avifauna, and wildlife habitats. The study recommends creation of three new protected areas (788.57km^2) in the immediate surrounds of the submergence area to mitigate the impacts and to conserve the biodiversity resources of the region.

Comments:

The study starts on a presumption that creating protected areas could mitigate the floral / faunal impacts of the two dams. This is a major limitation and drawback. The study employed rigorous field investigations and analytical techniques to identify the impacts and uses HSI models to predict the impacts on habitat quality. However, all this information is used only to justify the creation of the Protected Areas.

Source: WII (1994) **"Impact Assessment of Narmada Sagar and Omkareshwar Projects on Flora and Fauna with Attendant Human Aspects (1994**). WII – EIA Technical Report 9. Wildlife Institute of India, Dehra Dun.

7. REVIEW OF EIA PROCEDURES IN INDIA

7.1 Environmental Initiatives in India

The constitution of India includes statements about environmental protection *"the state shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country" (Article 48 A)*. The need to integrate environmental factors into the process of planned economic development is first officially voiced during the formulation of the fourth plan (1969-1974), which stated *"Planning for harmonious development is possible only on the basis of a comprehensive appraisal of environmental issues"*. The government has gradually furthered the aims of protecting the environment through institution building and strengthening; planning for environmental matters; and development of existing and new legislation and guidelines. Ministry of Environment and Forests (MoEF) has been set up at the national level in 1984, to exclusively deal with environment related issues. The MoEF is responsible for studying the causes and consequences of environmental degradation and establishing an environmental intelligence and early warning system; monitoring and controlling of air and water pollution; promoting EIA; encouraging eco-development and restoration of ecologically fragile ecosystems; protecting and conserving wildlife; establishing an environmental information system and data bank; promoting environmental research; and promoting international, regional and bilateral cooperation in environmental matters.

The environmental impact assessment in India was started in 1976-77 when the Planning Commission asked the then Department of Science and Technology to examine the river-valley projects from environmental angle. This was subsequently extended to cover those projects, which required approval of the Public Investment Board. These were administrative decisions, and lacked the legislative support. The Government of India enacted the Environment (Protection) Act on 23rd May 1986. To achieve the objectives of the Act, one of the decisions that were taken is to make environmental impact assessment statutory. After following the legal procedure, a notification was issued on 27th January 1994 and subsequently amended on 4th May 1994, 10th April 1997 and 27th January 2000, making environmental impact assessment statutory for 30 activities. This is the principal piece of legislation governing environmental impact assessment.

Besides this the Government of India under Environment (Protection) Act 1986 issued a number of other notifications, which are related to environmental impact assessment.

The history of environmental consideration in development planning and decision-making in India can broadly be divided into three periods:

1. Until 1972
2. 1972 to 1980, and
3. 1980 onwards

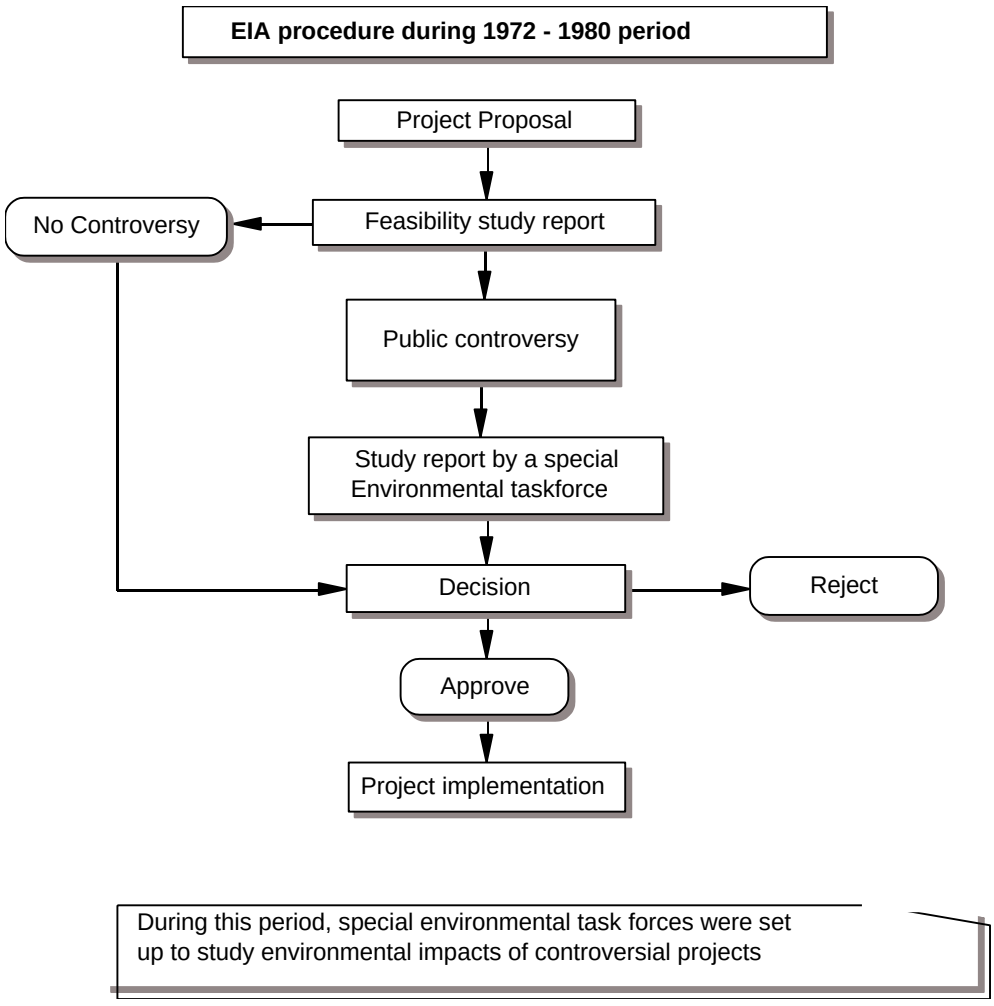
7.1.1 Period until 1972

Since independence in 1947, India pursued a policy of rapid technology-based economic growth in order to enhance quality of life and alleviate poverty. In the process, environmental degradation was not given due consideration. The only consideration in terms of environment is the immediate economic cost or the face value of the affected resources (like forest timber) and even the long-term and overall costs of them were not considered. There are cases of costly projects for which construction started even before the completion of Technical report, as in the case of Hirakud dam. The common practice was to reclaim land from forests to resettle project affected population. Increase in number of dam projects resulted in the settling of people in the peripheral forest-land nearer to the reservoirs which resulted in deforestation as well accelerated siltation of reservoirs. During this period there was no effective environmental legislation to protect the forests or wildlife from

alternative development options. The project cycle during this period is shown in **Figure 3.**

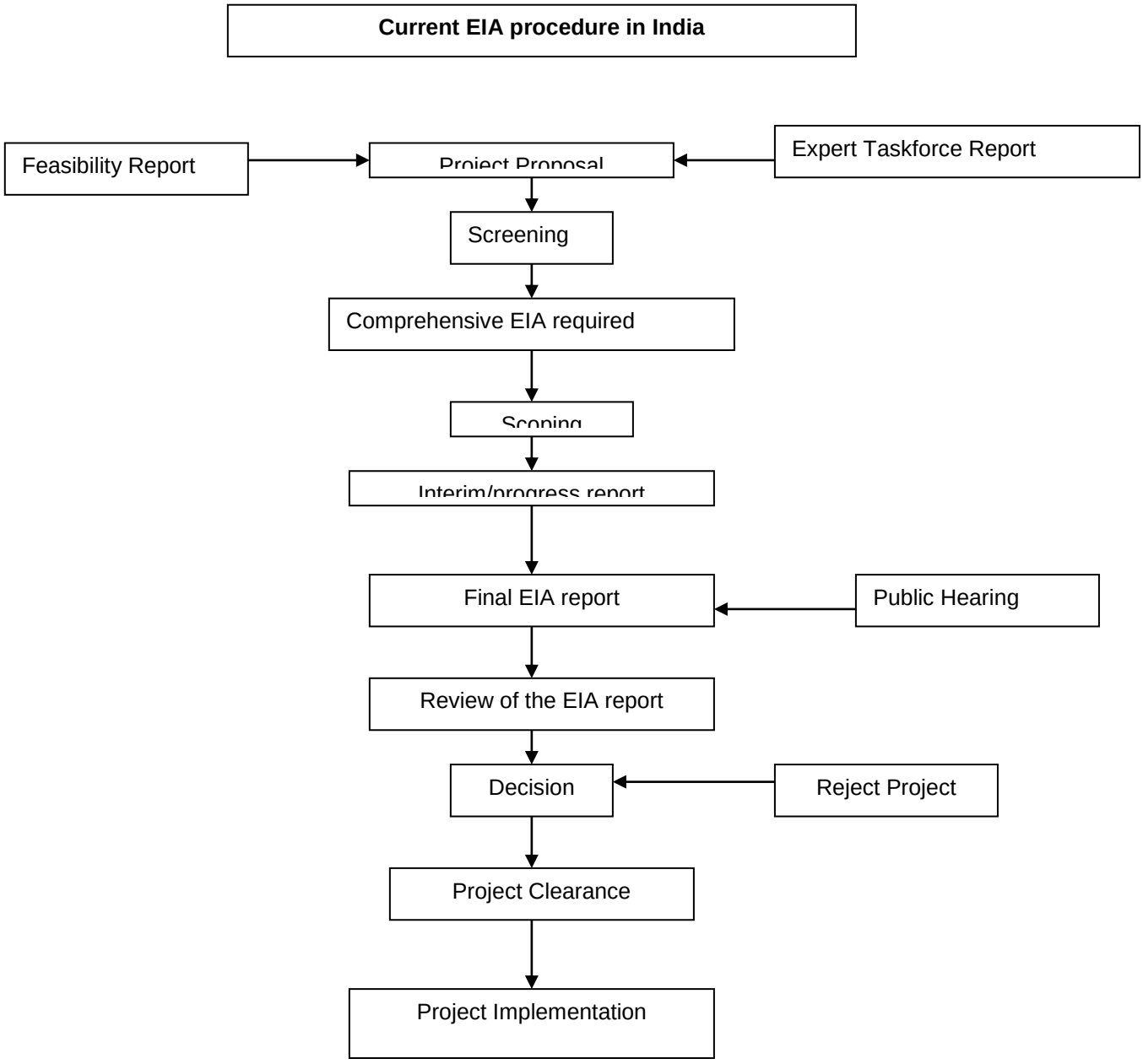
7.1.2 Period from 1972 to 1980

An environmental movement started in India since the Stockholm Conference in 1972. National Committee on Environmental Protection and Co-ordination (NCEPC) was formed that year. NCEPC tackled a number of complex national issues involving the environmental implications of development projects. Major environmental legislation such as the Wildlife (Protection) Act 1972, Water (Prevention and Control of Pollution) Act, 1974 were passed during this period. EIA for development projects was introduced in 1977. The procedure followed was simple: the projects that attract public criticism and agitation (controversy) are subjected to investigation by a special task force (with specialists in the environment field).



7.1.3 Post 1980

The Ministry of Environment and Forests was set up in 1984. Carrying out environmental appraisals of development projects is one of the primary responsibilities of this ministry. Important environmental legislations developed during this period are the Forest (conservation) Act, 1980; the Environment (protection) Act 1986 and Air (prevention and control of pollution) Amendment Acts 1981 and 1987. Ministry of Environment and Forests has issued important EIA and public hearing notifications from time to time ever since as under: Principal Notification - S.O. 60 (E) 27.01.1994; Amendments vide - S.O.356 (E) 04.05.1994; S.O. 318 (E) 10.04.1997; S.O.73 (E) 27.01.2000; S.O.1119 (E) 13.12.2000; S.O.737 (E) 1.08.2001; and S.O.1148 (E) 21.11.2001.



7.2 The EIA Cycle and Procedures

Impact Assessment Authority (IAA) in MoEF is responsible for overseeing the EIA process. IAA which has a multi-disciplinary base, carries the tasks with the help of an inter-ministerial appraisal committee consisting of experts from related disciplines like civil and mining engineering, landscape and human settlement planning, instrumentation, pollution control, ecology, forestry and environmental sciences etc.

The EIA process in India is made up of the following phases:

7.2.1 Screening

Screening is done to see whether a project requires environmental clearance as per the statutory notifications. Screening Criteria are based upon:

- Scales of investment;
- Type of development; and,
- Location of development.

A Project requires statutory environmental clearance only if the provisions of EIA notification and/or one or more statutory notification mentioned cover it.

7.2.2 Scoping and consideration of alternatives

Scoping is a process of detailing the terms of reference of EIA. It has to be done by the consultant in consultation with the project proponent and guidance, if need be, from Impact Assessment Agency.

The Ministry of Environment and Forests has published guidelines for different sectors, which outline the significant issues to be addressed in the EIA studies. Quantifiable impacts are to be assessed on the basis of magnitude, prevalence, frequency and duration and non-quantifiable impacts (such as aesthetic or recreational value), significance is commonly determined through the socio-economic criteria. After the areas, where the project could have significant impact, are identified, the baseline status of these should be monitored and then the likely changes in these on account of the construction and operation of the proposed project should be predicted.

7.2.3 Baseline data collection

Baseline data describes the existing environmental status of the identified study area. The site-specific primary data should be monitored for the identified parameters and supplemented by secondary data if available.

7.2.4 Impact prediction

Impact prediction is a way of 'mapping' the environmental consequences of the significant aspects of the project and its alternatives. Environmental impact can never be predicted with absolute certainty and this is all the more reason to consider all possible factors and take all possible precautions for reducing the degree of uncertainty. The following biodiversity related impacts of the project should be assessed:

- Deforestation/tree-cutting and shrinkage of animal habitat.
- Impact on fauna and flora (including aquatic species if any) due to contaminants/pollutants
- Impact on rare and endangered species, endemic species, and migratory path/route of animals.
- Impact on breeding and nesting grounds

7.2.5 Assessment of alternatives, delineation of mitigation measurements and environmental Impact statement

For every project, possible alternatives should be identified and environmental attributes compared. Alternatives should cover both project location and process technologies. Alternatives should consider 'no project' option also. Alternatives should then be ranked for selection of the best environmental option for optimum economic benefits to the community at large.

Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements. The EMP is a crucial input to monitoring the clearance conditions and therefore details of monitoring should be included in the EMP.

An EIA report should provide clear information to the decision-maker on the different environmental scenarios without the project, with the project and with project alternatives. Uncertainties should be clearly reflected in the EIA report.

7.2.6 Public hearing

Law requires that the public must be informed and consulted on a proposed

development after the completion of EIA report. Any one likely to be affected by the proposed project is entitled to have access to the Executive Summary of the EIA. The affected persons may include:

- Bonafide local residents;
- Local associations;
- Environmental groups: active in the area
- Any other person located at the project site / sites of displacement

They are to be given an opportunity to make oral/written suggestions to the State Pollution Control Board.

7.2.7 Decision Making

Decision making process involves consultation between the project proponent (assisted by a consultant) and the impact assessment authority (assisted by an expert group if necessary). The decision on environmental clearance is arrived at through a number of steps including evaluation of EIA and Environmental Management Plan (EMP).

7.2.8 Monitoring the clearance conditions

Monitoring should be done during both construction and operation phases of a project. This is not only to ensure that the commitments made are complied with but also to observe whether the predictions made in the EIA reports were correct or not. Where the impacts exceed the predicted levels, corrective action should be taken. Monitoring will enable the regulatory agency to review the validity of predictions and the conditions of implementation of the EMP.

The difference between **Comprehensive** EIA and **Rapid** EIA is in the time-scale of the data supplied. Rapid EIA is for speedier appraisal process. While both types of EIA require inclusion/ coverage of all significant environmental impacts and their mitigation, Rapid EIA achieves this through the collection of 'one season' (other than monsoon) data only to reduce the time required. This is acceptable if it does not compromise on the quality of decision-making. The review of Rapid EIA submissions will show whether a comprehensive EIA is warranted or not.

It is, therefore, clear that the submission of a professionally prepared Comprehensive EIA in the first instance would generally be the more efficient approach. Depending on nature, location and scale of the project EIA report should contain all or some of the

following components related to biological environment.

- Survey of flora and fauna clearly delineating season and duration.
- Assessment of flora and fauna present within the impact zone of the project
- Assessment of potential damage to terrestrial and aquatic flora and fauna due to discharge of effluents and gaseous emissions from the project
- Assessment of damage to terrestrial flora and fauna due to air pollution, and land use and landscape changes
- Assessment of damage to aquatic and marine flora and fauna (including commercial fishing) due to physical disturbances and alterations
- Prediction of biological stresses within the impact zone of the proposed project
- Delineation of mitigation measures to prevent and / or reduce the damage.

NOTE: The word "BIODIVERSITY" does not appear anywhere in the EIA notification or the EIA manual prepared by the MoEF. There is no direct reference to ECOSYSTEM or ECOSYSTEM SERVICE LOSSES.

7.3 EIA Studies in India

There are mainly three kinds of EIA studies that are conducted in India.

1. EIA reports that are submitted by project proponents as a mandatory requirement,
2. EIA reports from studies mostly funded by the MoEF and conducted by academic community; and
3. Reports prepared by voluntary private organizations and / or academic institution on the basis of their research work.

More than a thousand EIA reports of the first kind were submitted to the MoEF. Among the development activities the river valley projects are the largest in number. These voluminous reports are prepared by the project proponents, and deal extensively with technical details. The main purpose of such reports is to get the project proposal approved. Therefore most of these reports portray greatly biased evaluation so as to make the project appear viable.

More recent data (**Table 3**) indicates that between 1986 and 2001, the MoEF has received 276 fresh proposals to build river valley and hydroelectric projects, appraised 328 projects and EIA reports, cleared 149 projects and rejected 216.

Table 3: Status of River Valley and Hydroelectric Projects at MoEF

Year	Projects pending at the beginning of the year	Projects received during the year	Projects Appraised during the year	Projects cleared / exempted	Projects rejected	Additional information sought
1986				37		
1987	68	36	87	17	70	
1989	9	27	36	10	22	4
1990	4	41	45	15	26	4
1991	4	17	17	3	12	6
1.2.92 to 31.1.93	6	20	26	5	12	9
1.2.93 to 31.12.93	9	19	45	13	11	4
Jan – Dec 1994	4	31	47	8	16	11
Jan – Dec 1996	10	23	25	06	17	10
Jan – Dec 1997	10	13		04	06	
Jan – Dec 1998	13	13		9	10	
Jan – Dec 1999	07	08		05	06	
Jan – Dec 2000	04	10		05	04	
Jan – Dec 2001	04	18		12	04	
Total	152	276	328	149	216	48

Source: Various Annual Reports of the Ministry of Environment and Forests, Government of India.

8 IMPACT ASSESSMENT AND BIODIVERSITY – THE CHALLENGE

The impact assessment community is debating the implications of international obligations on biodiversity conservation for impact assessment. The impetus for this has come from the Convention on Biological Diversity (CBD) negotiated at the Earth Summit in Rio de Janeiro in 1992 and ratified by over 170 nations. The objectives of the CBD are to:

- Conserve biodiversity
- Use biological resources sustainably, and
- Equitably share the benefits arising from that use.

The CBD provides a strong international platform for applying impact assessment techniques to biodiversity conservation. It specifically calls for impact assessment measures to ensure that biodiversity is addressed in projects, plans and policy decisions (Article 14).

An underlying justification for the application of impact assessment is given in other articles, such as promoting the protection of ecosystems, natural habitats and

maintenance of viable populations, promoting environmentally sound and sustainable development in areas next to protected areas (Article 8); calling for the integration of biodiversity concerns into national decision making and the adoption of measures relating to the use of biological resources to avoid or minimize adverse impacts on biological diversity (Article 10).

One of the main tasks the CBD commits signatories to is preparing a biodiversity action plan. The National Biodiversity Strategy and Action Plan (NBSAP) under which this sub thematic review paper is prepared is to fulfill India's obligation under the CBD as a signatory state.

This paper argues that the CBD provides an opportunity to identify opportunities for enhancing the biological resource of habitats and species through EIA. Bagri and Vorhies, 1997 proposed a new impact assessment tool - Biodiversity Impact Assessment (BIA) as an extension of EIA. It is proposed to ensure that biodiversity issues are explicitly considered in impact assessments. Although a new tool may not be necessary, a serious review of existing tools is needed to ensure that the obligations of the CBD are met.

8.1 What is biodiversity impact assessment?

Full range of biodiversity and ecological impacts are not considered in Indian impact assessment studies. Where ecological impacts are included, these are often restricted to the results of brief habitat surveys and species lists. Often, the ecological information provided was so limited in quantity, or of such poor quality, that it was not possible to assess the ecological implications of proposed schemes. Traditionally, EIAs have focused on impacts upon protected species and habitats. They have been less likely to address other aspects of biodiversity such as diversity between species and habitats, trends over time, species abundance and distribution, and the functional components of biodiversity. Singh et.at (2000) found that functional biodiversity in particular, was inadequately addressed. Positive conservation measures such as the rehabilitation of degraded ecosystems are also unlikely to receive explicit attention. Components of biodiversity which are already protected, either by established protected areas or by a listed status, are more likely to be included in an EIA study than components which have been given less attention but may be important to the long term productivity of ecosystems and

maintenance of biodiversity. Even without the obligations of the CBD therefore, the requirements of existing EIA legislation such as the EIA notification of 1994, which requires the assessment of impacts on flora and fauna, were not fully met.

Biodiversity impact assessment on the other hand advocates a more sophisticated investigation and analysis of potential impacts on a ecological unit and the species and communities within it. The CBD defines biodiversity as being concerned with diversity at the levels of species (both within and between species), and ecosystems. Biodiversity impacts could therefore be seen as a subset of ecological impacts, looking at the wider relationships between organisms and their environments at the species, community and ecosystem levels.

Biodiversity impact assessment should therefore be seen as part of existing impact assessment systems, and not promoted as a separate entity. There is an impetus behind the biodiversity agenda, and so the term 'biodiversity impact assessment' can be used to raise awareness of these issues within the impact assessment community. This enables a focus on the more positive aspects of biodiversity, looking at the ecosystem approach, dealing with fragmentation issues and so on, not just the traditional EIA approach of mitigating impacts. Biodiversity is not just about rare species and habitats, but about enhancing degraded areas, reversing species declines, and creating new habitats.

8.2 How to dovetail biodiversity in to EIA Process?

To mainstream biodiversity into EIA process we need to

1. Improve existing impact assessment tools to address biodiversity impacts.
2. Expand the tools to provide more positive benefits for biodiversity.

The existing EIA process can be made more sensitive by integrating the provisions of CBD at every stage. For example, it is important to ensure that screening procedures include biodiversity criteria, so that projects with potentially detrimental effects on biodiversity are subject to EIA. The scoping stage is vital, to identify the impacts which will be fully addressed. Four principles can be considered at the scoping stage for biodiversity: spatial context, cumulative effects, public participation and biodiversity criterion. The EIA study itself must consider potential biodiversity impacts, determine their significance, and recommend measures to mitigate adverse impacts and maximise positive impacts. Finally, the post-project monitoring and

review stages are essential to determine whether impacts were predicted accurately, to assess if mitigation measures are effective, and to address any unexpected impacts. This feedback loop is crucial to maximize the effectiveness of EIA, and is sorely left out of the present process chain.

This integration provides the much needed ecosystem approach to EIA, which looks at potential impacts on the ecosystem as a whole, particularly its functions (for example wetlands provide a 'storage function' and forests perform carbon regeneration function). The potential knock-on effects of impacts, for example the loss of species at lower levels of the food chain having implications for the food source of predators higher up the chain.

Achieving the objectives of the CBD requires more than just mitigating impacts on biodiversity. A proactive approach is required, which seeks first to avoid impacts, and identifies opportunities to enhance biodiversity. For example, opportunities to create wildlife corridors or links between habitats could be considered, or the potential for management practices to enhance the biodiversity interest of existing features.

- ✓ EIA is a reactive tool, as it responds to impacts through mitigation rather than examining the potential to design out impacts through the consideration of alternatives. However, examining alternatives may not exactly fit into the scope of Indian EIA procedures, particularly those related to dams. But a strong case exists for more careful examination of alternatives at a Strategic Environmental Assessment (SEA) level. This also enables a more positive approach to be taken to biodiversity conservation, particularly through identifying opportunities for enhancement.

8.3 How to mainstream?

Changes are needed at all levels of impact assessment, from legislative requirements, guidelines, training and impact assessment practice, if the objectives for biodiversity and impact assessment are to be achieved. At national level, changes to impact assessment notification are necessary to introduce formal requirements for biodiversity issues to be addressed. India has already signed up to the obligations in the CBD, and these need to be transferred into existing impact assessment requirements.

Opportunities to integrate CBD provisions into Indian EIA process

Screening

- ✓ Include all activities likely to impact biological diversity
- ✓ Apply biodiversity thresholds measures, especially those relevant to over-exploitation of plant and animal species

Preliminary Assessment

- ✓ Impact lists should include impacts on ecosystems, habitats, species, communities and ecosystem services important to biodiversity

Scoping

- ✓ Temporal and spatial parameters should reflect biodiversity considerations
- ✓ Cumulative effects on biodiversity should be taken into account
- ✓ Public participation should be maximized to minimize bias in defining impacts

Identification

- ✓ Methodology should be such that it must capture the direct and indirect impacts on biodiversity such as habitat loss and fragmentation, introduced species, pollution of soil, water and atmosphere, and global climate change
- ✓ Indicator species could be used as criterion

Examination of Alternatives

- ✓ Alternative development options should be assessed for their potential impacts on biodiversity and for the distribution of their costs and benefits. If not as part of the EIA process but as a precursor at SEA level.

Prediction

- ✓ Existing baseline data should be supplemented by further studies
- ✓ Data produced through studies and predictions should be made available to all the stakeholders, thereby furthering the exchange of information.

Evaluation of Significance

- ✓ All stakeholder groups should be involved in the process of attaching significance to impacts.

- ✓ Amendment to Indian EIA notification and manual are necessary to more explicitly mention the biodiversity requirements.
- ✓ It is obvious from the case studies that institutions in India have the capability to address the issues. Unfortunately this expertise is scattered. While ZSI and BSI are strong in taxonomic studies, institutions like WII and SACON have expertise in impact identification, habitat / ecosystem approach to EIA and better impact prediction and mitigation planning skills. It is the need of the hour to create an independent, autonomous institution to conduct biodiversity impact assessment of various projects and policies. This institution should have a broad expert base that is capable of addressing all aspects of biodiversity (genetic, species and ecosystem levels and experts who can address the complete spectrum of biodiversity from micro organisms to large mammals). The funds to create such an institution may come from the project proponents and MoEF. This will

introduce transparency into decision-making and will also ensure a broader; more ecosystems based perspective of impact assessments.

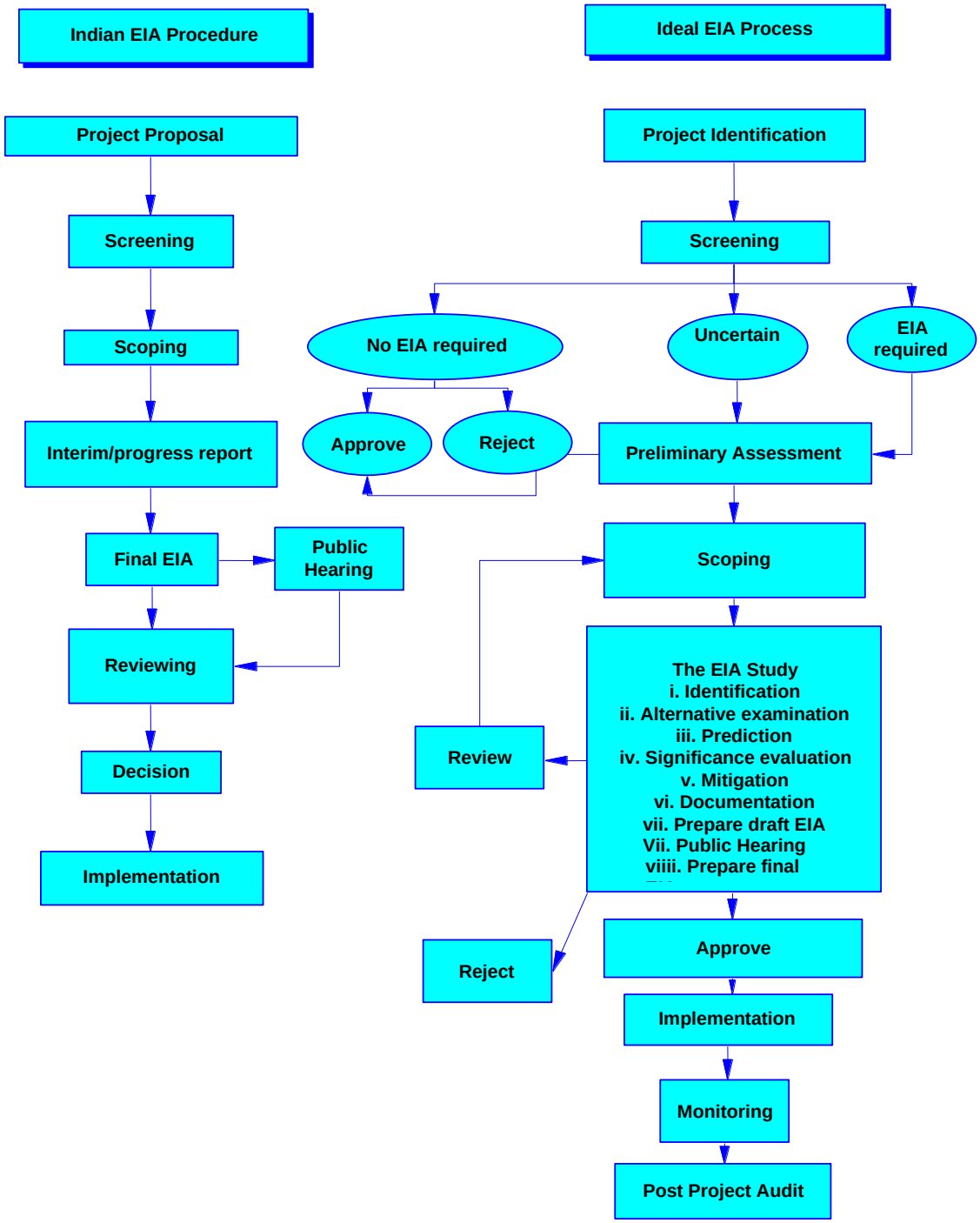
- ✓ Broaden and expand the scope of benefit cost analysis of dams to incorporate monetized biodiversity and ecosystem value losses in an integrated economic and environmental accounts framework
- ✓ Ensure representation to local NGOs, / stakeholders at the draft EIA report preparation stage to capture their perceptions and indigenous knowledge.
- ✓ Disseminate 'best practice' EIAs that explicitly addressed biodiversity issues to bench mark standards and practices.
- ✓ Disseminate guidelines on how to explicitly incorporate biodiversity issues into impact assessments on a priority basis.
- ✓ Ensure transparency of decision-making and right to information to stakeholders, so that it can be clearly seen how biodiversity impacts have been taken into consideration.

8.4 The challenge ahead

The challenge ahead is enormous, but very exciting. The biodiversity agenda provides an opportunity to take a new look at impact assessment, to review whether it is delivering its fundamental objective of protecting the environment, and to move impact assessment practice forward to provide a tool that will serve the needs of a changing society in the 21st century.

Its time that we take advantage of the CBD mandate to strengthen existing methodologies and techniques and advocate stronger application of those techniques to protect biodiversity. In addition, we need to make the most of opportunities to expand impact assessment into a more positive, proactive tool, in order to reverse some of the damage and declines of the past, rather than just mitigating the impacts of current activity. In this way, impact assessment can help to deliver the objectives of sustainable development, *to meet the needs of the present without compromising the ability of future generations to meet their needs.*

Comparison of Indian EIA procedure with an Ideal EIA Process



Note: Poor post project monitoring and evaluation programs are the main shortcomings in Indian EIA procedure.
Source: Maudgal (1988a, b); World Bank, 1991 a; Devuyst (1992); Bargi et al (1998).

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