Reconciling Environment and Economics : Executive Summaries of EERC Projects

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PREFACE


Jyoti K. Parikh

The Environmental Economics Research Committee (EERC) was constituted to build nation-wide capacity in environmental economics research under the Ministry of Environment and Forests implemented, World Bank aided "India: Environmental Management Capacity Building (EMCaB) Technical Assistance" Project.

When we began, we needed innovative approaches. As there were no readymade environmental economists we had to invest in capacity building. EERC provided a new opportunity to those who wished to branch out into this area. Those who were already working in the area of environment such as pollution, solid waste, land-use and natural resources such as forests and biodiversity, benefited by incorporating economics to make their research more relevant for policy guidance. On the other hand, some economists diversified their interests to address the environmental externalities of economic development. After scrutinizing nearly 320 projects that were submitted, 61 projects were funded. A vast number of areas are covered which can be seen in the table of contents.

"Reconciling Environment and Economics: Executive summaries of EERC projects" presents executive summaries of 51 selected projects. The summaries cover the objectives, methods used, analysis, results and policy recommendations. Considerable efforts were put in for capacity building by giving continuous feedbacks. During project execution, inputs from EERC members, national experts and international reviewers helped to refine the outputs and monitor the progress to ensure quality. More than 20 project review workshops improved the understanding, led to capacity building and synergy.

The projects contain case studies rooted in India with data and coefficients based on Indian situations. Some of them would be useful in teaching environmental economics and some in solving problems or managing conflicts, as they relate to local conditions and real life. The methods, approaches, databases and results may be of interest to not only academics in India but also elsewhere. Many of these projects are helpful for decision-making and of interest to relevant ministries, administrators, non-government organizations, local communities and stakeholders.

On behalf of the EERC and the project investigators, I acknowledge the help of a large number of national and international experts who reviewed the projects whose names appear in the annexure. In addition, I thank Paul Appasamy, Dilip Biswas, Sudarshan Iyengar and S C Pathak for reviewing some of the summaries. It was a formidable task to obtain these summaries from 51 projects spread across the country and across many disciplines and to edit a number of draft versions to ensure some uniform level. Despite the best efforts, some errors may have remained. The full text is also available from our website and a CD.

I thank Seema Roy and Y N Rao for their support to bring this publication out. I thank Ministry of Environment and Forests, Madras School of Economics and the World Bank for their cooperation.

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WETLANDS AND BIODIVERSITY

Valuation of Bhitarkanika Mangrove Ecosystem

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Introduction

The Bhitarkanika mangrove conservation area (BCA) comprises of Bhitarkanika National Park and Wildlife Sanctuary and parts of Gahirmatha Marine Sanctuary. It covers an area of 1006.5 km^2 of which around 4.8% area has mangrove cover. This deltaic, estuarine-mangrove wetland system harbours the highest diversity of Indian mangrove flora, the largest known rookery of the olive ridley sea-turtles in the world, among the last three remaining wild populations of salt-water crocodiles in India, the largest known population of king cobra, one of the largest heronry along the east coast of India and one of the highest concentrations of migratory waterfowls - both ducks and waders. The loss of mangrove in Bhitarkanika is mainly due to human encroachment, reclamation of land for agriculture and unsustainable resource use practices such as aquaculture activities. Around 336 villages with a total population of 1.5 lakh in the adjoining areas depend for fuel, fodder and other non-timber forest produce on the Bhitarkanika mangrove ecosystem. Recent developmental activities such as the construction of jetties and roads and the proposed development of a major port at Dhamra threaten the existence of this ecosystem. The declaration of the mangrove forests of Bhitarkanika as a Protected Area has affected the local people as they have lost access to their life support systems. The unsustainable resource use by the locals is a major threat to continued existence of the mangroves as well, resulting in conflict between the forest department and the local population.

This study attempts to fill the information gap by exploring the varied functions and uses of the mangroves. It endeavours to assist planners and PA managers to make informed decisions on the management of the Bhitarkanika mangrove ecosystem.

Objectives

The major objectives of this study are to:

- Enumerate ecological functions and key productive uses of the BCA.
- Estimate the usage values and ecological services provided by BCA.
- Quantify the extent of the local community's dependency on Bhitarkanika and identify marginalized stakeholders.
- Examine the local community's attitude towards present and proposed management alternatives.
- Derive a predictive model to assess the impact of sea level rise on the Bhitarkanika mangrove ecosystem.
- Recommendation for management of the area.

Vegetation Structure

The Bhitarkanika mangrove ecosystem was characterized in terms of vegetation structure to relate it with the major ecological functions performed by this ecosystem. The vegetation map at the landscape level was prepared to identify distinct habitat types by using Indian Remote Sensing Satellite (IRS-1D), LISS – III data of November 2000. The vegetation of BCA was divided into 9 major vegetation communities - Salt Marsh/Wet marshland, Palm/Tamarix Swamp, Brackish Water Mixed Forests, Salt Water Mixed Forests, Mangrove Forest, Mangrove Scrub, Village Woodlot/Agriculture and Agriculture/Habitation/Prawn culture/Barren areas and mangrove and non mangrove mixed. For the micro level assessment the Bhitarkanika National Park was stratified into distinct blocks. Stratified random sampling was employed to collect the field data on mangrove plant species composition and tree species diversity.

A total of 64 species of plants were recorded from Bhitarkanika Mangrove Protected Area, which included 28 true mangroves, 4 mangrove associates and 32 others. The mean canopy cover of Bhitarkanika mangroves was found to be 33.25% of the total area while the mean ground grass cover in the meadows of Bhitarkanika was established at 47%. Grasses were the main contributors to the ground cover. Tree density was 1376.93 per hectare. Sapling density was 83.33 per hectare while seedling density was found to be 45.79 per hectare. The total tree basal area (m^2 per hectare) was 220.26. Tree, seedling and sapling diversity varied within the mangrove area. The Bhitarknika mangroves differ considerably from other Indian mangroves because of their dominant trees: *Sonneratia apetala* and several *Avicennia* species. In addition *Myriostachya wightiana* a species of grass is very common here.

Ecological Services

The information on ecological functions and the key productive uses of mangrove ecosystems were collected from existing literature, as well as from discussions with the park management and staff, field biologists, scientists, commercial fishermen and local people. These were also partly identified during the door-to-door socioeconomic/attitude survey. Four parameters - nutrient retention, land accretion, storm abatement, and fish and shellfish production - were selected for valuation.

Nutrient Retention

By applying the market price method, the monetary value of major nutrients present in mangrove and non-mangrove soil was compared. The NPK (Nitrate, Phosphate and Potassium) in one ha of mangrove and non-mangrove soil was estimated. The total value of nutrients is given in Table 1.

Fish and Shellfish Production

To estimate the contribution made by Bhitarkanika mangrove ecosystems to fish production, data from another ongoing project of the Wildlife Institute of India, Dehra Dun, titled "Experimental Trawling Along the Orissa Coast to Estimate the Mortality of Sea Turtles," was extensively used. The market price method was used to value the offshore fishery. We found a significant difference in the total catch/hr between mangrove and non-mangrove area. The Gahirmatha coast (with mangrove) has considerably high fish yield (123 kg/hr) as compared to the Paradip coast (without mangrove) where the yield is 17 kg/hr. Hence, earnings per hour are also considerably higher in Gahirmatha, amounting to Rs.1784 per hour, while in Paradip only Rs. 104 is earned per hour. Data from secondary sources indicates higher species richness from Dhamra – a fish landing site closer to the mangroves.

Data on inshore fish productivity was collected between March and June 2002 from six creeks originating from the main Bhitarkanika River, which has rich mangrove vegetation cover. The estimated value of the catch per hour for inshore fishery was Rs. 90 for 3.77 kg of fish.

To verify the role of mangroves as nursery ground for fish and shellfish, a circular drag net was used. Prawn and fish seedling catch per hour was calculated. Fifteen species were caught, of which three were commercially

Table 1. Estimated value for total nutrients available in the mangrove area

Nutrients	Amount of nutrient in mangrove (kg/ha) (1)	Amount of nutrient in non-mangrove (kg/ha) (2)	Amount of extra nutrient in mangrove (kg/ha) (3)=(1)-(2)	Total Area under Mangrove Forest (4)	Amount of extra nutrient in total Mangrove area (kg/ha) (5)=(3x4)	Market Value (Rs./kg) (6)	Estimated value for total extra nutrients in total mangrove area (Rs.) (7)
Available N	2907	2057.67	849.33		12315285	10	123152850
Available P_2O_5	28.11	20.08	8.03	14500 ha	116435	15.43	1796592
Available K_2O	1564.55	1222.46	342.09		4960305	7.09	35168562
Total value of N+P+K							160 million

exploited. The catch (kg/hr) was 65 for White prawn, 6 for Tiger prawn and 15 for Mud crab, while earnings (Rs./hr) from these species were Rs. 7 to 33, Rs. 2 to 3.5 and Rs. 3 to 6 respectively.

Storm Protection

Damage cost avoided approach was used to evaluate the storm protection function of the Bhitarkanika mangrove ecosystem. Actual figures on damage avoided due to presence of mangroves were estimated using information from the super cyclone of 1999. Three villages, namely Bankual, Bandhamal and Singidi were identified to represent three situations viz: Mangrove areas with dykes, Non-mangrove areas with dykes, Non-mangrove areas without dykes. All the three selected villages were equidistant from the seashore. The two villages outside mangrove covers were located close to each other, but both were far from the forest in order to eliminate the effect of mangroves. A door to door survey was conducted and a 100 percent sampling of the households was done to assess the socio-economic status of the villages, the actual damage to houses, livestock, fisheries, trees and other assets owned by the people and the rate, level and duration of flooding. Information was gathered by focused public interviews about the direction of the entry of water and probable reasons for flooding.

The mean household size in the three villages was 4.5 to 8.2. The overall human density in the study villages ranged between 260-340 persons/ km^2. The literacy level was highest for Singidi and lowest for Bankual. In Singidi and Bankual majority of the people (70%) were engaged in agriculture, where as in Bandhamal around 61% were labourers. Most of the houses (94%) were made of mud and thatch. The damage to houses was measured on a '0' to '19' scale, where 19 is maximum damage. The maximum damage to the houses was 10.44 $\pm$ 0.848 for Bandhamal. The least damage took place in Bankual, amounting to 5.34 $\pm$ 0.578. Majority of the houses in Bandhamal, the villages protected by dyke but without mangrove cover, were flooded while the least flooding took place in Bankual, the village protected by mangrove cover. The highest level of flooding in the fields occurred in Singidi, a village situated outside the mangrove area and not protected by dyke, followed by Bandhamal and then by Bankual. The agricultural production was highest in Bankual in 1999 with a value of 6 $\pm$ 0.376 qtl./acre and the lowest was in Bandhamal with 1.4 $\pm$ 0.956 qtl./acre. The highest damage to fish seedlings was in Singidi where Rs. 311 $\pm$ 144.975 worth of the seedlings released were washed away and it was the least in Bankual (Rs. 70 $\pm$ 32.198). The maximum number of livestock casualties occurred in Bandhamal, followed by Bankual and Singidi. The loss incurred per household was found to be greatest in Bandhamal Rs. 6918.63 $\pm$ 1136.201 per household followed by Singidi and Bankual.

Significant difference were found among the variables used to assess the contribution of mangroves in avoiding damage from cyclones and floods for mangrove and non-mangrove areas. No reports of breaches in the dyke located around the forest area indicate the protection provided by mangroves to the dykes, although this is not conclusive as further data authentication is required. However, in areas far from the forest several breaches in the dyke were reported. This resulted in higher level and longer duration of flooding at Bandhamal. The object of this study therefore, is to highlight the importance of mangroves as an effective barrier to storms, surpassing man-made structure such as the dyke in this case.

Land Accretion

Mangroves trap sediments and accelerate land formation on the coast, initially as islands or mudflats. Subsequently due to succession, these newly created landforms develop into tidal swamps with mangrove species. The Bhitarkanika mangrove ecosystems have significantly contributed to the formation of mudflats and islands along the coast and in the associated riverine ecosystems. Newly created landmasses were identified from Survey of India toposheets and remotely sensed using IRS-1D, LISS – III data of November 2000. A total of 4.68 km^2 of land formation has occurred within the Bhitarkanika mangrove area in a time span of

111 years from 1889 to 2000. The market value method was used to estimate the contribution of the Bhitarkanika mangrove ecosystem in land accretion. The value of 468 ha of land at the current market price is Rs. 46 million. The cost of reclaiming land should have been used to estimate the value of this function. Since cost of reclamation was not available for the study area, a conservative estimate of the value of this function has been given by stating it as the current price of land in the area.

Among the four parameters valued, the nutrient retention function was Rs. 16450 /acre/ year, quite high as compared to the valuation results of other studies. The fish and shell fish production valuation was done at three levels and the estimated value for offshore fishery, inshore fishery and fish seedling was determined by using the market value method, which amounted to Rs. 1785/hr, Rs. 90/hr and Rs. 1/hr respectively. The storm abatement function was valued using the damage cost avoided method. In the village with mangrove cover, the damage cost avoided was estimated to be Rs. 5465/ household. The value of land accretion function was estimated to be Rs. 46 million over a period of 111 years.

Socio-economics of local people and their dependence on BCA

The data on socio-economic and dependency aspects was collected in three stages. The first stage involved a rapid assessment of the 403 villages located in the impact zone of Bhitarkanika Wildlife Sanctuary. Information on 35 parameters concerning socio-economic status, location and distribution of villages with respect to the forest and the villagers' dependency on forests for fuel wood, timber, fodder etc., was collected. In the second stage, hierarchical cluster analysis was carried out to identify relatively homogeneous groups of villages. A sample size of 35 villages was identified and the villages were then randomly selected from the clusters in proportion to the size of each cluster. In the selected villages from 10% of the housing units, data regarding the socio-economic set up, dependency on mangrove ecosystems and attitude of the people towards conservation were gathered. In the sampled villages the family size obtained was found to be a little over 8 individuals per household. Overall literacy rate was 69.19% (male 79.82 % and female 59.12%). Majority of the people were involved in the primary sector i.e. agriculture. The percentage of skilled labour was low (4.01). The primary occupation of 6-9% of the people was fishing, 2.2% of people were involved in NTFP collection. Mean months of employment were 6.25 $\pm$ 0.212. The average income per household per annum was Rs. 22976.3 $\pm$ 1791.486. Agricultural income was Rs. 2039.7 $\pm$ 297.076. Mean cattle holding per household was 2.3 $\pm$ 0.184.

The results reveal a high degree of resource use by villagers despite the protected status of the Bhitarkanika mangroves. Wood from the Bhitarkanika mangroves is being used, particularly by the communities in the periphery of the forest for firewood. An overall 14.2 percent of the needs of each of the household was being met by the forests with a mean consumption of 3.1259 $\pm$ 0.3216 qtl./annum in the sample villages. The highest consumption was noticed in the villages located within 1.5 km. from BNP (5.8 $\pm$ 0.533 qtl./annum). The highest fish extraction (1.25 $\pm$ 0.391 qtl.) was observed for the villages located in the peripheral areas of the mangroves and the least (0.60 $\pm$ 0.495) for those farthest from it. Thus, highest consumption of Non Timber Forest Products (NTFP) was seen for villages in the adjoining areas of forest while the villages situated more than 3 km away from the forest did not use this resource.

- Around 90% of the local people in the area are aware that Bhitarkanika forests have protected status and that it is a declared Wildlife Sanctuary.
- 84% of people feel that they have a responsibility towards conservation of flora and fauna and 92.9% are in favour of an ecodevelopment programme for the area. 43% of people are willing to cooperate with the forest department in this regard. Only 18.3% of people feel there has been a violation of their rights with the park's declaration.
- 52% of the respondents felt that the local community should take initiative in the ecodevelopment programme and

consequently be involved or at least informed of the management decision.

- Very few people (0.7%) are in favor of cutting down the forests and 76.9 % of the people have said more mangrove plantations should be carried out.
- 80% of the people living close to the forest seemed to be more willing to cooperate with forest department in the conservation of flora and fauna, as compared with those living away from it.
- Majority of the respondents (87.7%) favored the Dhamra port extension.
- Very few respondents (8.6%) favoured aquaculture practice.
- In case, free access to forest resources was stopped, 30.6% respondents said they would buy alternatives available in the market, while 10% opted for stealing the produce from the forest. Only a few respondents (2.6%) opted for growing fodder and a very small percentage (0.4%) were willing to reduce the number of livestock.

The findings point out that the local people appreciate the contribution of Bhitarkanika mangroves to their lives and livelihoods. A high percentage of people (88.6%) recognize the contribution of mangroves in cyclone and flood mitigation. The people have even recognized functions such as biodiversity conservation and ground water recharge.

Sea Level Rise and BCA

A predictive model to assess the extent of impact of sea level rise on Bhitarkanika has been developed. Data was generated from different maps in the form of point information of elevation. After this, the digital elevation model was interpolated. The map was depicted with two levels of inundation (a) 0-1 m, which indicates the predicted sea level rise of 1 m and (b) 1-2 m of sea level rise. The local coastal process and wave patterns were not considered at present due to lack of reliable information that can be extrapolated on a large scale.

The land between 0-1 meter elevations has 73.2 to 63.9 percent estimated probability of inundation by 2200. The possible area of inundation at three levels i.e. 0-1, 1-2 and 0-2 m rise are 194.77 km^2 (6.5%), 253.71 km^2 (8.5%) and 448.48 km^2 (15%) of BCA respectively. Though this seems small and relatively insignificant, it will ultimately adversely affect the vegetation of the entire Bhitarkanika Conservation Area.

The estimated goods and services provided by the Bhitarkanika Mangrove Ecosystem is significantly high when compared to other land uses in the area such as aquaculture, paddy cultivation and development options. Moreover, the ecosystem services provided by the natural systems cannot be substituted by man-made capital. Despite this, the Bhitarkanika mangroves are facing threats of extinction due to anthropogenic and developmental pressures. There is a high degree of resource extraction by the locals due to limited availability of livelihood options such as paddy cultivation and fishing. Land use changes coupled with developmental activities all around the area threaten the ecological integrity of the Bhitarkanika Mangrove Ecosystem.

Recommendations

The Bhitarkanika area has had a strong protection policy since 1951. In 1975, the Government of India declared 670 km^2 of the area as a Wildlife Sanctuary under the Indian Wildlife Protection Act, 1972. A core area of 145 km^2 was upgraded to a National Park status in 1988. In 1997, 1435 km^2 area was declared as Gahirmatha Marine Sanctuary, with a core area of 725.5 km^2. Despite this , at a higher spatial scale there is ample evidence to suggest that in the area market faliure, informatioin faliure and intervention faliure are occurring because of inability of the government to implement the Wildlife Protection Act effectively; and lack of inter-sectoral coordination.

Between 1951-61 there was an unprecedented increase in the population of the area due to resettlement of refugees from Bangladesh. Between 1994-95 the Revenue

Department legalized a large number of illegal settlements within the Sanctuary area, with little regard to Wildlife and Forest Conservation Acts. Similarly, despite the protected status of the Bhitarkanika area and the existence of a strong Maritime Act (1982) of the Government of Orissa and Orissa Marine Fishing Regulation Act (1982) and Rules (1983), unabated development has been taking place in the area such as the construction of port and defense structures and inshore fisheries using mechanized vessels. This is the result of information failure on part of the fisheries, waterways, defense and other government departments. In the absence of valuation studies the forest department is unable to articulate the importance of this ecosystem against the developmental activities, that though promise higher economic returns are unsustainable.

All these factors are together exerting pressure on the Bhitarkanika Mangrove Ecosystem. Integrated Conservation and Development Plan for the area is needed to manage the area.

Legal Protection

MoEF recently declared Bhitarkanika as a Ramsar site and its wise use would imply careful planning, management, regulation or even prohibition of certain activities. This can be made possible through proper consultation and an agreement with the stakeholders, which would also garner more support for its conservation. The existing positive attitude of people towards conservation need to be creatively channelized for sustainable development of the area. The following policy initiatives are suggested for long-term conservation of BCA.

Stakeholder Participation

Resource extraction from the PA is not permitted under the current law (Wildlife Protection Act, 1972). However, the 336 villages located inside the Sanctuary have no option but to use the resources from the PA. The use in this case is de facto, which is usually indiscriminate. It is crucial to address the dependence of the local communities on the PA resources. We suggest that:

- The National Park i.e., the core zone be maintained as a sanctum sanctorum and all resource use therein stopped.
- The livelihood needs of the people (living within 1.5 km of forest boundary) on the PA, be met from the buffer zone. The buffer zone in this case is a Wildlife Sanctuary where resource extraction is not permitted. Controlled resource extraction in this zone be permitted, in such a way that it does not affect the ecological balance. This will also develop stakes of the local people in the conservation of the area.
- The status of the buffer zone be changed to other categories of Protected Areas as proposed under the amended Wildlife Protection Act.
- Subsistence fishing in rivers like Dhamra, Brahamani, Baitarani, Hansua and Pathsala be legalized. This is unlikely to have a major impact on the ecological balance as long as the nursery grounds of the fishes i.e. the small creeks- Thanpati, Ganjeikhia, Jalahar, Suajore, Gokhani and main Bhitarkanika River remain undisturbed.
- Alternative fuel to the local people needs to be provided to reduce their dependence on the BCA. It is imperative to develop better supply and distribution mechanisms. Since the income levels of people in this area are relatively high, it can result in a shift to more efficient alternate fuel.
- For the poor, the Sanctuary still remains the source of wood biomass. Mangrove plantation should also be taken up extensively in and around forest blocks, which are under tremendous pressure and are already degraded due to excessive lopping (e.g. Mahisamunda, Ragdapatia and Kalibhanjdia forest blocks).

Employment Generation

- The villages located within 0-1.5 km distance from forests have higher numbers of unemployed population. For these villages income-generating programmes are needed

to counter high unemployment. Programmes that have been successfully initiated in few villages by the forest department and local NGOs should be extended to more villages.

- Pisiculture and apiculture can be introduced as these have tremendous scope in the region. Most of the villages have sufficient number of ponds to sustain fish population and have basic equipment and knowledge to carry out such programmes.
- Local communities can be involved in tourism (as guides) in the area. This will provide employment opportunities for the local population. It should be made mandatory for visitors to have a trained tourist guide with them, which will not only facilitate these visitors but will also help in monitoring the activities of the visitors.
- The entry fee to the park should be increased to generate revenue for the forest department. Funds generated should be used to set up ecodevelopment / village development funds as is being done by the states of West Bengal, Madhya Pradesh and Rajasthan.
- Overnight stay facilities for tourists should be developed at other sites beside Dangmal, and measures taken for up-gradation of existing forest guesthouses at Ekakula and Habalikhati so as to distribute the tourism pressure.
- Villagers can be encouraged to build ethnic huts at places like Khola and Gupti to facilitate boarding arrangements for tourists and provide the villagers with an alternate income source. Existing nature trails inside Bhitarkanika forest block and the heronry at Bagagahana should be properly maintained.

Infrastructure

- Maintenance of existing roads and bridges should be done so as to improve transportation facilities for locals and tourists. Boat transportation in the inner creeks should be regulated to reduce disturbance to birds and crocodiles. Though people support construction of Dhamra Port, its building will have detrimental impact on the Bhitarkanika National Park. Increased movement of boats due to construction of the port will be detrimental to the nesting sites of turtles, and the social impact will hamper the integrity of the entire ecosystem.
- Small sluice gates should be made at strategic locations on the dyke so that storm water drains out quickly after extreme disasters like cyclones.

Conflict minimization

Although prawn farming is banned in the sanctuary area, a number of illegal prawn farms (Gheries) continue to exist. The forest department frequently demolishes these farms, resulting in a conflict of interests between the local people and the forest department. Awareness programs should be run along with the demolition of Gheries to educate the people about the negative impact of aquaculture on agricultural production.

Trawling too is prohibited within a 5 km range from the shoreline. In spite of this, illegal fishing by mechanized trawlers continues, causing large-scale mortality of sea turtles. Restriction on mechanized fishing in the coastal zone should be imposed with the help of the Coast Guard and Fishery Departments. The number of field staff presently employed is inadequate to patrol the BNP and efforts must be made to attract employment of qualified professionals in the area. Cooperation of the local villagers is crucial to check the smuggling of timber and wildlife articles. Sufficient number of enforcement staff with VHF sets and transport facility should be deployed at all entry points at Dangmal, Khola, Gupti and Chandabali.

Awareness Creation

A large section of the population, particularly those living in and around Bhitarkanika in remote areas are uneducated. In order to reach out to and educate them, visual literacy programmes should be implemented using the skills and expertise of local NGOs.

Conservation of Gir Eco-System: Assessment of Benefits and Costs under Alternative Management Systems

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The context

The policy discourse on Protected Area (PA)-management has come a long way from purely conservationist strategies to participatory approaches. In between these two there is a wide range of options that combine different elements of resource sharing, market regulation and privatization. Ideally, the PA-management strategy should pick and choose from these broad strands of approaches to suit the location specific situations, especially with respect to important parameters such as: economic and ecological services flowing from the ecosystem; size and status of the system; extent of people's dependence and conflicts; scope for revenue generation from eco-tourism; and availability of financial resources for PA-management. The experience from a large number of developing economies suggest that none of the pre-conceived, 'blue-print' solutions may work across different PAs, though it might have worked in the situations of wilderness without much human activities around. This implies that the analysis of the cost of bio-diversity loss and the development of appropriate institutions and incentives should primarily be local exercise. The choice of PA-management approach therefore, has to be in tune with the location specific situation - ecological, socio-economic-political and financial. Also, the choice is time specific; it may undergo changes along with the different stages of PA-management. Exploring options and evolving new approaches therefore, are important aspects of policy formulation on PAs.

Gir Protected Area (PA) represents one of the successful cases of design and implementation of a management plan. This has been achieved through effective protection and habitat development practices. As a result, it has succeeded in reviving wildlife population, especially the Asiatic Lion, which is fairly close to its 'optimum size'. The next stage therefore, is to evolve sustainable strategies for regeneration and conservation of vegetation and biodiversity. Given a large number of local stakeholders, sharing of the regenerated resources might help both conservation as well as people's participation in PA-management.

The analysis is to be carried out in light of the important postulations emerging from the above description of the ecology, people and the management approach adopted for the PA. These postulations are:

- Given the large size of human population in the periphery, there is an inherent trade-off between conservation and livelihood requirements of the people. However, the trade-off could possibly be resolved by taking into consideration the carrying capacity of the area to support the Asiatic Lion, for which the PA is primarily designated. It is estimated that Gir PA can support 300 lions, the maximum population of lions that had ever existed in Gir.
- Maldharis are a part of the Gir ecology; hence the carrying capacity should also be defined in terms of human as well as livestock population of this community within and in the periphery of Gir.
- Conservation efforts over the past two-and-half decades have improved the wildlife habitat, especially by enhancing vegetation (or restocking) in the core area and effective punitive measures. This however, has left a large part of the pastures within (and also outside) the sanctuary in degraded condition.
- While the protection measures have resulted in reducing poaching of wildlife, illegal grazing continues, though on a significantly lower scale than before.

- Nevertheless, continued degradation of pastures is a combined effect of: (a) illegal grazing; (b) climatic conditions (i.e. frequent droughts); and (c) inadequate measures for regeneration.
- Intrusion of wildlife on crop fields in the peripheral region has increased mainly due to degraded conditions of forests especially during droughts.
- The problems of water and shelter (i.e. vegetation) within the PA could be mitigated by proper measures for soil-water conservation within the PA. This in turn, might also help promoting sustainable use of water for agriculture in the lower reaches of the watersheds.
- Regeneration of vegetation within the PA could help reduce the pressure from outside provided (a) pastures in the periphery are developed; and (b) management of fodder supply is streamlined.
- Development of pastures both within and outside the PA requires substantial resources - financial (i.e. land, water, manure, etc.), natural and institutional. Given the budgetary support, these aspects so far, have received a lower priority despite the recognition of their critical importance.

Given this backdrop the present study tried to examine the status of Gir ecology, people's dependence, and alternative approaches that might be more relevant for the next phase of management in the PA. Valuation of economic and environmental services has special relevance in this process.

Objectives:

The main objectives of the study are:

- Identification as well as valuation of economic and ecological services from the PA.
- Assessment of people's dependence on the PA across different categories of households-farmers with and without irrigation, landless, and traditional herder communities. Also, estimation of cost under alternative management practices, especially for regeneration of pastures, wastelands, and reserve/protected forests.
- Drawing implications for a management strategy that incorporates people's stakes while ensuring ecological sustainability of the PA.

The above analysis will help contributing to certain long-term objectives such as:

- Getting a clearer understanding of the interface between development of the core and the peripheral regions, which may lead to evolving a sustainable strategy for PA-management; and
- Identifying effective mechanisms for protection and also sharing of resources through development of markets, institutions and community participation.

Methodology and Approaches for Valuation

The study has been based on data collected from both secondary as well as primary sources. The assessment of the value of economic and ecological services (benefits) has been done by using the estimates of various indicators - intensity and diversity of vegetation across different areas within the PA, availability of irrigation, farm yard manure (FYM) and other non timber forest produce (NTFP), conservation of soil-nutrients, carbon sink function and wildlife diversity, etc. from the various studies on the Gir-PA and/or other comparable situations in India. The estimates of costs are based mainly on the norms used in the official management plan. However, these sets of secondary information have been supplemented by primary data collected from: (i) a complete house listing in 8 revenue villages; (ii) a detailed survey of 162 households in four revenue villages; (iii) meetings with key informants, which included group discussions on the status of common property resources in 29 villages; (iv) a series of focus group meetings with various stakeholders viz; people, members of the eco-development

committees and functionaries of the forest department; and (v) informal discussions with policy makers.

The four villages where the detailed survey of sample households has been undertaken were selected from the West and the East divisions within the PA – two in each division. Of these, one village is on the border i.e. within the periphery of 2 kms., and the other at a distance of 2-7 kms. from the PA-boundary. After completing the house-listing exercise in the four (out of the 8) revenue villages selected for detailed study, a sample of households was selected from five categories viz; large farmers with irrigation (LI); small farmers with irrigation (SI); farmers without irrigation (UI); landless (LL); and traditional herder communities (LH). The sample households were selected by adopting a stratified random sampling procedure.

The basic purpose of the primary survey was to ascertain (a) dependence on the PA households across different categories; (b) people's perceptions about the relative importance of non-use values; and (c) preferences about alternative land-use, and their implications for alternative management systems. Together, the secondary and primary data provided a comprehensive picture of the ecological status, prevailing management practices, and implications on alternative systems for regeneration and conservation of the Gir-PA in a sustainable manner. It is expected that the analysis would provide inputs for further fine-tuning of the issues and policy alternatives for management of Gir and therefore, would be a useful addition to the rich set of existing literature on various aspects of the ecology.

Given the specific context of Gir, a wide menu of valuation methods, and feasibility of data collection, the present exercise will attempt assessment of various benefits and costs as listed in Chart 1.

Chart 1.

Benefits from Environmental and Economic Services			Cost of Conservation		
Direct Benefits	Loss of Potential Benefits	Benefits Under Alternative Management Plan	Direct Cost	Opportunity Cost	Replacement Cost
Actual Use as well as Non use Values	Untapped potential of Use as well as Non use Values due to Incomplete Conservation Efforts	For Alternative Systems of Land Use, Incentives and Institutional structures	Actual according to the Management plan for Mitigation of Forest Degradation	Under Alternative Land Use For Ensuring Practices	Effective Conservation through Alternative Management Plan

Major Findings:

People's Dependence on the PA

- Local stakeholders consist of a human population of 3-5,000 and livestock population of about 14,000 within the PA. The periphery, consisting of 99 revenue villages has an estimated population of about 1,80,000 persons and 95,000 livestock.

- People within the PA have rights for grazing their livestock, and depend entirely on the PA for their livelihood. The total economic benefits accruing to the Maldharis within the PA amount to Rs. 1,035 lakh per year or Rs. 2.87 lakh per household per year. Against this, the major cost incurred by the Maldharis is in terms of loss of livestock, which is estimated to be Rs. 112 lakh per year, besides the difficulties arising due to lack of basic amenities like education, roads and electricity. While the present size of livestock inside the PA is well within the carrying capacity of about 22,000, there are other costs due to human settlements within the PA. These are infiltration of outside animals, faulty grazing practices, damaging the regeneration process, selling of FYMs outside the PA, extraction of fuel wood for commercial purpose, and offering less productive livestock as easy prey, and thereby distorting the genetic characteristics of lions.

- More than 50 percent of the households in peripheral villages access fodder from the PA. Similarly, a large proportion (i.e. about 80%) of the households obtain fuel wood from the PA - directly or indirectly from the markets. These constitute about 74 percent of the total requirements for fuel wood in the peripheral region.

- There are no systematic estimates on fodder production or its requirement in the peripheral villages. Ascertaining the actual extraction of fodder by the people is difficult because it is illegal. However, assuming an average fodder yield at the national level, i.e. 3000 kgs/ hectare, the surplus fodder (after meeting requirements of the livestock and herbivores within the PA) can support about 21,000 adult milch cattle in the periphery. Another 19,000 can be supported by the crop-residue. This still leaves a large number of adult milch cattle, plus other small livestock, which need to be supported through regeneration of pastures within the periphery of the PA.

- Since landless as well as small farmers without irrigation can hardly afford to keep milch animals, they tend to depend mainly on agriculture of the largefarmers with irrigation, and also on collection of MTFP + fuel wood from the PA. Nevertheless, increased irrigation leads to depletion of ground water resources at the expense of soil-moisture and availability of water inside the PA. Reducing the use of irrigation for growing water-intensive crops may result in stagnating/ declining demand for labour on farms. But this could be compensated by increased availability of fodder and MTFP from pastures, possibly by applying irrigation within and outside the PA.

- Enhancing the livestock base among landless/small farmers without irrigation, thus needs to be preceded by a realistic assessment of livestock population in the periphery and carrying capacity of the PA. The reported livestock population of about 95,000 in 1991 appears to be an over estimation. With an average of 2-2.5 livestock per household, the total population among approximately 30,000 households in the periphery may work out to be around 60-75,000. The recent droughts in the late 90s might have further reduced the number closer to the lower end of the range i.e. around 55-60,000. A realistic estimate of livestock in the peripheral villages is therefore, quite crucial for assessing the requirement as well as pressure on the PA.

- Against the various economic services, people in the periphery have to face several difficulties, especially when protecting the crops and livestock from wildlife. While the actual incidence of crop damage is not very significant, the efforts and the risk involved in protection is fairly high.

- A large proportion of people recognize the present level of dependence on the PA as non-sustainable. While they consider conservation as necessary, they don't endorse the present system of protection and restrictions, which in their opinion, leads to corruption and over-exploitation of the PA-resources.

- People's expectations from PA-management are availability of fodder through a regular supply system, limited grazing rights, fuel collection, and employment in PA-management activities. Settlement of the issues pertaining to land acquisition are also an important concern, absence of which leads to non-cooperation among a large number of villages that have lost a part of the community pastures or private land to the PA.

Benefits and Costs of PA-Conservation

The total value from various economic services from the PA is estimated to be Rs. 477 million, of which about 20 percent is comprised of the various direct use-values like fodder, fuel wood, irrigation, etc. The estimated fodder value is based on the national average of Rs. 3000 kgs/hectare for the Indian forest. Since there are no systematic estimates of the production of a large number of (MTFPs) available from the PA, we used the national average to estimate the market values. We tried to keep a downward bias for estimating the benefits, so that they do not

become unrealistic vis-à-vis the estimated cost of investment, necessary for regeneration of the PA.

Valuation of Non-Use Benefits

More than direct as well as indirect use-values, non-use benefits have special relevance in the context of a protected area. These include benefits like existence value, rarity and aesthetic value, option value, cultural value and ecological value. Assessing the monetary value of these benefits however, is difficult. Alternatively, what we have attempted here is obtaining stakeholders' perceptions about the relative importance of some of these non-use benefits in comparison with the benefits of direct as well as indirect use, the value of which we have already estimated. This will provide some kind of an indirect assessment of the non-use value of the resources within the PA.

We have tried to assess the value of non-use benefits by obtaining a relative ranking of various functions/services provided by the PA. The exercise is based on the perceptions obtained from a sample of 162 households in four villages in the periphery of Gir. The relative score is highest for fodder as well as fuel, closely followed by vegetation and biodiversity. The next group contains the other environmental services like rainfall, wildlife and soil conservation. Benefits like NTFPs, timber and income-employment were among those, which are perceived to be relatively less important from the viewpoint of the perceived benefits from conservation of the PA.

We also tried to capture the relative importance of the five major attributes of the Gir-PA by obtaining people's perceptions about the desirability of conservation of the PA. This was obtained by asking the respondents to rank the five major attributes, which can be broadly classified as Watershed Functions, Rarity of Lion, Bequest value, religious-aesthetic value and consumptive value (grazing + fodder). Apart from consumptive use, people in the peripheral villages attach significant importance to the religious-aesthetic aspects of the PA, which is closely followed by watershed services, rarity and bequest value. It may be noted that the religious aspect has a close link with the overall ambience of the forest ecology and its aesthetic value. It is clearly believed that the religious spots may also lose their importance if the forest/ vegetation get deteriorated.

Cost of PA-Management

Budgetary Allocation and Expenditure

The estimated budget for the period (1995-2000) is Rs.598 million, of which Rs.187 million (45%) is contributed by the GEF-supported Eco-Development Project (EDP). The average budget for the year is estimated to be Rs.119 million. The proportion of the budgetary resources allocated for measures that have direct bearing on regeneration of the PA is about 52.4 percent of the total budget, including the Eco-Development Project. Compared to this, a significantly large proportion of the budget is allocated for infrastructure and recurrent expenditure. Moreover, the budgetary allocation for regeneration measures noted above also has some components that may not have a direct impact on regeneration. For instance, the amount spent on tourism, socio-economic and village eco-development could be spent in a manner that may not directly improve vegetation and other ecological aspects with the PA. A similar pattern is also observed in the actual expenditure for Gir region, which also includes Barda Sanctuary. In fact, if one looks at the component of soil-water conservation (SWC), it is fairly low i.e. < 4 percent.

It is possible that the PA-region is also receiving benefits from other on-going schemes like Watershed Development from the Ministry of Agriculture and Rural Development. A large proportion of expenditure on Integrated Forestry Management could yield better results if the SWC-component is also properly integrated with it. The important point is that of 'appropriate' allocation of resources, especially when funds are limited.

The Eco-Development Project constitutes a major proportion (31.45 %) of the total expenditure. If the major part of expenditure under the Eco-Development Project is on development/support to the household's immediate requirements like land leveling,

deepening of bore wells, purchase of agricultural employment/inputs, or obtaining alternative sources of fuel and building material, as it appears to be true in a large number of cases, regeneration of vidis and degraded forests may once again take a back seat in the total expenditure on the PA. The management team often finds it difficult to obtain permission for regeneration of village pastures from eco-development funds. Encroachment of the pastures and illegal grazing in the degraded forest in the peripheral villages is another important issue that constrained utilization of funds for some major activities like fodder development/nutrient enrichment programmes in the region.

Overall, a comparison of monetary benefits and costs suggests that the former is significantly higher than the average budgetary allocation for the PA management plan. Even if we compare the value of direct use benefits, the estimates are fairly higher than the actual expenditure. A summary of the major benefits and costs has been summarized in chart 2.

Chart 2

Summary of Benefits and Costs (Rs. Lakh at 1995-96 Prices)

Value of Benefits		Value of Costs	
Details	**Value**	**Details**	**Value**
Direct Use	9669	Average Budget for Management per year	1191
Indirect Use	37883	Crop Damage	419
Opportunity Cost	39524	Loss of livestock	143
Loss of Crops to replace the fodder	2592		
Potential loss of fodder	1170		
Soil Loss	9793		

Impact on Environment:

The substantial gap between direct economic benefits and the cost of PA management seems to have led to inadequacy and/or slower pace of regeneration measures. This, along with climatic factors and human interference, as large as 34 per cent of the area is categorized as degraded or highly degraded. Obviously, this would lead to environmental costs that need to be checked as early as possible. For instance, the Gir region is presently classified under 'high' degree of soil erosion. Based on this categorization, we have tried to estimate soil loss from the Gir PA. The estimated loss amounts to Rs. 979 million per year. Mitigating this loss may trigger a chain of positive impacts such as: improved soil-productivity, better vegetative cover, increased availability of fodder and fuel, increased income from crops and livestock, and above all, better rainfall and thereby reduced risk of drought which is of prime importance to the people in the peripheral region. The task is to check soil erosion and regenerate degraded land within and outside the PA.

The reported low vegetation density within the PA may also affect the carbon-sink function of the ecology. We have tried to estimate this by using the estimated densities of teak and miscellaneous trees. The total c-stock in the Gir eco-system is estimated to be 6.58 Tg. There is significant scope to improve this ecological function by improving the status of vegetation within and outside the PA.

While soil-water conservation is considered to be the basic treatment for changing the scenarios of environmental as well as economic services, major constraints are faced by the PA management in terms of financial resources.

Alternative Approaches for PA Management

The Forest Department of the Government of Gujarat has already worked out the second phase of the management plan, envisaging a special focus on regeneration of pastures, and also a significant expansion of the home range in order to sustain a population of 500 lions. This of course, is a detailed plan for resource management, people's livelihood and implementation strategy. Given the need for regeneration of vegetation within and outside the PA, and the critical role of soil-moisture and water thereof, we have tried to explore alternative land and water use planning for the region.

Since SWC is a resource intensive activity with a long gestation period of about 7-10 years, the initial investment has to be funded by external resources. Convincing fund-givers / sponsors

(national or international) would require a realistic assessment of the impact of resource regeneration, and sharing a part of the regenerated resources with the local stakeholders, so as to mitigate the future loss in terms of continued pressure and degradation within the PA. Lessons from the Eco-Development Project in Gir and other PA sites should get integrated into the fresh planning. Some of the important suggestions for the next phase of the PA management have been highlighted as follows:

Components	Costs	Benefits
SWC to be given a top priority	Average cost Rs.15-20000/ ha, including the cost of water harvesting structures	Triggers a chain of improvement in terms of: Availability of soil-moisture Improved vegetation in PA Providing fodder+fuel through regulated operations Reduced illegal extraction and grazing Saving of the value of soil-loss Employment generation
Regenerating vidis within PA through additional inputs to be used as incentives to reduce irrigation and grazing	Average cost of Rs.10,000/ ha (including seedling, water, manure, labour)	Replenishing groundwater Reallocating water to CPLRs and vidis Reduced damage due to illegal grazing within PA
Regeneration of CPLRs in periphery	Fodder + plantation Rs. 35,000/Ha	Better employment + income to small farmers +landless Reduced dependence for fodder, fuel-wood, illegal felling Reduced risk of fire
Institutional arrangement for collection of fodder, fuel and NTFP	Involving a professional developmental agency to arrange supply and distribution at a reasonable price	Saving of cost of drought relief programmes Reduced impact of droughts Reduced pressure on PA Reduce conflicts with FD-staff and better cooperation Improved quality of livestock Reduced pressure of grazing Preventing entry of outside animals
Mobilisation of Funds	Loan from national govts. Grant from environmental groups and donor agencies Credit support to people	Evolving a mix of incentives through Increased availability of resources, cost-sharing, and subsidies rather than subsidies and compensation alone

Recommendations

- While regeneration of vegetation should primarily look into the requirements of the wildlife in the area, it should, at least for the next 10-15 years, also provide a stable supply of fodder, fuel, and NTFP through a regulated management system adopting the 'cut and carry' method. Improved vegetation and habitat management should thus, ensure that incidence of attack on crops and wildlife is reduced. A professional agency might be involved to help organize the supply system. At present, the allocation for soil-water conservation accounts for only 3.85 percent of the total budget. This needs to be increased significantly.

- Soil-water conservation measures should take a lead in the process of regeneration of the ecology. This should be done by adopting the ridge-to-valley approach, covering the entire area of the major watersheds in the region. This is critical for reducing the frequency as well as impact of droughts. In turn, it should also result in improving the soil-moisture profile, and promoting a more sustainable use of ground water resources in the periphery.

- While the management plan has already envisaged development of irrigated fodder plot in the periphery, its actual implementation is found to be difficult. The experience of the Eco-Development Project is also not so encouraging with respect to regeneration of Common Property Land Resources (CPLR) in the peripheral villages. Hence, development of pastures within and outside the PA should be undertaken as an integrated activity with people's participation and reciprocal commitment for protection. The next phase of the Eco-Development Project, focusing mainly on community pastures and other resources should therefore be closely interlinked with the plan for regeneration of pastures within the PA.

- Given the high cost of an effective resettlement package, the present approach of relocation of the Maldharis within the PA boundary appears reasonable. Nevertheless, the Maldharis within the PA should be made to adhere to the norms of a 'sustainable' size of livestock and replenishment of FYM for

regeneration of the PA. Against this, some basic amenities like housing, schools, electricity, drinking water, and health services should be provided to the households, which should shift close to the PA boundary. For the Maldharis who have already shifted outside the PA, a comprehensive plan for their effective rehabilitation on various land-based activities should be worked out. This is essential not only for checking further deterioration of their livelihood base, but also for mitigating the problem of 'illegal' re-entry of human as well as livestock population into the PA.

- A large number of visitors coming to the PA for pilgrimages could be reoriented towards eco-tourism by involving environmentally conscious leaders / organizations for sustainable development in the region. This could also help strengthening the institutional base in the region.
- The management plan needs to be strengthened by filling up some of the crucial information gaps. These include assessment of vegetation and changes over time; carrying capacity in terms of wildlife as well as livestock; dependence of human and livestock population within and outside the PA; size and status of CPLRs in the periphery of the PA; and interface between regeneration of vegetation and habitat management. These are some of the crucial aspects on which information is not readily available in the public domain. It is pertinent to recognize that filling this information gap is an essential pre-condition for designing a management plan for the PA. This is particularly important at this stage of the PA management, when the initial objective of conservation of wildlife is more or less achieved, and the task ahead is to strengthen the process of ecological regeneration.

Given the large area of the PA and also in light of the perspective plan for a still larger home range for its core wildlife specie, i.e. the lion, it is essential that the next stage of the PA management is much more interactive and inclusive of the people in the region. The above suggestions should thus, be appreciated in the context of the long-term goal of a sustainable management of the Gir PA.

Economics of Protected Areas : A Case Study of Pench National Park

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Introduction

The establishment and management of Protected Areas (PA) has been one of the most important ways of ensuring conservation of the world's natural resources and biodiversity to meet the needs of the present as well as future generations. The modern concept of conservation is a combination of three principles - to plan resource use on the basis of accurate inventory; take protective measures to ensure that resources do not get exhausted, and consider stakeholders perceptions. The present study was undertaken to focus on issues associated with Pench National Park (PNP), such as the dependence of local stakeholders on PNP, status of biodiversity, tourism and fishing, and estimation of cost-benefits to the local community.

Importance of Pench National Park

Most nations consider it desirable to protect outstanding examples of their natural heritage, and acknowledge that this is a contribution to the worldwide effort to protect living resources and conserve biological diversity. The Pench National Park contributes significantly to such tangible and intangible benefits to mankind. The study of Pench National Park is important as the general physiognomy and floristic of the tiger reserve are indicative of the two types of forests – Southern Tropical Dry Deciduous Teak and Southern Tropical Mixed Deciduous Teak. PNP is very rich in its faunal representation and most of the wild animals prevalent in the area, have taken shelter here . It is also equally rich in the floral diversity. PNP serves as a living repository of various economical, medicinal, aromatic, ornamental plant species. It has such potential values so as to perceive the real worth of this beautiful treasure house of nature, which must be protected as a part of our national heritage. The importance of this study is based on an attempt to highlight the ecological, faunal, floral, conservational, employment generation, educational and research value of PNP.

Objectives

The main objectives of the study are to:

- Identify the stakeholders of PNP.
- Estimate the dependence of the local population in and around the National Park for biomass consumption, and examine the impact of human intervention on the biodiversity status of the PA.
- Identify and estimate the benefits and costs of PNP.
- Suggest short term as well as long-term policy measures for management of PAs and conservation of natural resources for sustainable economic development.

Study Area

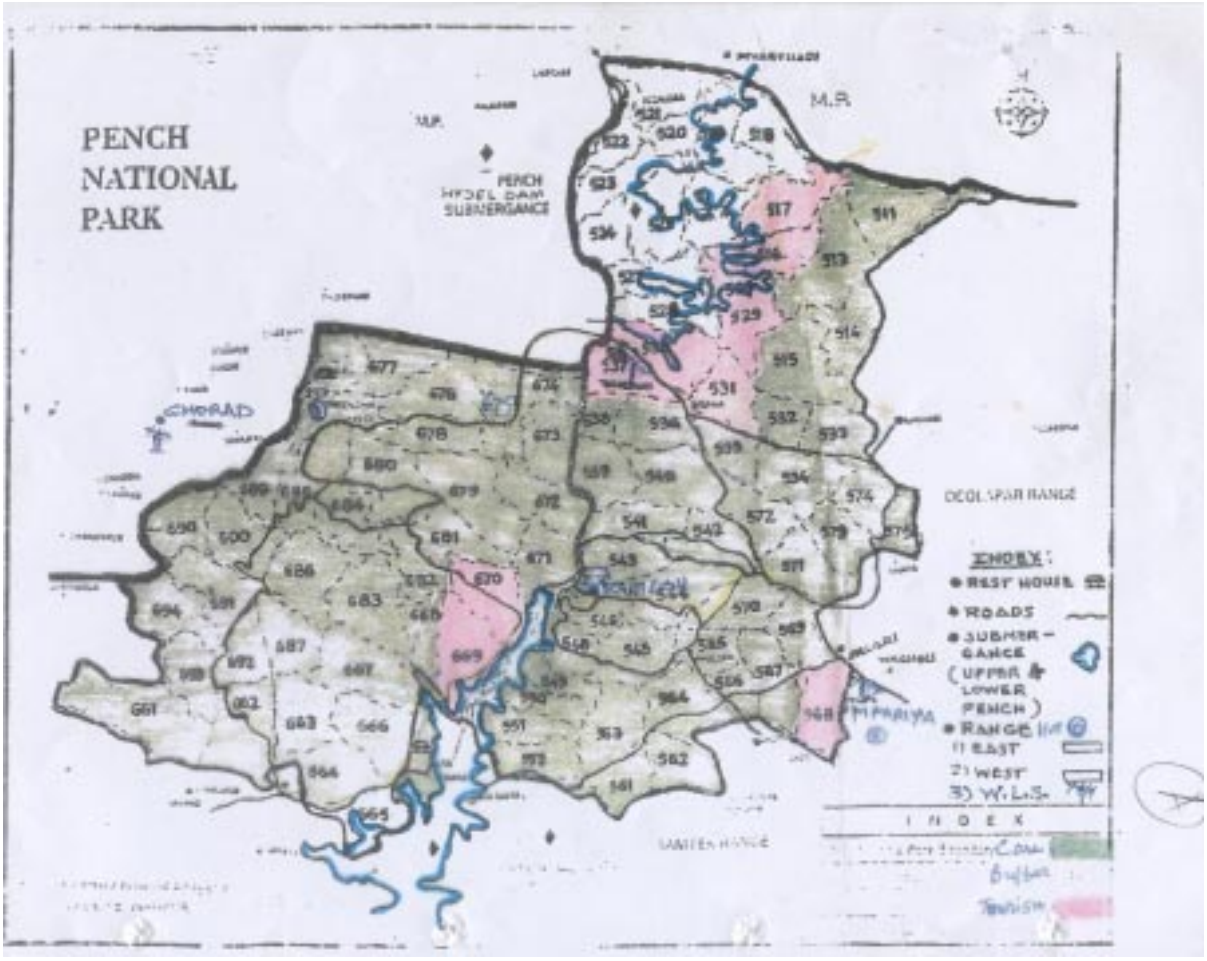
Pench in Maharashtra was declared the 25th Tiger Project in 1999. It is a magnificent forest and boasts a healthy population of predators and prey. In 1975, it was formally declared a protected area known as 'Pench National Park'. After years of protection and conservation, it was included in the Network of Project Tiger.

The Pench Tiger Reserve (with National Park Status of 257.26 sq. km.) derived its name from the river Pench that flows through the reserve in a north-south direction. It is about 67 km from Nagpur by road on the Nagpur-Jabalpur National Highway.

Methodology

Data was collected by using both primary and secondary sources at two levels:

- Village level
- Forest level



The methods adopted to estimate resource dependency of local communities in and around the PA involved the following steps: (1) questionnaire survey; (2) personal observations; (3) monitoring of entry points at village boundary; and (4) monitoring of selected households.

A combination of both census and sample methods were used to collect relevant information. A complete census of 42 households was undertaken to examine their dependence on the forests of PNP. The parameters for explaining dependence were identified to facilitate econometric analysis of the data by using the technique of multiple regression analysis.

A 33 percent sample of surrounding villages within 10 kms of the PNP boundary were drawn by stratification of villages in three distance zones, i.e. 1 to 3 kms, 3 to 5 kms, and 5 to 10 kms. The total area under the eleven sample villages is 2,077.17 hectares with 895 households. A 10 percent random sample of households from each village were drawn for detail investigations. The status of biodiversity was studied by taking the internationally accepted method, i.e. IFRI for taking a sample of plots in the core zone, tourism zone and other zones in proximity to the villages. With the help of this method, the impact of human intervention on the status of biodiversity was examined. The demand for tourism was estimated by using travel cost method. The log linear model was used to quantify the dependence of locals on fishing in PNP.

Main Findings of the Study

An attempt has been made to identify the main parameters of dependence. Income from forest and forest related activities has been estimated to assess the degree of dependence on PNP for the village Fulzari, lying within the

PA as well as for the villages surrounding PNP within a radius of 10 km of PNP. Resource use pattern of tribal communities has also been examined to quantify their dependence on PNP for fuel and fodder.

Dependence of Fulzari Village

Occupational distribution of the population of Fulzari village shows agriculture as the main source of livelihood. Almost 43 percent of the population is engaged in cultivation. However, agriculture contributes only 16.87 percent to the annual average income of the village. Low productivity of land and small size of land holdings are the main factors for disproportionately small income originating from agriculture. This has been a major factor in enhancing their dependence on the forest of PNP as a source of livelihood. Landless population constitutes almost 48 percent of the total population. Landless villagers find only a meagre source of income either as agricultural labourers or as forest labourers. Working as agricultural labourers supports only 12.5 percent of their income, whereas income from forest labour offers them employment opportunities, and thereby generates only 5 percent of the total income. For quantification of income from agriculture, shadow prices have been used. Self-consumption and non-marketability of agricultural produce has compelled researchers to use this technique for estimating income from agriculture.

The resource use pattern of the village community in Fulzari also shows heavy dependence on forests for fuel and fodder. Almost 32.7 percent of the imputed value of the household income comes from fuel wood. In the absence of any other source of fuel, the dependence on forests is almost total.

The dependence of the livestock population on forests is also equally high The imputed value of fodder for grazing is estimated at Rs.1,738.00 per household annually, constituting 54 percent of the total income of the households in Fulzari. Agricultural waste contributes only marginally in meeting the requirements of fodder to the livestock population of the village.

The resource use pattern of households in Fulzari shows the importance of the Non Timber Forest Products (NTFPs) in contributing a major source of livelihood to the tribal communities in the village. The prominent NTFPs found in the forest of PNP, and collected by the villagers are Charoli, Amla, Gum, Bamboo, Tendu leaves, Mahua flowers, etc. Household surveys show that 44.22 percent of the annual average income of the village households is derived from NTFPs. In spite of legal restrictions on the collection of NTFPs, this dependence on the forests is quite high. Almost one-third of an average household's income is earned through collection of NTFPs. Dependence of the village community on timber for construction of houses has also been found to be significant. The imputed value of timber for construction of houses for the village is estimated at Rs. 10 lakh at current prices.

Dependence of Sample Villages on PNP

A sample of households from three distance categories within 10 kms of the PNP boundary i.e. 1 to 3 kms, 3 to 5 kms and 5 to 10 kms - show equally high dependence of village communities on the forest. Distribution of households according to different occupations show that in 80 percent of the villages, the proportion of the households working as cultivators is more than 70 percent. The proportion of households working as agricultural and forest labourers is also equally high, and constitutes 80 percent of the households in Wagholi village, followed by Ghatpendhari village.

The dependence of village communities as reflected in income derived from forest related activities, shows heavy dependence on the forests of PNP. In villages like Kolitmara, Khapa, Tuyapar, Ghoti Dahoda and Kadbikheda, more than 50 percent of the annual income of the household is obtained from forest related activities. Only three villages have other sources of income like fishing, hunting and government service.

Income from non-forest sources like agriculture, self-employment, and dairy, have contributed around 40-50 percent of the income of the households, with wide variations for different distance categories of villages. The common feature of all the sample villages, where dependence on agriculture as a source of livelihood was found to be high, has been to relieve the pressure on the forests to some extent.

The estimate of dependence of local communities for fuel-wood consumption shows per capita consumption of fuel-wood at Rs.704 annually. The dependence of livestock population on the forests also shows equally high values. The total annual consumption of grass for the sample households is reported at 3,35,720 bundles of grass. The estimates based on local market rates shows monetary value of dependence at Rs.0.34 million. These are gross underestimates, as these villages are prohibited from extracting forest resources from PNP.

Three variables, fishing, income from agriculture plus agriculture labour, and collection of firewood, explain more than 87 percent of the dependence of Fulzari households on the PNP

Table 1: Regression Results for Fulzari

Dependent Variable: p1

Independent Variable	Estimate	t-value	p-value
Constant	97.940	26.274	0.000
Firewood2	7.061	2.22	0.033
Fishing	—0.00341	—11.442	0.000
P2*	—0.899	—13.366	0.000

$R^2 = 0.873$

* P2 = income from agriculture and agriculture labour

Fishing, income from agriculture plus agriculture labour (p2), and firewood2 are the variables that have significant impact on household's dependence on PNP. Out of these variables, p2 and fishing have a negative impact, whereas firewood2 has a positive impact.

The regression results for the sample households of the combined sample (Fulzari + Other Villages within 10 kms) are presented in the following table:

Table 2: Regression Results

Dependent Variable: p1

	Combined Sample		
Independent Variable	**Estimate**	**t-value**	**p-value**
Constant	36.198	9.579	0.000
NTFP	0.001489	4.478	0.000
Hunting	0.002137	2.369	0.019
Fishing	—0.00134	—2.182	0.031

R^2= 0.216

All the four exogenous variables together explain a 21.6 percent variation in the dependence of the households of villages in PNP.

In the case of these households, the exogenous variable NTFP seems to be playing a very important role in determining the dependence on PNP.

Biodiversity Status

The study describes the biodiversity status of PNP by providing a checklist of the fauna and flora in PNP. A sample of plots from the core zone, tourism zone and other zones with high probability of human intervention has been drawn to test the impact of human intervention on the vegetation structure and status. The study shows that Pench biodiversity is negatively affected by tourism, but not necessarily due to grazing and construction and other extraction by the people living close to the Park boundary. Because of the proximity of revenue forests, the locals fulfil their basic needs from there. They utilize natural resources only for small timber, fuel, and for other non timber forest products like fruits, leaves, gum, medicinal plants, grass for thatch, etc.

The study also attempts quantification of some major tree species for the sample plot of 250 m x 400 m, by calculating market value of these tree species. Separate quantification of timber and fire wood value is attempted for Tendu, Dhawada, Salai, Moie, Bija, Haldu, Kalam, Shiwan and Saja. The estimated timber value amounts to Rs.4.52 lakh, and the fire wood value is Rs.32,000, resulting in a total timber and fire wood value of Rs.4.84 lakh for the plot. An inventory of medicinal plants in PNP and their medicinal use have also been attempted to show their use in curing various diseases and their valuable potential contribution in the preparation of life saving drugs.

Tourism

The tourism aspect of the study focuses on the role of the protected area as a source of recreational benefits. The Travel Cost Method was used to estimate demand for tourism. The visitors to Pench have been divided into three tourism zones i.e. Nagpur, M.P and Mumbai. Various functional forms like linear, log linear,

etc, were estimated to find the best fit. The endogenous variable used in the model is the total number of visits from Zone I to Site m. Exogenous variables are population of zones, mean income of zones, entrance fee, characteristics of zones, travel cost from zones (TC) to substitute site, entry fee in substitute site, and quality characteristics of wildlife viewing available at substitute site.

The constant term that captures the joint effect of the factors exogenous to tourism in PNP has a statistically significant positive effect. This implies that the prevailing environment and infrastructure in PNP are not conducive for tourism. However, the positive signs of the constant terms for the entire three samples indicate that there is scope for tourism development. Tourism, so far, has not posed any threat to the environmental aspects of PNP.

Fishing

The role of fishing in PNP, and the dependence of local communities on fishing for their livelihood is also an important issue of the study. The estimated growth rate of fishing is 5.9 percent. The value of R^2= 0.07.

The estimated growth rate indicates that in spite of sufficient stocking of fishes and fingerlings, the harvesting is very low. This further implies that it is not at all a threat to the water bodies or environment.

Cost Benefit Analysis of PNP

Quantification of the various benefits and costs of PNP at cross section data set has been attempted. The benefits from forests, in the form of income from NTFP, grazing of livestock, environmental benefits - oxygen, soil conservation, etc., income from tourism or benefits from recreation in PNP, biodiversity benefits, etc. have been quantified as far as possible. The incidental benefits from water supply, irrigation and power supply have also been estimated.

Direct as well as indirect cost of PNP has been estimated. The cost of maintaining PNP, establishment cost, opportunity cost of labour in PNP, cost of resettlement, crops damaged by wild animals, have been measured to focus the cost of PNP.

Table 3: Estimates of Cost & Benefits

A) Estimates of Costs

Sr. No.	Items	Estimate of Cost (Rs. in Lakh)
1.	Resettlement (Fulzari)	179.47
2.	Land Development	81.40
3.	Crop Damage (Fulzari + 11 Villages)	4.30
4.	Opportunity cost of labour time spent in NTFP (Fulzari + 11 Villages)	10.79
5.	Environmental loss (Construction and submergence)	3.31
	ESTIMATE OF TOTAL COST	279.27

B) Estimates of Benefits

Items	Income from (Rs. in Lakh).	
	Fulzari	11 Villages
1. NTFP Collection	2.31	7.08
2. Hunting	0.27	0.01
3. Fishing	1.10	0.32
4. Forest Labour	0.26	5.14
Total	**3.94**	**12.55**

Recommendations

Based on the findings of the study, the following policy recommendations are suggested:

Economic Upliftment of Target Groups in and around PNP:

The small and marginal farmers, as well as landless tribal population constitute the target group for provision of income / employment opportunities. Their dependence has roots in poverty and lack of employment opportunities in non-forest based economic activities. Low agricultural productivity appears to be a major factor for their low livelihood status. Economic development plans for these target groups need to be directed towards improving productivity in agriculture or providing them with alternate sources of livelihood. These groups may be provided technical, financial, logistical support to improve yield from land, or training facilities in agro-based industry.

Providing Local Communities in and around PNP with Alternate Source of Fuel:

The major threat to conservation of valuable natural resources arises from lack of alternate source of fuel like LPG, Kerosene, Gobar gas, solar cookers, etc. The lack of purchasing power to use LPG, Kerosene or solar cookers may be one of the major reasons for heavy dependence on PNP for fuel wood. The Forest Department's schemes of providing Gobar gas to the locals seem to have created only a marginal impact on the villages in and around PNP. The huge ownership of livestock population will certainly work as an asset to extend the services of Gobar gas to most of the households.

Establishment of Herbal Research Institute:

The cultivation of medicinal plants in the agricultural fields owned by the local population may be popularised by emphasising their value in curing and preventing life-threatening diseases. The establishment of an Herbal Research Institute may help the local people to transmit their traditional knowledge of medicinal plants, which is on the verge of extinction in the absence of intergenerational transmission. Special institutions may be created to preserve this knowledge if family institutions no longer serve this purpose.

Involvement of Local Communities in the Management of PNP:

The observations based on the sample of biodiversity plots have shown no adverse impact on regenerative potential of vegetation due to human intervention. This indicates the awareness of tribal communities in ensuring sustainable use of forest resources. No conservation strategies will succeed in India unless the biomass requirements of the locals are harmoniously integrated with conservation of resources. For sustainable development of PNP and conservation of natural resources, a management plan embracing the goal of conservation without adversely affecting the livelihood of the local communities needs to be evolved on priority basis. The present emphasis on exclusive management of PNP needs to be changed by inviting participation of locals in various conservation activities. In designing the management plan of PNP, collaborative participation of academicians, research scholars, social workers, and most importantly, the stakeholders of PNP should be facilitated. Workshops may be organised to initiate participation of this cross section of the population in the formulation of management plans of PNP. The management plans should focus on:

- **Awareness Creation:** Strengthening of the interpretation centre at Sillari, Construction of auditorium, audio-visual aids, publicity material, etc.
- **Capacity Building and Research:** Training provided to staff, research and monitoring for scientific management, research on floristic and faunistic forest wealth, regeneration survey of PNP, establishing links with governmental and Non-government organisations / institutions
- **Management:** Use of funds collected through the entry fee, beautification of Ambakhori, conversion of Ranidoh Forest Rest House to Ranidoh Research Centre, environmental education for sustainable development, creation of new water holes, etc.

Eco-Tourism Plan

The eco-tourism plan should focus on the following objectives of tourism:

- Picnic sites
- Education and Research
- Religious tourism

An attractive package should be created for tourists, which may include audio-video publicity, educating tourists, organisation of nature camps, imparting training to local people, etc. Facilities to be made available to the tourists should include machan rest houses , transport facilities, development of picnic spots, children's park, etc.

With the implementation of these suggestions, tourism activities are likely to create demands of different forms. Some of the avenues can be – repairs of various vehicles, boating and fishing etc. Two types of visit plans for tourists can be arranged during:

- Summer or leave-shedding period
- Lush green (spring) period

The development of agro-eco tourism development plan will be useful for the local people, particularly the tribals, whose livelihood is highly dependent on agriculture. The plan should aim at improving the material life of the local people. It should involve educating farmers, local communities, government officials, NGOs, as well as industry tourists.

Promotion of eco-tourism is one of the main goals of National Parks and Tiger Projects. The occupational structure of locals in PNP is highly skewed in favour of cultivators, which necessitates promotion of economic activities conducive to the development of agro-eco-tourism. The age structure of the population with a predominance of youth may be a blessing in disguise for the development of tourism related activities. Failure to provide employment opportunities to these youngsters may impose a high social cost of resettlement.

If the above policy recommendations are translated into policy decisions, Pench National Park will be a “paradise” of flora and fauna” and a model Tiger Project for the region.

Economic Analysis of Biodiversity Conservation: A Case Study of Tropical Forests in the Western Ghats

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Introduction

Tropical forests cover 14 percent of the earth's land surface (8 mil.sq.km). They are rich in biodiversity. Half of all vertebrates, 60 percent of known plant species, and possibly 90 percent of the world's total species are found in tropical forests. The Western Ghats of India spread over five states of South and Western India (i.e. Kerala, Karnataka, Tamil Nadu, Maharashtra and Goa), is one of the eighteen biodiversity hotspots listed in the world. The Nilgiri Biosphere Reserve is located in this region. It is a treasure house of several known and unknown flora and fauna, including several endangered species such as the Lion-tailed macaque, Nilgiri Thar, Nilgiri Langur, Malabar Civet, Malabar giant squirrel and Asiatic Elephant among others. Due to demographic and economic pressures, market failures and inappropriate policies, the biodiversity of the region is under various stages of degradation and therefore, needs to be conserved through appropriate policies and adequate measures.

Objectives

The objectives of the study are to:

- Assess the benefits of biodiversity conservation as against alternate land use options of forests.
- Assess the socio-economic and institutional factors inhibiting or promoting biodiversity conservation, and people's perceptions and attitudes towards biodiversity conservation and wildlife protection.
- Estimate the Willingness to Pay or Willingness to Accept compensation for participatory biodiversity conservation.
- Assess the institutional alternatives and mechanisms for conserving biodiversity without retarding growth.

Data and Methodology

The study is based on both secondary as well as primary data collection. Secondary data was gathered to provide basic information on the biodiversity of the Western Ghats and of the study regions. Analyses of the changes in land use pattern, human and livestock pressure on land and forest resources over time in the selected districts are also carried out so as to serve as a backdrop to the in-depth study based on primary investigation.

For the present study a cluster of tribal villages/hamlets in Mysore district were selected, which are in the vicinity of the Nagarhole Wildlife Sanctuary which has witnessed considerable tribal unrest due to the establishment of the sanctuary, covered under the World Bank aided Ecodevelopment project. These included a coffee-growing village in Kodagu district of Karnataka and two farming villages in Uttar Kannada district having close interaction between agriculture, livestock and forests. These villages were selected purposively, after consultations with forest department and village officials.

The data for the in-depth study has been collected through a sample survey of households/respondents. Data has been collected on the following:

- Socio-economic data of sample households, covering demographic particulars, operational holdings, income, etc..
- Cropping pattern.
- Cost and returns from crop production and other allied activities such as livestock rearing and forest-based activities.
- Extent of dependence on forest resources (land, timber and NTFPs) and value of forest products extracted.

- On-farm consumption and marketing of forest products.
- Respondents' perceptions and attitudes towards biodiversity conservation.
- Respondents' Willingness to Pay (WTP) or Willingness to Accept (WTA) compensation for forest conservation / protecting wildlife species (e.g. elephants).

The survey covers 303 households/ respondents from the selected villages to elicit information about the extent of their dependence on forests for various socio-economic activities, their production activities and income, on-farm consumption and marketing of forest products and also to elicit their value preferences for diverse forest products and services.

Sampling Design

A two-stage sampling design was followed to conduct the in-depth study. Maldari village in Virajpet taluk of Kodagu district, which is close to a reserve forest, where coffee growing is predominant, and where man-animal conflicts are conspicuous, was selected. This village has a mix of coffee plantations of different size groups including some managed by large companies. Households in this village were listed and selected on stratified random sampling based on land holding categories and other criteria such as coffee growing, etc.

In or near the Nagarhole sanctuary, due to the small size of tribal villages or hamlets (some having just 10 or 15 households), a cluster of tribal villages or hamlets were selected in order to have a reasonable sample size. Eight tribal villages or hamlets, viz., Nagapura, Dammankatte, Sungattkatte, Kaimara, Nannachi, Kolangeri, Ganakoor and Majjighalli were selected for an in-depth survey. Of these, Nagapura is a rehabilitated village outside the sanctuary, whereas Dammankatte is a non-rehabilitated village near the periphery of the sanctuary. The remaining six tribal villages or hamlets are located within the sanctuary. All the households within the selected cluster of villages were surveyed. A total of 100 households were covered out of 250 households in this cluster of tribal villages.

In the case of Uttara Kannada again due to the small size of villages and the requirement of a reasonable sample size, a cluster of two agricultural villages, viz., Kegdal and Badakanasirada in Haliyal taluk of Uttar Kannada district were selected for our sample survey. Of them, Kegdal is within the Dandeli wildlife sanctuary and Badakanasirada is outside the sanctuary. All the households in these two villages were surveyed for an in-depth study. This included 32 households from Kegdal village and 48 households from Badakanasirada village, making a total of 80 households from this region.

Thus, in all, the study covered about 303 households from these villages or cluster of villages located in Kodagu, Mysore and Uttar Kannada districts.

Analytical Techniques Used

While collecting data the following analytical techniques were used:

- Cost benefit appraisal, contingent valuation method (discrete choice methods), logit or probit models, descriptive cum tabular statistics, and averages and proportions.
- Survey method and Contingent Valuation Method (CVM) to estimate the use and non-use values of the tropical forests.
- The dichotomous method or discrete choice method, which seeks simple "yes" or "no" replies to an offered bid, was used for the contingent valuation method (CVM) study. The discrete choice method is preferred over other methods (e.g. open ended methods) since it would be easier for villagers to understand and respond to the question. Also households could respond keeping some budget constraint in view i.e. the upper bound on bids could be controlled. This method also minimises any incentive to strategically over-state or understate WTP. Dichotomous choice methods require the use of parametric (typically logit or probit) probability models relating yes or no responses to offer amounts, the computation of an expected mean, and relating the WTP or WTA response to relevant socio-economic and other variables.

Major Findings

The following are the major findings of the study:

- An analysis of land use and crop pattern changes in the selected regions between 1960-61 to 1996-97 reveals that the net area sown and total cropped area as a proportion of the reporting area has risen for Karnataka and selected districts and Taluks in Kodagu, Mysore and Uttar Kannada. This increase in net area sown has largely come due to reductions in area of other land use categories such as permanent pastures and grazing lands, land under miscellaneous tree crops, cultivable wastes, etc. Total forest cover in the country and Karnataka seems to have increased slightly over the time period under review. Across districts it is seen that while Kodagu and Uttar Kannada report a marginal decline in their forest cover in recent decades, Mysore district interestingly records a marginal rise in the forest cover. This however, doesn't tell us anything about the forest and biodiversity in these three districts, which are degraded in many parts due to encroachments and other human interventions. An analysis of crop patterns and changes over the same time period, reveals that the relative share of crops like rice and banana which are highly prone to attacks from wildlife like elephants and wild boar have declined in the selected areas, which may be a coping strategy by farmers to reduce losses arising from damage to these crops by wildlife. Area under coffee cultivation has increased rapidly in Kodagu district and Virajpet Taluk in particular.

- The population pressure on forests and other natural resources are increasing over time. This trend is more conspicuous in Karnataka and the three districts under review.

- The livestock pressure measured in standardised animal units per hectare of forest and other natural resource has increased from 1961 to 1990 in Karnataka as compared to all-India figures/trends. Among the three districts, Mysore reported relatively greater pressure per hectare of forest area as compared to Kodagu and Uttar Kannada districts. However, a rising trend in livestock pressure per hectare of forest area is seen in Uttar Kannada over the last three decades.

- The opportunity cost of biodiversity conservation in terms of the foregone coffee benefits among the sample farmers in Maldari in terms of net present value (NPV) would be about Rs.1,94,900 per acre at 8 percent discount rate, and Rs.1,38,500 per acre at 10 percent discount rate, assuming a time horizon of 50 years. When the external costs of coffee production such as damage due to wildlife and preventive costs are also added, the NPV declines to Rs.1,88,500 per acre at 8 percent discount rate, and Rs.1,33,300 at 10 percent discount rate. Across land holding groups these benefits in terms of NPVs are positive and significant for all strata of holdings. Sensitivity analysis revealed that even if the expected benefits from coffee were to decrease by 20 percent and costs rise by a similar proportion, the benefits from coffee would still be positive and significant (IRRs range between 19.5 to 20 percent). Out of the total external costs incurred by coffee growers, 57 percent is due to damage caused by wildlife. The average damage cost due to wildlife attack was estimated at Rs.331.2 per acre, and the cost of preventive measures at Rs.196.5 per acre.

- The foregone benefit due to biodiversity conservation from Non-Timber Forest Products (NTFP) in terms of Present Value among sample Nagarhole tribals was estimated at Rs.67,123 at 8 percent discount rate, and over Rs.57,076 at 10 percent discount rate, assuming a time horizon of 25 years.

- The foregone benefit of biodiversity conservation in terms of paddy and cotton production among the sample farmers in Uttar Kannada in terms of NPV was estimated at over 29,400 per acre at 8 percent discount rate for paddy (excluding external costs), and Rs.23,400 (including external cost), assuming a time horizon of 25 years. For cotton, the NPV was Rs.56,801 per acre at 8 percent discount rate. The external costs of agriculture due to damages from wildlife were estimated at Rs.566 per acre.

- The foregone grazing benefits of biodiversity conservation among the sample farmers in Uttar Kannada in terms of Present Values was estimated at Rs.19,481 per standardised animal unit at 8 percent discount rate, and Rs.16,566 per standardised animal unit at 10 percent discount rate assuming a time horizon of 25 years. Aggregating over the animal units owned by the sample farmers this worked out to about Rs.6.43 million (at 8 percent discount rate), and Rs.5.47 million (at 10 percent discount rate) for the same time horizon.

- As regards attitudes towards biodiversity conservation and wildlife protection, majority of the sample households had a positive attitude. Regarding biodiversity conservation, the sample farmers in Kodagu felt that biodiversity should be conserved due to its value for future generations, its ecosystem functions, and use value for developing new products. The Nagarhole tribals emphasised its livelihood functions, importance for future generations, aesthetic and recreation values as well as its ritual and cultural values. The sample farmers in Uttar Kannada emphasised its ecological functions and livelihood aspects for biodiversity conservation.

- Elephants, which are a keystone species, and are vulnerable in the study area, were the focus of the study. Sample farmers in Kodagu, Nagarhole and Uttar Kannada emphasised the existence value of elephants, their beauty and use value for domestic work.

- A CVM study revealed that sample farmers in Kodagu were willing to spend 25.8 human days on an average per household per year for participatory elephant conservation, which amounted to over Rs.6,003 per household per annum in terms of the opportunity cost of income foregone.

- A logit function which related the "yes" or "no" responses to Willingness to Pay for Participatory Elephant Conservation in Maldari, Kodagu district, to a number of variables revealed that land ownership, age settlers and a dummy variable for decentralised government institutions were the significant variables influencing the yes or no responses of the sample farmers.

- In Nagarhole and Uttar Kannada, Willingness to Accept (WTA) Compensation was found to be more relevant. A probit function of Nagarhole respondents which related the "yes" or "No" responses to WTA to selected variables revealed that age, sex and income were the important variables influencing the "yes" or "no" responses. Nagarhole tribals, who report more income from work in neighbouring coffee estates, are reluctant to move out of the sanctuary due to uncertainty about their future, especially if relocated far from the coffee estates. Older people and women are also less likely to prefer to move out of the sanctuary. Those not willing to accept the rehabilitation package to relocate outside the Nagarhole sanctuary cited difficulty and uncertainty in coping with new surroundings, protests from community leaders, etc., as major reasons.

- A majority (96%) of the sample farmers in Uttar Kannada were willing to participate in participatory conservation. On an average, the villagers were ready to spare 85 hours in a year for activities related to elephant conservation. In terms of the opportunity cost of time of foregone labour benefits, this was estimated at Rs.585 per household in a year (assuming a wage rate of Rs.7 per hour).

Economic Valuation of Ecological Functions and Benefits: A Case Study of Wetland Ecosystems along the Yamuna River Corridors of Delhi Region

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Introduction

Wetlands are one of the most threatened ecosystems in the world. Whether they are mangroves, paddy fields or lakes, they are disappearing or are getting degraded owing to the process of urbanization, industrial and agricultural activities, and other formal and informal encroachments from various economic agents. At the formal decision-making level too, contribution of wetland ecosystems is ignored due to their public good/ Common property nature. Wetland ecosystems provide innumerable tangible and intangible benefits to society, but somehow they remain away from the domain of the market force. Thus, these benefits are left as "external" to the management decision makers of this natural resource, which keep getting depleted and degraded over time. Perhaps the most threatened riverine ecosystem in India is the 25 kilometer stretch of the River Yamuna, extending from Wazirabad to Okhla. It faces anthropogenic pressures on the riparian habitat, particularly in the floodplain areas. The ecological services performed by the wetlands in the river corridor region provide immense benefits to human society. The floodplains of the Yamuna River have continuously been confronted by the encroachments and conversions of land for various commercial purposes, threatening the very existence of this wetland. If the economic valuation is done for the wetland of the Yamuna River, a conservation strategy can be developed in a convincing manner with adequate justification for investable funds for the purpose. The question before policy makers and planners is whether this habitat needs to be conserved to maintain ecological functions, or used for alternative purposes. To address this issue, it is imperative that the wetland ecosystems be identified and delineated and their ecological functions quantified in a way that is suitable for economic analysis.

Objectives

The objectives of the study are to :

- Delineation of the floodplain areas and their ecological functions e.g. water recharge, nutrient retention, habitat to biodiversity, recreation and other biological productivity.
- Identification of crucial flora and fauna sustained by these floodplain wetlands.
- Estimation of economic values of ecological functions of floodplain wetlands.
- Estimation of total economic value of these floodplain areas in terms of user and non-user benefits.
- Providing rationale for conservation and sustainable use of the wetlands of Yamuna floodplains.
- Contributing towards the policy formulation for planning of Delhi in a more comprehensive and sustainable framework.

Study Area

For identification, delineation, mapping, and valuation of wetlands, the study area was divided into three sectors:

Wazirabad to I.S.B.T.	= Wazirabad Sector
I.S.B.T. to I.T.O.	= I.T.O. Sector
I.T.O. to Okhla	= Okhla Sector

Exact location and size of the different wetland ecosystems were mapped using Geographic Positioning System (GPS) during the field surveys where the GPS coordinates of a particular type of wetland were recorded. These geographic coordinates were then used to show the distribution of different wetland types on the toposheet of the study area.

Floodplains

Floodplains are the areas between man-made embankments and the levee of the river channel. These areas are inundated with water during floods. Floodplains are used for a variety of purposes, which include dry season agriculture and temporary makeshift human settlements, natural vegetation of the floodplains is today restricted to small pockets near the Wazirabad barrage. These pockets harbour pure strands of *S.munja*. The local people use a major portion of the floodplains for practicing dry season agriculture.

Seasonal Pools

Seasonal pools are present predominantly on the western banks of River Yamuna. These pools are formed due to the filling up of water after floods in the low-lying areas of the river corridor region. Seasonal pools are spread in both Wazirabad and I.T.O. sectors. These pools dry up during the late winter and summer seasons, and human settlements come up in their place. The seasonal pools abound with a large number of commercially important fish species. Local people fish in these waters for about 4-5 months every year. Water present in the seasonal pools also recharges the ground water of the neighbouring areas in a gradual and sustained manner.

Marshy Areas

Marshy areas are spread from Chilla regulator to Okhla barrage. *Typha angustata* is the dominant plant species present in the marshy areas. Fragmentation and destruction of marshy areas have taken place due to the construction of the Noida toll bridge and other civic structures. Marshy areas present on the banks of the Yamuna River provide nesting and feeding grounds for many migrating waterfowl species. Thus, marshy areas are of prime importance with respect to their potential to act as waterfowl habitat.

The extent of these wetland types were mapped out by field surveys of the respective areas. The area of various wetland types is given below:

Types of Wetland Ecosystem: Area in Ha

Floodplain	3100
Marshy Area	110
Seasonal Pools	40
Total Area of Wetlands:	3250

This floodplain area is shrinking due to the rapid urbanization of Delhi. In this way, valuable ecological functions and their corresponding benefits are irrevocably lost. The major hurdle in the process of an efficient decision regarding sustainable use of these natural resources is generally due to the lack of a monetary value of these functions so that it can be incorporated into extended cost-benefit analysis of the conversion of these areas.

Methodology and Data

Since the identification of the area of floodplains in the Yamuna Basin is a complex issue, we primarily depended upon the data generated through the primary experiments and observations. Scientists of our investigating team, especially ecologists and hydrologists, have gathered information pertaining to ecosystem functions of floodplains through physical mapping and laboratory-based experiments. The data gathered was further verified through ground-truthing and consultation with the scientists working in this area at institutes like the Indian Agricultural Research Institute and the Central Ground Water Board.

Various methods followed for evaluating the functions and benefits accruing to the stakeholders have been provided in Table 1 and the findings are summarized in Table 2.

Table 1: Estimation Methods of Different Ecological Functions of Yamuna Floodplain

S. No.	Ecological Functions	Benefits	Beneficiaries	Valuation Methods
1.	**Water Recharge**	i) Low-cost irrigation cultivation ii) Potential source of water supply	Farmers in floodplains Households in Delhi	Production Function Approach Alternate cost of water supply
2.	**Nutrient Retention (N P)**	i) Fertility of soil	Farmers in floodplains	Replacement Cost Approach
3.	**Biological Productivity** I) Fish Breeding and Fish Fry II) Sustenance to the Grass ecosystem	i) Fisheries Production i) Fodder production ii) Thatching Grass Production	Local people & Government Departments Local people Local people	Market Value Indirect Substitution Method Market Value
4.	**Habitat to Wildlife and Cleaning of the surrounding water**	i) Recreation, Existence and Bequest Values	Local and general people in the region	Contingent Valuation Method (CVM)

Table 2: Annual Economic Estimation of Selected Ecological Functions of the Floodplain

S. No.	Ecological Functions	Value (in Rs. Lakhs)			Remarks
		Min.	Max.	Mean	
1.	Water Recharge Benefits to Agriculture	535943	535943	535943	• Production function for six major crops have been estimated from the cross section survey of farmers in the floodplains • Only water input has been allowed to be used optimally. • Cost of pumping of water has been linked with the fuel cost (variable cost only).
2.	Water Recharge Benefits to the households of Delhi Region	511	609	560	• Alternate cost of water has been estimated for different sources of supply. • The cost of supply includes raw water cost, transportation cost and treatment cost. Distribution cost has been excluded. • For calculation purpose, only that water, which reaches the aquifer in the study area, has been considered.
3.		1.66	3.44	2.55	• The cost in procuring the equivalent amount of N, P & K through the chemical fertilizers (Urea, DAP and Muriat or Potash) has been treated as the nutrient retention benefits. • Maximum and minimum values of nutrients are according to the availability of nutrients along with the amount of sediments in the flooding season.
4.	Biological Productivity				• Two prices (composite) i.e. contract and market gives the lower and higher estimate. • Current market price of fodder gives the higher value, while opportunity cost of labour to collect the equivalent quantity of fodder gives the lower range of value. • Primarily two types of grasses namely *S.Munja* and *T.augustata*, which are in great demand for Mats and Roof purposes. • Here, the production of Watermelon, Sweetmelon etc. have been accounted.
	i) Fishery	377.28	503.04	440.16	
	ii) Fodder	5.57	342.43	174.00	
	iii) Thatching Grass	4.82	6.02	5.42	
	iv) Others (production of Cucurbits etc.)	19.20	19.20	19.20	
		213.00	277.74	245.37	Under Contingent Valuation Method (CVM), through the dichotomous choice questionnaire has been used to derive the value for use, bequest and existence values. Choice of model (linear and log-linear) gives the range of values.

Preservation vs. Development of Land Uses in the Floodplain Area

The study shows that the benefits of preservation of land under floodplain as they exist currently, far exceed the benefits of conversion of the same land for other uses e.g. township development, industrial activity, etc. The benefit-cost analysis performed on the preservation of land versus conversion of the floodplain area sufficiently justifies the preservation argument.

Since these floodplains are part of the metropolitan area of Delhi, there is a constant pressure on this area for conversion for different developmental activities like construction,

industrial township and thermal power stations, etc. Also, a major part of the floodplains area has been encroached upon by illegal slum dwellers. The developmental benefits of the floodplains are slightly problematic, as far as their estimation is concerned. Since the developmental activities are heterogeneous and involve substantial cost on which reliable information is not available, computation of developmental benefits became difficult. One good approximation of developmental benefits could be the price of the land paid by the development agency like Delhi Development Authority (DDA). This one-time price paid by the DDA may be treated as the discounted value (Capitalized Value) of all the development benefits accruing over a period of time extending to infinity.

The B/C ratio varies from 6.91 to 1.15 at 2 percent and 12 percent rates of discount respectively. Such a favourable ratio eminently justifies the conservation arguments on the basis of efficiency criteria. Moreover, a few ecosystem functions, e.g. bioremediation and recharge of distant aquifers, remain unaccounted and unpriced in this study due to time and resource constraints. In any case, this exercise provides a rationale for preservation of this floodplain. This also suggests that any activity like channelization of the river, which impairs the health of floodplain ecosystems, should be avoided.

Recommendations

- The annual flow value of ecological functions of the floodplains of the Yamuna River is quite substantial. This value is much higher than the return or alternate uses i.e. for housing and industrial activities.
- The value of habitat and recreational element of the floodplain is also very significant. Since the area of the floodplain has considerably reduced due to the rapid urbanization of Delhi, the relative value of these areas will increase exponentially as Delhi continues to expand at the present rate. Therefore, keeping alive this productive ecosystem is crucial for the city planners and the public.
- The loss of ecological functions provided by floodplain inflict a heavy cost on society in terms of its tangible and intangible benefits. Among all the values, the value of water recharge function is highest. Since the urban ecosystem of Delhi is water scarce, the conservation of the floodplain becomes a prerequisite.
- As recharged water into the aquifer from Yamuna floodplain area is of very high quality, maintenance and preservation of this wetland will substantially save the treatment cost of water, which the city of Delhi would have to meet otherwise.
- Since the floodplain provides habitat to a large number of bird species in the Okhla Bird Sanctuary, and the Willingness To Pay (WTP) for preservation of biodiversity is quite high, floodplain preservation needs added attention. Water is already a scarce commodity and in coming years, it is going to be more scarce and precious. Any human activity impairing the water recharge function of the floodplain ecosystem will create problems not only for the present but future generations as well.
- The River Yamuna should be allowed to flow as a river in Delhi. This would be possible only when a minimum level of water is allowed in the river round the year. The volume of water, which is diverted at Wazirabad barrage, should be determined keeping this fact in view.

Economic Valuation of Bhoj Wetland for Sustainable Use

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Introduction

The Bhoj wetland, located in the heart of Bhopal city, is a prime example of a wetland ecosystem vulnerable to degradation due to multiple uses by a rapidly increasing urban population. The various benefits that accrue to multiple stakeholders from this wetland are either under priced or not priced at all. The existing management strategy of the wetland does not value these various environmental services.

Objectives

The objectives of the study are to:

- Value various wetland benefits / resources so that planners and policy makers can make appropriate allocation of wetland uses and services.
- Develop a socially acceptable, environmentally sound and economically feasible strategy for Bhoj wetland management.

Study Area

The Bhoj Wetland comprises of two lakes: the Upper Lake and the Lower Lake. In 1988 the Ministry of Environment & Forests (MoEF) of the Government of India declared the Upper and the Lower Lake to be a Wetland of National Importance. Bhoj Wetland is among the 16 wetlands in India to be included in the National Lake Conservation Plan (NCLP). In 2002, MoEF declared it as an internationally important wetland by including it in the Ramsar Convention list. The present Upper Lake is the highly diminished remains of a large lake constructed by Raja Bhoj in the 11th century. Its catchment area measures 361 km^2 and it has a water-spread area of 31 km^2. The Lower Lake also known as the Chota Talab or Small Lake is situated towards the east end of the Upper Lake and is almost fully surrounded by built-up areas. It has a small catchment area of 9.60 km^2 and a water spread area of 1.29 km^2. The Lower Lake receives its inflow in the form of seepage from the Upper Lake in addition to the drainage coming from 8 nallahs or drains. The water level is maintained at a constant point by regular outflow through a waste weir at Pul-Pukhta into Patra Nallah.

Multiple Uses of the Bhoj Wetland

The Bhoj Wetland provides:

- Drinking Water: Nearly half the city's drinking water supply comes from the Upper Lake, which provides 64.4 million litres of water per day. This is the most important use of the wetland, directly impacting the welfare of the citizens of Bhopal.
- Employment: The Wetland directly and indirectly provides employment to various communities like fishermen, washermen, boatmen, vendors and others. Approximately 300 families are engaged in fishing and trapa (water chestnut) cultivation while about 100 washermen make their living from the Wetland. There are approximately 50 boatmen whose livelihood depends on the Bhoj Wetland.
- Microclimate Stability: The microclimate of Bhopal is quite moderate as compared to the surrounding areas. According to its geographical location, the city should actually have an extreme type of climate. The Wetland's moderating effect on temperature however, results in cool land breeze during the evenings which make the environment of the city enjoyable, even during the peak of summer. Vegetative cover adds to this effect.

- Recreation Opportunities: The Wetland offers recreational activities to the people of Bhopal such as boating and other water sports, as well as scenic views.

Threats to the Wetland

The Bhoj Wetland faces major threats from siltation, solid waste pollutants, sewage, pollutants resulting from washing clothes, trapa cultivation, encroachment, increasing population, weeds and eutrophication, boating, agricultural waste, idol and tadjia immersion, and hospital waste on account of excessive use by large numbers of stakeholders.

Methodology

The study first identified the various stakeholders of the Bhoj Wetland through a pilot survey. Following this, a stakeholders' workshop was conducted to identify the management issues of the Bhoj Wetland. The stakeholders' workshop used the 'Sticky Cloth and Paper' method to facilitate discussion. The multiple stakeholders were identified as the entire population of Bhopal city, washermen, boatmen, water chestnut or trapa cultivators, fishermen, NGOs, various line departments, and corporators of different wards, among others.

Stakeholders of the Bhoj Wetland

- **Entire Population of Bhopal city** – for drinking water and recreation
- **Lake front property owners** - for aesthetic beauty
- **Washermen** - for washing clothes in the lake
- **Fishermen** - for fishing activities
- **Trapa cultivators** - for cultivating trapa
- **Water supply agencies** - for water purification and distribution
- **Bhopal Municipal Corporation** - for management of the Lake
- **Department of Housing & Environment, Govt. of Madhya Pradesh** - for decision making processes
- **Madhya Pradesh Tourism Development Corporation (MPTDC)** - for tourism development on the lake
- **Vendors** - for secondary benefits

Three major issues, viz. sewage and waste disposal, fishing and washing activities and recreational activities were recommended to be addressed for sustainable management of the wetland. This was followed by development of an ecosystem model using STELLA software based on water quality parameters. Various simulation runs were carried out by changing the parametric values. The results of the modelling exercise were used for scenario building to administer the valuation techniques such as Contingent Valuation Method (CVM) and Hedonic Pricing by conducting a sample survey of all the wards of the Bhopal City.

Results

Ecosystem Modelling of the Bhoj Wetland Using Water Quality Parameters

The main objective of the Ecosystem Modeling of the Bhoj Wetland was to understand its physical characteristics to enable stakeholders to have a better understanding of the resource which is to be valued.

An ecosystem model using the water quality parameters was developed to study the current status of the lake, followed by changes in these parameters over the last few years. The model was also used to project the status of the Upper and Lower Lakes in the future, based on past data and information from the restoration activities currently being carried out. A base scenario was developed and then by changing the value of various parameters, simulation runs were carried out.

The basic ecological parameters brought under the purview of the conceptual model for the Bhoj Wetland are sewage and proliferation of weeds. The other water quality related parameters like Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH, Total Hardness, Total Alkalinity, phosphate, Turbidity, Total Dissolved Solids (TDS) and Bacterial Count are correlated with these variables and with each other. Their dynamics in the lake's ecosystem is studied. Data from seven out of 32 Quality Monitoring Stations were used for water quality parameters representing different kinds of pressures on the Upper and Lower Lake.

An advanced ecological model was developed using a system's dynamics software package STELLA. A model was developed representing the base scenario and simulation runs were carried using data of 1991-92 and 1999. The scenarios so obtained actually represent the health of the lake ecosystem and stress the need to value the impact of the changing health of the lake on an economic system. They further throw light on prioritization of future policy interventions, which shall be required if the lake is to be sustainably managed.

Economic Valuation of Wetland Benefits

The scenarios so obtained through ecosystem modeling exercise were represented through various visual presentations and figures. These graphs were then converted into picture cards for easier explanation of status of the lake to the respondents in the survey. Having attempted the ecosystem modeling and knowing the extent of degradation and threats, valuation was undertaken so as to cover the extent of monetary benefits or losses to various stakeholders where benefits are directly or indirectly marketed. As the benefits as well as the users are multiple, a spectrum of valuation techniques have been used to capture the economic value of various uses.

The valuation exercise included: calculating the benefits of supplying drinking water to the city; the value of benefits accruing to various people whose livelihoods depended on the wetland; the value of preventive measures that people used to avoid water borne diseases, and the willingness of the people of Bhopal to pay for enjoying better recreational facilities from the Bhoj Wetland. In addition to this, the effect of the presence of the Upper Lake on the value of property prices was also studied and estimated.

Valuation of Recreation

To estimate the recreational value of the Bhoj Wetland, all 66 wards of the city covering 1500 households were surveyed, as this value accrues to all the residents of Bhopal. The technique of CVM was employed to obtain the willingness to pay by people (WTP) for improved recreational facilities at the Bhoj Wetland. The CVM was administered through a questionnaire-based survey with an initial open ended, followed by closed ended bidding model. The questionnaire comprised of attitudinal questions and scenario building. Two types of payment vehicles were proposed - one in the form of a voluntary payment to the body that would undertake the management of the Bhoj Wetland in the future; and the second, a compulsory tax imposed on the people of the city, the collections of which would go to this maintenance society.

The following were expressed by the people in terms of the WTP in terms of the voluntary payment and tax (Table 1). The values so obtained were then extrapolated for the entire city to estimate the value of the lake in terms of recreation (Table 2).

Table 1. Mean and median willingness to pay voluntarily (FINVOL) and in the form of tax (FINTAX)

	FINVOL	FINTAX
Mean	537.85	219.17
Median	241.00	29.50

Table 2: Estimated WTP For Entire City

Median FINVOL per household per annum = Rs 241/-	Total Number of households in City = 2,01,116	Total Voluntary WTP per annum = Rs 48.4 million
Median FINTAX per household per annum = Rs 29.50/-		Total WTP as tax per annum = Rs 5.9 million

Valuation of Property Prices

This valuation exercise attempted to calculate the proportion by which the closeness to the Upper Lake affects property prices. For this exercise, people's attitudes and the importance they give to particular factors while buying a piece of property, were studied. In the second step property prices in particular areas of the city were obtained, and these areas were then

ranked against parameters of neighborhood, proximity to markets, ease of access, environment, housing density and presence and absence of the lake. A regression model was created for this equation and from that, the effect of the presence of the lake on property prices was gauged. The analysis found that the price of a site near the lakes, similar in all other respects to a site away from the lakes, would be nearly 50 percent higher.

Comparative analysis of Various Values

Various other values generated incomes to stakeholders from activities like fish production, boating, Trapa cultivation, washing of clothes, and secondary selling activities, among others. Then the values were measured in terms of cost incurred by the population for treatment of water borne diseases, as well as the cost of getting high-quality water. Agencies incurred supply costs to purify and distribute water. The values so estimated using various valuation techniques are summarized in Table 3.

Table 3: Estimation of Economic Values of the Bhoj Wetland (Annual 1999-2000)

Uses / Impacts	Stakeholders	Valuation Techniques	Value (in Rs.)
A. Drinking Water	Water supplying agencies	Supply Cost	9,54,13,962
B. Fish Production	Fishermen	Market Price of Existing Production	80,00,000
C. Boating	Boatmen	Income Estimation	24,37,880
D. *Trapa* cultivation	*Trapa* (water chest nut) Cultivators	Market Price of Existing Production	50,00,000
E. Washing of clothes	Washermen	Income Estimation	36,00,000
F. Secondary Activities			
Maize cob selling	Maize Cobb sellers	Income Estimation	1,44,000
Sugar cane juice selling	Sugarcane juice sellers	Income Estimation	2,73,600
Snacks &cold drink stalls	Individual owners	Income Estimation	2,06,400
Horse rides	Individual owners	Income Estimation	7,92,000
MPTDC	MPTDC		
a. Cafeteria		Revenue Generation	18,00,000
b. Boating		Revenue Generation	6,74,635
G. Water borne Diseases	Population using lake's water	Cost of Illness	12,00,254
H. Quality water	Population using lake's water	Purification Costs	1,24,35,876
I. Recreation	Entire population of the city	CVM (i) As Voluntary Payment (ii) As Compulsory tax	4,84,68,956 59,32,922
J. Increase in property prices	Lake front property owners	Hedonic pricing	50% higher property prices

Conclusion

It is evident from the Table 3 that the drinking water, recreation and property attributes command high values from the lake, whereas other income based values are important to specific sections of the people. All the values so estimated have not been aggregated, as some stakeholders use the lake for multiple values and such overlapping could not be avoided. Other important values like biodiversity and microclimatic effects have not been estimated due to lack of availability of data. The undertaken exercise however, does give a good insight of the multiple values that have not been considered to the extent possible in the current management activities.

Further, even if one is able to collect the revenue through what people were willing to pay in the from of voluntary payment to the society (Rs. 4,84,68,956 per annum), or in the from of tax to the government (Rs. 59,32,922/- per annum), the amount so collected would be much more than the existent estimated cost of maintenance of various subprojects of the Bhoj Wetland agency (Rs. 80,70,00/- per annum), if the collected revenue is from voluntary payment and reasonably collects 74% of the amount through taxes. With this, it is hoped that the authorities would keep the following recommendations in mind while implementing the current work and also before taking up fresh activities in the Wetland.

Technical Recommendations

The following suggestions are proposed to effectively implement the restoration sub-projects:

a. ***Preventive measures:*** Floating fountains have been put up in the Lower Lake at huge costs without completing the garland drain project, responsible for stopping sewage from entering the Lower Lake. As a result, on the one hand, sewage continues to flow unabated into the Lower Lake, while the floating fountains are supposed to aerate the Lake. The effect of the fountains is thus negated, and cannot be observed unless the flow of sewage is stopped.

b. ***Problems with the road:*** The Retghat–Lalghati Road has been constructed on the left bank of the Upper Lake, and is supposed to act as barrier to prevent encroachment. However, sewage through neighbouring colonies continues to flow underneath.

Policy Related recommendations

The critical need today is to recognize the inter-linkages and benefits that could be obtained if the Wetland is managed in an 'integrated manner' and is 'sustainably used'. It is a challenging task and requires action at many levels as well as delicate integrity of diversity of issues and management institutions. Such an approach must begin with involving all stakeholders in the Wetland in the form of a local area institution. This would be helpful in eliciting their views for the use and future management of the Bhoj Wetland. The Institution so formed could frame an action plan to cover all ecological, economic, social and institutional issues. To cover the above issues, the following set of policy recommendation is proposed:

- People's Participation
- Effective co-ordination
- Transparency in the System
- Setting up of a Bhoj Wetland Management Committee
- Economic Valuation
- Setting up of a Management Fund
- Cost Benefit Analysis
- Promotion of Eco-tourism
- Development of View Points
- Prioritisation of Activities Using Simulation Runs of the Proposed Ecological Model.

Integrated Management of Water Resources of Lake Nainital and its Watershed: An Environmental Economics Approach

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Introduction

It is widely recognised that water resources are greatly influenced – both qualitatively and quantitatively – by their catchment (watershed or drainage basin). Though the impacts of water pollution have been discussed from the viewpoint of environmental economics in several studies, the impacts of catchment-based activities have received little attention.

This project takes an integrated approach to understanding the problems of availability of water resources and aims at bringing an environmental economics perspective into water resources management by evaluating the resources of both the Lake and its watershed. Since the dependence of the lake on its watershed is emphasised, the lake condition is analysed both in relation to human activities in the watershed as well as in-lake activities. The study explores the hypothesis that if catchment-based degradation factors are not taken care of, the cost of conservation of the lake ecosystem would increase multi-fold.

Lake Nainital along with its watershed in Uttranchal was selected for the present study in view of its importance for at least two major ecosystem services: (i) as the major water source for the township of Nainital, and (ii) high recreational value for tourists. Since tourism is the principal economic activity in Nainital, the presence of the Lake becomes life supporting for the local population. Besides, it is a lake where the lake and its watershed are intimately connected.

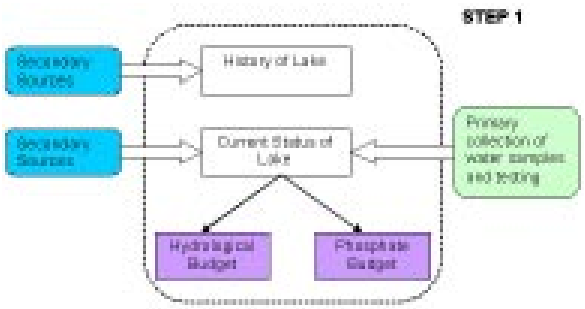
Objectives

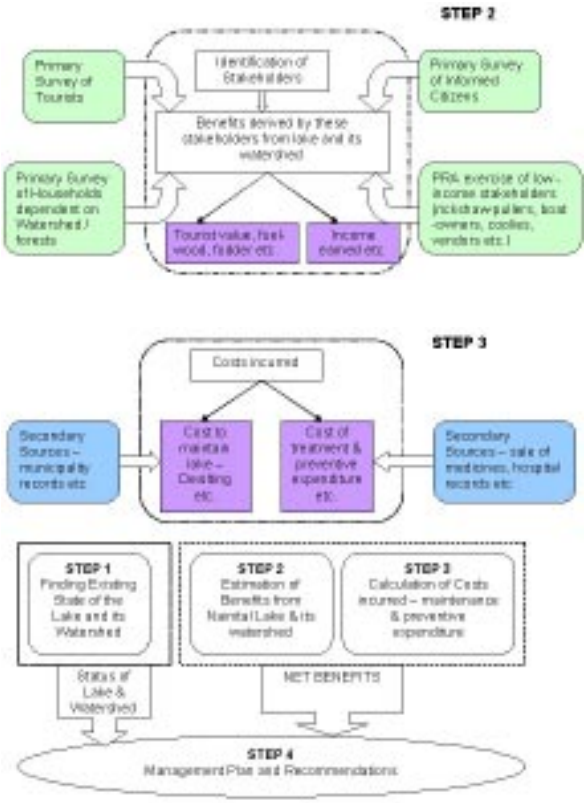
The specific objectives of the projects are to:

- Estimate costs and benefits of resource use of Lake Nainital and the lake watershed as well.
- Estimate cost of water quality degradation in Lake Nainital and its relationship with anthropogenic activities in the watershed.
- Develop a resource management policy for Lake Nainital and its watershed.

In order to meet the objectives of the study, both primary and secondary data was collected. The lake water quality was ascertained using secondary data as well as testing of samples at different points in the lake. On the other hand, the pollutant load to the lake was found from the water samples taken from the inflows and outflows to the lake. The primary survey involved interviewing tourists, households dependent on the watershed especially forests, and informed citizens of Nainital town. Besides these, a PRA (Participatory Rural Appraisal) exercise was carried out on a number of low-income stakeholders – boatmen, horsemen, coolies, rickshaw-pullers, vendors, etc. – entirely dependent on the Lake and its watershed for their livelihood. The entire exercise of meeting the three objectives was carried out in the following four stages / steps (Figure 1).

Fig. 1: Different Steps followed to fulfil Project Objectives





Organisation of the Work

The work is organised in seven core parts. Part 1 gives in brief the historical sketch of Lake Nainital and its watershed, the current status of the lake and how the status has changed in the past and what are the factors contributing to these changes. Part 2 identifies the stakeholders and the possible values they derive from the lake. Though different stakeholders are benefiting from a unique ecology of the lake, the whole is much greater than the individual sum. The clear indication of this synergy effect is the tourism activity in Nainital. The tourists visit Nainital for the whole and not for an isolate and individual attribute. What values do they give, or in other words, how much they are willing to contribute to preserve the ecology of the lake forms Part 3. A revealed preference method, i.e., the Travel Cost Method, has been employed to calculate the tourist values.

It is generally argued that stakeholders are narrow in their viewpoint. The profession shapes their views / perceptions. For instance, a boatman would be more concerned with the well-being of the lake health; horsemen might wish to concentrate on peaks; tourists visiting Nainital will be more interested in the features around the lake and in the peaks, etc. Most of them would disregard, or are unaware of the services of the Lake and its watershed. It is the informed or aware citizens, who would value a natural resource for its totality not for an individual aspect. Part 4 is an attempt to look into how the informed citizens of Nainital perceive valuation exercises as such and which aspect of the Lake and its watershed they view as the most important for humankind and to the system.

The questionnaire method adopted in Parts 3 and 4 concentrates on responses from individuals. However, it is argued sometimes that they remain passive contributors. Therefore, in order to complement the questionnaire method, Participatory Rural Appraisal (PRA) exercise was carried out, which seeks the opinion of different stakeholders. Part 5 gives in brief the PRA technique and the results obtained therein from the exercise. Part 6 calculates the direct benefit in the form of fuel wood and fodder as obtained from the forests followed by summarising the benefits derived from the Lake and its watershed. Part 6 also gives the costs of maintenance or cost incurred by individuals to prevent any illness (i.e., preventive expenditure). The analysis shows that the Lake and its watershed provide innumerable tangible (and intangible) benefits to the local economy. The continuation of these benefits in the future requires proper maintenance and management of the Lake and its watershed. The last part is devoted to the management aspects and incorporates both technological and institutional components of management.

Study Area

Ecology of the Lake and its Watershed

Discovered first in 1841, Nainital (29°24' N latitude and 79°29' E longitude at 1,938 m above sea level) is one of the major hill resorts of North India. It supports a resident population of about 40,000 (with a floating population of nearly 7,000 during tourist season) and attracts 3-4 lakh tourists annually within a small area of 11-12 km^2.

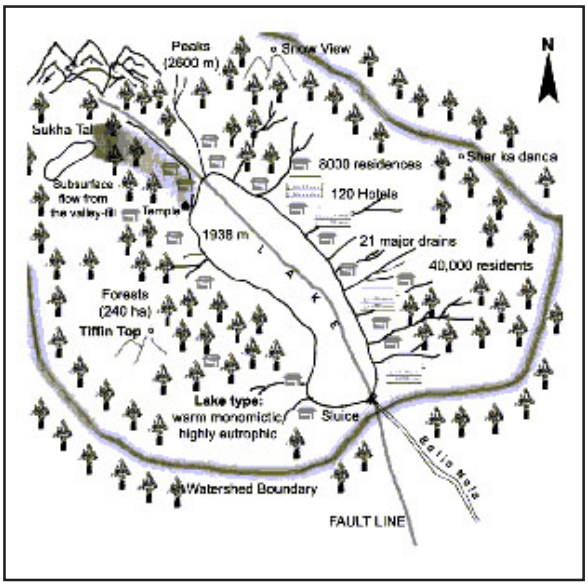
Of this, about 5 km^2 area that forms the watershed of the lake is densely populated. The climate is temperate monsoon type, with annual rainfall generally ranging between 200-250 cm. Geologically, Nainital is extremely complex and fragile, characterised by landslide scars and fans, and debris cover, mostly associated with the Nainital Fault that separates the lake and watershed into two roughly equal parts (Fig. 2). Already seven major landslides have occurred during the last century.

The lake receives water from its catchment through 21 major drains, springs, runoff and subsurface inflows (Fig. 2). The hydrological budget of the lake shows that most of the water in the lake owes its origin to the watershed in the form of surface flow (25%) and subsurface inflow (42.8%). Direct precipitation accounts for only 15 percent of the total annual inflow. However, much of the water that enters the lake is affected by organic and heavy metal pollution. For example, the biochemical oxygen demand (BOD) of the drains range between 60-74 mg/l and bacterial population is up to 1,218 colony forming (coliform) units/ml. The concentration of lead in the lake water often exceeds the permissible level, vehicles and excessive use of lead containing paints particularly on tin roofs being the major sources.

The valley-fill in the catchment is the major source of subsurface water to the lake (accounting for over 40% of total inflow) and is used directly for drinking water supply. The forest cover (mainly oak and cypress) is still substantial, accounting for about 48 percent of the catchment area and providing habitat for nearly 700 plant species and about 200 species of birds.

The lake is small with the following morphometrics: maximum length of 1,423 m, breadth 253-423 m, maximum depth 27.3 m, surface area 48 ha and volume at maximum level 8.58 million m^3. The lake volume is gradually declining due to sedimentation caused by landslides, erosion and illegal dumping of construction waste in drains and on slopes. The young and rising mountains with immature topography are highly vulnerable to destabilising forces. Life expectancy of the lake is estimated to be less than 500 years.

Fig. 2: A sketch of Nainital Lake and its catchment



The lake is warm monomictic with fairly stable summer time thermal stratification and highly eutrophic with almost opaque water (Secchi disk transparency generally less than a meter).

Stakeholders and Benefits they derive from the Lake and its Watershed

As the study has three objectives, to fulfil them it is essential to find out what are the stakeholders in the Lake and its watershed and what benefits they are deriving from the lake and its watershed.

Conceptually, the total value of a system/ resource is the sum of use values – direct, indirect and option - and non-use values. Direct use values can either be consumptive or non-consumptive. In Lake Nainital and its watershed, taking water from the lake for drinking or other purpose is clearly a consumptive use, whereas boating in the lake is an example of non-consumptive value. Lake Nainital and its watershed provides a plethora of consumptive and non-consumptive values, besides having non-use values in terms of existence, culture, bequest, intrinsic, religious and heritage value. The study identifies a number of stakeholders in Nainital Lake and its watershed and the benefits they derive (Table 1).

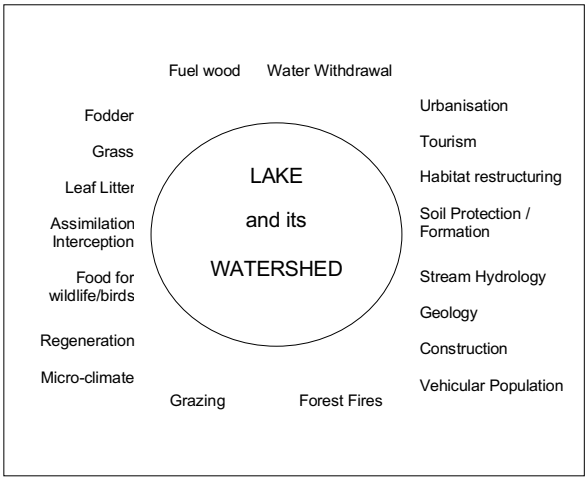
Table 1: Stakeholders in Nainital Lake and its Watershed with Benefits / Values derived

No.	Stakeholders	Benefit or Value Stakeholders Deriving from	Type of Value
1	Local Population	Income generated by hotel and tourism industries	Non-consumptive use value
2	Tourists	Derive services of recreation, education and tourism	Non-consumptive use value
3	Boatman	Lake through income generated from tourism	Non-consumptive use value
4	Horseman	Hills / peaks through income generated from tourism	Non-consumptive use value
5	Rickshaw -pullers, Taxi-owners etc.	Income generated from tourism	Non-consumptive use value
6	Vendors, Shop owners, Petty Traders	Income generated from tourism	Non-consumptive use value
7	Population of Nainital Town	Lake as the source of drinking & other water supply	Consumptive use value
8	Local Municipality	Revenue from the Toll charged from tourists & saving in water-treatment plant costs because of natural cleansing property of lake & its watershed	Non-consumptive use value
9	Lake Management Authority	Responsible for the maintenance of the ecological health of the lake & its watershed such that the economic benefits continue	Non-consumptive use value
10	Low-income group	Income / saving in expenditure through collection of fuel wood, fodder etc.	Consumptive use value
11	Scientists and Ecologists	By putting a premium on the existence value of the lake and its watershed such that research activity continues	Non-consumptive non-use value
12	Non-users	Value the existence of lake & its watershed	Non-consumptive Non-use value

Note: Many of the stakeholders like petty vendors, rickshaw-pullers, horse-owners etc. are not the local inhabitants; they migrate during the tourist season. Hence are given separately.

Thus a large number of stakeholders depend on the Lake and its watershed for a number of goods and services. It is quite ironic that some of these are, in fact the cause of anthropogenic pressure also. Figure 3 gives a simplified summary of anthropogenic pressures on Lake Nainital and its watershed.

Fig. 3: A summary of Anthropogenic Pressure on the Lake and its Watershed



Impact of Anthropogenic Pressure - Problem of Eutrophication

One of the implications of this anthropogenic pressure is that the lake has become eutrophic (i.e., with excess phosphate), and this has adversely affected its recreational and aesthetic values. The population of game fish has declined dramatically, and the lake is no longer used for recreational fishing and swimming. Seasonal oxygen depletion and consequent fish mortality, release of toxins and algal blooms, have become quite common in the lake.

The study has attempted to compute a phosphate (PO_4) budget for the lake using hydrological data of NIH, Roorkee and concentration of PO_4 in various inflows and outflows measured from the samples taken at various places. The budget indicates that the lake has approached the condition of irreversible eutrophication, as of the total annual inflow of 643.3 kg, nearly 25 percent i.e., 159 is retained in the lake. The phosphate budget points out that the steady state phosphate level cannot be reduced drastically by taking measures that control only the phosphorus input to the lake. The hypolimnion (up to 15 m thick) remains anoxic for much of the year; consequently the phosphorus of the sediment gets readily soluble and recycled. Restoration that involves the treatment of the sediment, which accumulates P at the rate of about 114 kg/yr and the anoxic hypolimnion, is necessary to revive the lake to a

healthy condition. Removal of phosphorus from detergents and treatment of the watershed (better network of sewer lines and afforestation) are some of the measures required.

Impact of Anthropogenic Pressure - Cost of unsafe drinking water

Another consequence of the anthropogenic pressure is the quality of water of the Lake, which in turn is used by the local population for drinking after some minimal treatment. Though the Jal Sansthan (Water Board) claims that the quality of drinking water supplied is safe, peoples' behaviour connotes differently, as they spend a substantial amount of money to make it safe. The cost of unsafe water includes the cost of buying bottled water, use of water purifying devices and the treatment of waterborne diseases, which are rapidly increasing. This amounts to about Rs.6 million annually, of which about 60 percent is spent on medical expenses alone. Decline in human resource capital and loss of working hours could not be calculated, as that requires an in-depth socio-economic survey of the local people.

Benefits and Economic Valuation

As given in Table 1, the Lake and its watershed bestows a number of consumptive as well as non-consumptive uses for a large number of stakeholders. Besides these, the Lake and watershed provides a number of goods and services, which have no substitute. Some of these services are:

- Lower cost of water treatment because of filtration while passing though forests and valley fills.
- Direct water supply without treatment from Sukhatal valley-fill and various springs.
- Increased turnover of lake water flushing.
- Increased hill-slope protection by the forests.
- Reduced cost of silt removal due to the forest cover.
- Carbon sequestration by the forests.
- Support to activities like bird watching and the trade of photography.

Estimating value of the Lake and its Watershed from Tourism – use of Travel Cost Method

In order to estimate the value of the Lake and its watershed from tourism, a revealed preference indirect proxy method – the travel cost method – is employed. Assigning a proper value to the Lake and its watershed from tourism is also a sine quo non from the policy-makers point of view if they aim at restricting / curtailing catchment-based anthropogenic activity in the watershed.

When the preferences are expressed on a market, it is easy to estimate the demand for a good or a service, provided the market price is not the distorted one. However, as seen above, most of the natural resources and the functions they perform have no market value. For such cases having no market, two alternate approaches are usually adopted. In one approach known as the stated preference method, a hypothetical market situation is created and individuals are asked their willingness to preserve the natural resource. The second approach, known as revealed preference method, uses the behaviour of the individuals to approximate the price of a natural resource.

To estimate the recreational value of Lake Nainital in the present study, a revealed preference method i.e., the travel cost method (TCM) is used. In the method, the expenditure incurred on visiting Lake Nainital is treated as a revelation of a tourist's preference for the (environmental) services provided by it. The variations in travel costs and visitation rate are used to estimate a demand curve. The area under the demand curve (i.e., the consumer surplus) measures the willingness to pay (WTP) of consumers for the environmental goods and services. The basic premise is to use the cost of travel as surrogate for the WTP for using the Nainital site. Besides actual transportation costs, the travel costs may also include tariffs paid at hotels and the opportunity cost of travel time spent on the journey, as a proxy for asset value of the recreation site.

Before moving further, it needs to be stressed that these non-consumptive direct use values are lower estimates of the total social benefits of the lake and its watershed. This is because the total economic value (TEV) of the natural resource requires estimation of both use and non-use values (refer to Table 1). Incidentally, in the present study the focus is only on the use value.

Zonal Travel Cost Method

In the TCM also, there exist two approaches to estimate the demand function – the Zonal Travel Cost Method (ZTCM) and the Individual Travel Cost Method (ITCM). In the ZTCM, the unit of analysis is the Zone. Under this method, visitors are divided into different zones of origin. A visitation rate is then calculated for each zone given by the number of visits to the Lake per year from a zone to the total population of the zone i.e., the rate of participation per capita. On the other hand, the dependent variable in the ITCM is the number of trips per period made to a site by each individual. Practically, ITCM works best when individuals take a highly variable number of trips in the period to the site e.g., a park or zoo in the city. However, when recreation sites are greater than 2-3 hours driving time distance from their homes, multiple visits to a site by an individual become less common. Under the situation, the ZTCM is better.

In the case of Nainital though, visitors are predominantly from the North Zone (nearly 75%), but in general they have to travel more than 3-4 hours to reach Nainital. This implies that multiple visits to Nainital by an individual are not possible and the utility of ITCM is highly restricted. This is also substantiated by our data on 273 surveyed visitors. More than 55 percent of visitors were visiting Nainital for the first time. Of the 122 visitors that had visited Nainital earlier, only 18percent had multiple visits during the year, while the remaining 82 percent had visited Nainital two or more years ago.

There is a basic difference between other studies and the present study - the earlier studies have used a larger definition of a zone, where concentric circles have been used to form zones. The underlying assumption is that the costs to travel will be the same within the circle. This assumption is valid mainly in the case of developed countries. But for a country like India, where available infrastructure is highly skewed, such a definition would not work. The discussion with the tourists and the local people revealed that some of the places in Uttranchal though are one-fourth the distance vis-à-vis Delhi or Meerut, but the time taken may be much more than coming from Delhi or Meerut, and sometimes even more expensive to reach. This motivated us to consider each district as one zone and do a Zonal analysis.

While constructing the variables, three major issues arose – (a) how to account costs for the persons who have come by car, but could not elicit precisely how much they had spent on travel; (b) how to value housewives time; and (c) how to assign value to the travel time (i.e., the opportunity cost of travel time). These issues were effectively tackled in the study.

The consumer surplus arrived at by the use of ZTCM from tourism suggests that the WTP to preserve Lake Nainital and its watershed varies from Rs.4.3 million to Rs.5.27 million, depending on the functional form used. However, when travel cost consists of local cost also, the consumer surplus increases to Rs.5.60 million (for the linear model) to Rs.6.55 million (for the semi-log model). Since the lake and its watershed are spread over an area of 14.32 km^2, the recreation value per unit hectare comes out between Rs.3,022 to Rs.4,260. The values obtained are an underestimate of the total value that the people are willing to pay to preserve the Lake, as the method captures only the use-value, and that too is under represented. This is because the sampling did not consider foreigners, people on package tours and children.

Informed Citizens Views

Analysis of the responses of the informed citizens of Nainital indicates that the valuation exercise is a step towards conservation of resources and can contribute significantly to the

planning for the study of watershed in other areas. The more educated and environmentally aware residents have given great importance to the existence value of the lake and pointed out that soil, water quality, streams and springs are the major benefits to humans from the watershed. A majority of such citizens are willing to pay about Rs.1,000 annually for its conservation.

Stakeholders' Perceptions

Issues of environment and development warrant integration, not only of ecological and economic factors but also social ones. The results of PRA techniques were based on nine stakeholder groups. These include boatmen, horsemen, coolies, rickshaw-puller, vendors, tourists, professionals, hoteliers and citizens. We treated it as a complementary tool to the questionnaire survey to look into the perceptions of different stakeholders. The difference in perception across different stakeholder groups clearly indicates that to achieve participatory management, they are to be effectively included in the development of any management plan. For example, while a number of stakeholder groups appear to be lake-centred, horsemen were mainly interested in peaks and view-sites, adding new dimensions to tourist interest and attractions based on nature.

Nearly Rs.400 million is primarily generated through tourism, of which about 17 percent is distributed across the poorer stakeholders groups numbering over 1,600 individuals comprising rickshaw-pullers, horsemen, boatmen, coolies and vendors. The average income of poor stakeholders as calculated by PRA during summer tourism season is as follows: rickshaw puller – Rs.6,750; horseman – Rs.31,500; boatman – Rs.36,000; vendors Rs.18,000; and coolies – Rs.13,500. When considered in relation to the lake area, the density of money flow is about Rs.10.5 million/ hectare annually, which is enormous given the fact that this is only a fraction of the total economy of more than Rs.420 million (a crude estimate) based on tourism (Table 2).

Table 2: Summary of Annual Benefits and Costs to different Stakeholders

Benefits/ Costs	Beneficiary/ Losers	Valuation Technique	Benefits (Rs.x10^6)	Costs (Rs.x10^6)
Primary Benefits#				
Direct	Income from Forests Use	Market Price of Existing Products (fuel wood & fodder)	1.8	
	Drinking Water Supply	Cost of alternate scheme	NA	
Indirect	Recreation Benefits	TCM	4.3– 6.6	
	Non-use Values		NA	
	Cost saved due to lower erosion from the forested watershed than from non-forested watershed	As Removal cost of Silt from the shallow parts of the lake	0.2	
Secondary Benefits$				
Direct	Total earnings of poor stakeholders like Rickshaw-pullers, horsemen, boatmen, vendors, coolies	Income Estimation	56.6	
	Hoteliers Earnings	Income Estimation	315.4	
	Taxi Earnings	Income Estimation	27.0	
	Municipality – Luxury Tax from Hotels	Revenue Generation	6.0	
	Municipality – Revenue from Vehicles Toll Tax Passes	Revenue Generation	0.4	
	Municipality – Revenue from Vehicles (Toll Tax)^2	Revenue Generation	3.2	
Costs	Purification Cost – cost of filtering, boiling, bottled water etc.	Purification Costs		2.4
	Cost of treatment for water-borne diseases	Cost of Illness		3.6
	Cost of construction of public toilets^	Cost of Prevention of Nutrients Inputs		13.3
	Desilting of Lake~			0.5
	Cost of maintenance of Sewer system			0.9
	Total		**423.6**	**20.7**

The approximate value of economy generated annually due to the Lake and its watershed comes to about Rs.50 million per hectare. It is quite apparent from the above table that most of the benefits are lake-centred, and the continuity of these benefits from the Lake would necessitate that it would not get degraded. In fact, generation of such a huge amount has heavy environmental costs on the eco-geologically fragile watershed. As a consequence of this, the restoration of the Lake is quite expected and justified.

Limitation of Travel Cost Method

The travel cost method we used to estimate the value of Lake Nainital and its watershed relates to several ecosystem services such as filtration and storage of water by the Sukhatal valley-fill, and concomitant influence on the lake level, pollution abatement, recreational values, and direct drinking water supply. However, their specific contributions go unestimated in this method. It is always difficult to estimate the entire valuation of non-consumptive components, and this applies also to the present lakescape. For example, we could not find the impact of decline in the Lake's aesthetic and recreational values on tourism. Also, it was not possible to address the specific questions such as how the ban of fishing and swimming affected tourism and attraction of Nainital as a living place.

Our study however, makes it abundantly clear that we must give appropriate weight to the "natural capital stock" (lake, forests and others) that produces various ecosystem services in the decision-making process. The health of natural capital stock heavily depends on ecosystem connections, and interactions between ecosystems and connected abiotic components, such as rocks and valley-fills, which store water and subsequently release it to the lake and forests.

Economic Valuation and Management

According to Constanza and others, if ecosystem services were actually paid for, keeping their contributions to the economy, the price system would be very different from what we have. Our study has also shown that the ecosystem services of Nainital Lake and its watershed have considerable value. The estimates we have arrived at should be incorporated into the regional accounting to have a more sustainable development, and a future that does not drastically suffer on account of ecosystem degradation.

The ecological observations indicate that the Lake is highly eutrophic, approaching an irreversible stage, and thus warrants restoration. Measures such as reduction in input of nutrients and maintenance of a healthy watershed are desired, as they have meaning even when the Lake is revived and the steady state P-level is drastically reduced. The restoration cost can be justified, considering the values of ecosystem services over a long horizon. In recent years, some minor restoration activities such as desilting of shallow parts of the Lake and construction and maintenance of drainage network have been taken up, involving an expenditure of Rs.3.9 lakhs annually. These activities have resulted in a minor improvement in the lake condition.

According to the recent estimates by CMPNL (Comprehensive Master Plan for Nainital Lake, 2002) approximately Rs.188 million would be required to bring about restoration of Lake Nainital. The major expenses are likely to be: (i) conversion of the Lake from the present hyper-eutrophic state to oligotrophic state through in-lake restoration works (siphoning-off the lake bottom, controlled aeration of deeper water, dredging of banks and introduction of ecologically appropriate fishes) would amount to Rs.81.7 million; and (ii) watershed treatment to prevent inputs of nutrients and pollutants (construction of additional sewer lines and community toilets, improvement of sanitation infrastructure, and activities such as plantation, bioengineering, and landslide treatment), which would amount to Rs.106.3 million. This one-time cost of Rs.188 million is justified keeping in view that the total economic activity generated through tourism is approximately about Rs.500 million/year.

Furthermore, while undertaking a specific project in the watershed, the benefits accruing should be weighed against the loss it may cause to ecosystem service and tourism value. For example, the construction of a car park in Sukhatal valley-fill may damage its capacity to provide filtered and clean subsurface water to the Lake, resulting in its rapid deterioration. This in turn, is likely to reduce its tourism value.

The study finds that the Lake warrants ecological restoration on a priority basis, and that is a difficult task given the geological sensitivities and insensitivities of administrators and decision makers (so far no Indian lake has been restored). Still, the study has come up with some policy recommendations – the adherence to which would lead to restoration of the Lake.

Recommendations

- At present the responsibilities of managing the lakescape is distributed across numerous departments in a fragmented manner. An integrated unit of development that focuses on the Lake and its watershed and their interconnections is required. In other words, the entire lakescape should be treated as the unit of management. Problems of the Lake as an ecosystem, rather than water as goods should be addressed. While addressing the problems of the Lake, both in-lake, and lake and watershed connections should be given due weightage. For example, we need to conserve Sukhatal valley-fill so that its services that are important for the Lake continue to flow, such as, water filtration, dilution of lake pollutants, and maintenance of lake-water level.

- A restoration work that addresses the issues of irreversible eutrophication is required. It is good that action is being taken to stop phosphorus input to the lake, but it may be insufficient to make the lake oligotrophic. This may warrant a complete documentation of P-budget and its recycling from the lake sediment, and treatment of the P-rich lake sediment. For removing P-rich sediment, information would be required on sediment chemistry, the area and thickness of the sediment that can be removed safely (from the standpoint of geological fragility and stability), periodicity of P-recycling from the sediment and cost involved. Other measures include siphoning-off anoxic hypolimnion water and deep aeration. For all these operations, the Ministry of Environment and Forests (MoEF), India has agreed to provide finances. However, maintenance costs would be required. Measures required to check input of P and other nutrients to the Lake include (i) ban on the use of P-containing detergents, (ii) connection of all bathrooms, toilets and kitchen to sewer lines, and (iii) provision of more public toilets.

- People's participation should be promoted at all levels: constituting bodies, decisions making, sharing responsibilities, and awareness programs, education, etc. Our PRA exercise showed that the participatory management should be stakeholder-based. There is a need to constitute an institution with due representation of all stakeholders (e.g. horsemen, boatmen, hawkers, hoteliers, tourists from different zones, traders), with the government as a facilitator. It would be an NGO or a cooperative of stakeholders. The scientists of Kumaun University would need to play a crucial role in monitoring and providing inputs relating to science and technology.

- A master plan keeping in view the carrying capacity should be the starting point of management.

- Arrangements should be made for pedestrians to promote safe walking along all motor roads. This would reduce traffic and air pollution.

- Both the zonal travel cost method and surveys undertaken to procure citizens perceptions indicate that direct payment for the lakescape conservation is possible. It could be in the form of a "green tax" for lake conservation, to be utilised under the supervision of stakeholders cooperative/NGO. Developing a conservation fund in such a way would also give the message that the lakescape is a precious resource to be managed sustainably.

- Forest cover should be maintained and forests should be well-stocked as they play a significant role in the control of soil erosion, retention of water and its release in the form of springs.

- The ban on tree cutting should continue for urban areas, even when it is lifted for the region.

Thus, to conclude, the study made an attempt to estimate the value of Lake Nainital and its watershed. The economic estimates we arrived at though did not consider all the ecosystem services; yet, they were reflected to some extent. The project has also attempted to integrate ecological economics and social perspectives by considering a variety of stakeholders while analysing various geological components.

Environmental Conservation and Valuation of East Kolkata Wetlands

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Introduction

Kolkata is a city of 14 million inhabitants in West Bengal. A wetland area of 78km^2 marks the eastern fringes of this city. Over the past 100 years, this area has developed into a very sophisticated waste treatment, nutrient capturing and recycling system. The wetlands take all the sewage and wastewater from Kolkata through drainage channels and canals. The wastewater is used for fish cultivation and irrigation of vegetable plots, having been cleansed by the natural action of a large mass of plant matter and sunlight in ponds of no more than three meters in depth. The wetlands also take the solid waste of Kolkata. After scavenging, the residue is spread on land and supports three crops of vegetables each year. The entire recycling and recovery system provides direct employment to over 70,000 people and has no fossil fuel energy requirements. This tradition is now endangered. These wetlands are today under threat of encroachment, and perhaps extinction - mainly because of the pressures exerted by the ever-expanding metropolis, Kolkata.

Kolkata is uniquely privileged to have a built-in tradition of using urban waste in fisheries and agriculture, and thereby employing a remarkable natural system to help meet three basic problems faced by megacities - shortage of food, shortage of employment opportunities and shortage of funds to treat the waste. Instead of using stagnant water pool effluents in fisheries as a conventional alternative, here, fisheries are using an indigenous technique of sequencing sewage ingress[1] to become more efficient, effective, economically viable and environment friendly.

The present study is an attempt to bring out an ordered assimilation of various environmental issues and disorders relating to these East Kolkata Wetlands (EKW). A concomitant attempt is made to arrive at an economic valuation of the goods and services generated by these wetlands. The study is based partly on empirical data and partly on expert opinion survey.

Objectives

The broad objectives of the study were to:

- Identify economic activities associated with EKW.
- Estimate direct or indirect income and employment generated.
- Examine and weigh the arguments and justifications, if any, to divert the growth process of EKW towards rapid urbanization.
- Ascertain the nature and extent of damage likely to be caused to the ecosystem by the urban expansion.

Site

The study was primarily based on the area of Waste Recycling Region (WRR) defined by the Government of West Bengal. The area consisted of 32 moujas[2] from four police stations of three districts. Out of total area of 10,685 hectares, the study area covered 4,093 hectares. This included six moujas adjoining Rajarhat Police station, which was not included in the official map. The study covered 30 percent of the total wetland area. Out of the total listed households, 10 percent of households were canvassed.

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[1] *Technical term for Paracitology. It means systematic use of sewage effluent*
[2] *Mouja is an administrative unit consisting of two or three villages*
[3] *it includes among others increased number of crimes like murder, extortion, rape, dacoity, etc.*
[4] *Garbage farming is cultivation of green vegetables with the help of organic manure out of solid waste*

Methodology

Three different surveys were conducted. The major thrust was on 443 households staying within the EKW zone. The other two were directed to wetland experts and non-stakeholder citizens of Kolkata. In the household survey, direct questions were posed. The survey on experts was based on Delphi technique. The third study was basically opinion survey regarding general awareness of the citizens. For the household survey, a stratified random sampling method was followed. For the expert opinion survey, a Delphi panel was formed consisting of 46 members from 15 disciplines. To understand people's perception about the wetlands, an attempt was made to find out the association between willingness to pay (WTP) for preserving the wetlands and any of the factors like consumption, income, fishing land, agricultural land, fish production and agricultural production. The association of willingness to pay was found to correspond with consumption, income, holding size of agricultural land, agricultural production and fish production.

With a view to capturing cumulative variance, a stepwise multiple regression was attempted. From the OLS regression results, it was found that fishing land and agricultural production were statistically significant at five percent level with WTP. It was thus observed that people engaged in two crucial activities, pisciculture and agriculture were very keen to protect the wetlands.

Finally, an opportunity cost had been attempted on 1,500 hectares of wetland that was converted during the past ten years. A popular financial and partial equilibrium approach was followed. Due to the dearth of relevant data on the benefits from the alternative use of wetlands, we restricted our cost-benefit results only on the estimation of potential losses of 57,000 quintals of paddy alone among other crops, and a money value of Rs.338 million including fish production.

Results

In EKW, with the continuous conversion of agricultural land to non- agricultural use, the phenomenon had also been reflected in the occupational patterns. The average occupational holding of agricultural land was found to be 0.46 hectare, and for fishing ponds, 0.35 hectare. The produced crops of wetland agriculture are many. Apart from two types of paddy and vegetables, pulses, maize, sugarcane and oilseeds like mustard are grown there. Productivity of paddy was found to be 48.71 quintals per hectare, and for sewage fed fish it was 31 quintals per hectare.

Household data of the survey explained the fact that poverty was, on an average, 24 percent in EKW. Lorenz curves for four police stations (viz. Tiljala, Rajarhat, Bhangar and Sonarpur) showed gross inequality. Distribution of the population under poverty was found to be uneven among police stations. The largest number of poor had been found in Bhangar followed by Tiljala, Sonarpur and Rajarhat. The expenditure of the households was also found highly skewed in favor of consumption of food. Average annual household income of the EKW area was found Rs.32,395.

It was observed from the present study that EKW supports 1 lakh direct stakeholders and 5.1 thousand hectares of cultivation. It provides annual direct employment to a population of approximately 70,000, produces 1.28 lakh quintals of paddy, 69,000 quintals of fish and 7.3 lakh quintals of vegetables. It also generates gross revenues of Rs.266.75 million and net returns of Rs.79.64 million a year.

Many of the observations raised by the panel members in the expert opinion survey were as expected. For example, waste recycling and resource recovery system received the highest priority. This led to better hygiene in the city as well as wise use of the wetlands. The present area of EKW is less than one third of what it was during the 1950s.

People living in the wetland area were found to be concerned about the existence of the resource and expressed their WTP for the preservation of EKW. But inhabitants, being less ecologically educated than experts, had far less clear and distinct priorities when identifying environmental problems, from the point of view of their importance. Hence, the opinion expressed by non-stakeholder city dwellers differed on many counts from that of stakeholders and experts.

While a majority of the experts were of opinion that the wetlands would affect the sewage system of the city and reduce agricultural and fish production, only 50 percent of the non-expert citizens were also of the same opinion.

The average willingness to pay of the stakeholders was found to be Rs.143 per year, whereas on the part of non-stakeholder citizens the amounts ranged from Rs.60 to Rs.1,200 per year for the existence value of EKW.

The wetland ecosystem of Kolkata is a delicate, complex and under studied area, which requires immediate attention for the survival of the city. The study confirmed most of the common apprehensions on the vectors of threat operating on EKW. Further research would undoubtedly identify more numbers of specific threats.

Recommendations

- Changes in hydrological regimes, thereby affecting ecological balances and functions.
- Inundation of periphery, causes loss of property and life.
- Loss of agricultural and fish production and diversity lead to unemployment.
- Rise in urban pollution and social unrest[3] .

From the producers' point of view, fishing activities are going to be less profitable due to various reasons, mostly related to labor and poaching. While the total area of sewage fed fisheries is declining at a rapid rate, the population in the adjacent villages is increasing. The poaching problem is due to rising unemployment. To face the situation, the following measures may be taken:

- Conversion of bheries (large fishing pond with shallow water) for other uses is to be stopped.
- Strict legislation on the wetland is urgently needed. The existing Fisheries Acts are welcome measures to this end, but these are not sufficient to protect the water bodies.
- Middle scale bheries are becoming unprofitable if considered in terms of opportunity cost of real estate use. Hence, ecological benefits are to be recognized with sufficient importance.
- Adequate amount of sewage-laden water is to be ensured. The fisheries frequently complain that they do not get sufficient amount of sewage water after the management of storm water flow and dry weather flow channels were handed over to the Irrigation and Waterways department from the Kolkata Municipal Corporation (KMC). Rational distribution of sewage water requires careful handling by a sensitive organization. There is scope to widen the command area of sewage fed fisheries.
- Due to poaching, conservation of wetlands faces risk and induces the owners to sell off their ponds or turn them into arable land. A concerted effort of the government, political parties and owners may lead to some solutions.
- Vegetable growers hardly get remunerative prices due to poor storage facilities. Better storage systems and faster transportation to far off markets of the country may give a boost to the garbage[4] farmers of this region, especially during winter.
- The paddy growers of the region do not get institutional credit from any agricultural bank in the area. This is a serious problem for the poor farmers. In spite of getting the advantage of both irrigation and organic manure, lack of institutional credit increases the production cost.

The popular belief that sewage fed fisheries are effectively solving the problem of sewage treatment is far from the truth today. After the development of Salt Lake City and the virtual non-functioning of the Bantala treatment plant, the problem of treating sewage has become acute. Moreover, underground sewer systems also failed to expand beyond the KMC's limit. Naturally, the waste enters the surface canals. Not only siltation, but also human interventions like unauthorized settlements along the canals have almost jeopardized the drainage system. To solve the problem, the followings were recommended:

- Existing canals are to be cleared through regular dredging.
- Canal sides are to be kept free from settlements.
- A sewage treatment tax can be introduced for financing the cost of canal development.
- Carrying capacity of EKW should be ascertained and additional avenues have to be found for waste.

Further recommendations are:

- The EKW was declared a Ramsar site by Ramsar International in November 2002, but the state government continues to work with a three-tier system comprising core, buffer 1 and buffer 2. This system must be scrapped.
- It is recommended that the wetland together with the surrounding agricultural land be declared as a No Development Zone (NDZ). The tract containing existing built up areas should be a Regulated Development Zone (RDZ). A buffer should be created in the shape of a green belt with variable width between the NDZ and RDZ.
- The proposed new township should have its own drainage outlets with treatment plants. Untreated waste should not be permitted to pass through the wetland core zone.
- Kolkata must have a long run action plan with canals. Canals like Bagjola, Krishnapur, Beleghata, Bhangarkata and Tolly's Nala should be brought under an organization like the Canal Development Authority. An apex body with sufficient financial and executive power should control the functioning of this Authority.
- Alternative transportation could be arranged using Kolkata's canals. If beautified and properly managed, these canals might attract tourists.

Degradation of Water Bodies and Wetlands in West Bengal: Interaction with Economic Development

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Introduction

The interaction between a wetland ecosystem and the economy has contrasting effects, both in terms of benefits as well as degradation. Wetland ecosystems, both inland and coastal, support a large biodiversity (flora and fauna). Besides, wetlands yield various products, which give substantial economic returns. To reap these benefits, different types of anthropogenic activities are performed in and around wetlands. As a consequence, water quality deteriorates and the habitat is disturbed. Moreover, to derive greater short term, often private benefits, wetlands are often converted to other uses. These conversions not only distort the food chain of the wetland ecosystem, but also deprive the beneficiaries who were users of the wetlands in their non-converted state. The present research is devoted to the analysis of these situations in the wetlands of West Bengal, India.

Objectives

The objectives of the present study are to:

- Find out the usage pattern of the wetlands in selected regions of West Bengal, both coastal and inland areas.
- Identify and select techniques to estimate the direct and indirect economic costs and benefits from all direct uses of these wetlands.
- Study the impact of economic activities on the degradation of the wetlands.
- Suggest policy changes for the sustainable management of wetlands.

Site

Ten inland wetlands were selected in Bardhaman district, which are natural water bodies, and three of them are seasonally drained. Villages and agricultural farmlands surround almost all the surveyed wetlands. Major economic activities in and around the wetlands are fishing, irrigation, jute retting and collection of fodder. Nine coastal wetlands were selected from Medinipur district, consisting of aquaculture ponds, saltpans and fish landing centers.

Methodology

To understand the current situation of the wetlands and the benefits derived by the households, a field survey was conducted where 10 percent of the households were randomly selected for a detailed questionnaire survey. Care was taken to include all segments of the stakeholders. Benefits derived from the wetlands were calculated in monetary units using the market price method and surrogate price techniques. In the present study, biodiversity loss is represented by reduced sighting of types of birds and aquatic animals, and non-availability of certain types of fish within a particular wetland in the survey period. The level of dissolved oxygen (DO) represents the deterioration of water quality. The deviation of actual value of DO from the standard level of 7 mg/l is considered to be the degradation of water quality of the wetlands.

Results

Inland (non-coastal) Wetlands

All the anthropogenic activities viz., fish catching, irrigation, jute retting etc., generate economic benefits to the surrounding households (Table 1). These benefits impinge upon the wetlands status, and the consequent degradation of the wetlands manifests in deterioration of water quality and biodiversity loss. The anthropogenic activities have adversely affected the ecological balance for most of the wetlands, and biodiversity has declined remarkably as

compared to the biodiversity present in the wetland ecosystem in its natural form. It is evident from the analysis of data that the loss in biodiversity is higher in wetlands that are drained off seasonally as compared to other wetlands.

Table 1: Benefits Derived from Different Wetlands ('000 Rs / year)

S. No.	Wetland name	Fishing	Irrigation	Jute retting	Total
1	Haruabhanga	160	160	0	320
2	Kalobaur	144	70	20	234
3	Lakshmipur	112	60	0	172
4	Chakkobla	180	70	0	250
5	Barokobla	300	40	0	340
6	Bara Beel	600	350	0	950
7	Jalanga	200	350	0	550
8	Srikhanda*	125.5	0	50	175.5
9	Bater Beel*	500	0	75	575
10	Padma Beel*	10	0	12	22
	Mean	**233.15**	**110**	**15.7**	**358.85**

* Seasonally drained

The linkages between degradation and benefits derived through anthropogenic activities are presented by estimating some functional relationships. As more and more benefits are derived from these wetlands, the loss in biodiversity increases. Similarly, the level of dissolved oxygen falls as irrigation activities intensify, while the opposite phenomenon is observed for fishing activities.

The benefits derived from these wetlands in their natural state play an important role in determining the fate of the wetlands. In spite of these benefits, a part of the wetlands were converted to other forms. Field survey reveals that the extent of conversion of the wetland, on one hand, was higher in cases where the wetland ecosystem yielded comparatively low direct benefit in its natural state. The types of conversion, on the other hand, have been influenced by the value of expected benefit from the desired conversion. For inland wetlands, that part of the wetland area that has been temporarily or permanently converted to other apparently more productive uses is considered to be the loss of wetland area. In most of the cases, converted wetland areas have been devoted to agricultural operation (92%). Other types of conversion are aquaculture ponds (6.5%), horticulture and reclaimed land for construction . These conversions have a direct impact on the wetland ecosystem and degrade them.

A comparison of benefits from wetlands in their natural form and that from their converted form explain the crucial economic forces that result in further conversions. In this study, the comparison has been captured through the benefit-cost ratios. In this cost-benefit analysis, benefit foregone collectively by the losers (due to conversion) is defined as the social cost and benefits accrued collectively by the direct beneficiaries (after conversion) is defined as the social benefit. The ratio is high for seasonally converted wetlands.

The external factors like Government and Non-Government organisations, and also interest of the stakeholders influence the conservation of wetlands. Had the benefits and costs from all aspects of degradation been incorporated in the cost, the benefit-cost ratio would have declined to a smaller value, which in turn could exert a negative influence on conversion. The degradation should have forced the government to take necessary steps to restrict anthropogenic activities that are performed in and around wetlands. Although the policy makers may well have been aware of the degradation of wetlands through conversion, they are not concerned about the degradation of non-converted wetlands due to their indiscriminate uses. For example, the government has emphasized in the West Bengal Town and Country Planning and Development Act, 1979, that no permission for filling of tanks, ponds, water bodies, marshy land, etc. will be given if it is considered necessary for being used as (a) public water body, (b) maintaining drainage facility, (c) fire fighting purposes, (d) environmental and ecological reasons, (e) pisciculture purposes, etc. These policies are either overlooked or ignored.

Coastal Wetlands

The district of Medinipore was selected to study the benefits from, and degradation of coastal wetlands. Nine converted coastal wetlands were selected in this district. Coastal

wetlands are continuously transformed from one state to another to derive more and more benefits from them. It was observed that higher benefits from one type induce the others to convert wetlands generating lesser benefits to that particular form.

Economic benefits have been calculated for each form of the converted coastal wetlands (Table 2). Among the aquaculture ponds, this is least for traditional practices and highest for prawn culture. So there is a natural tendency on the part of the stakeholders to shift from traditional fishing and salt production to the higher valued option of prawn culture. But the practice of prawn culture in most cases did not last. Even in some cases, the continuous conversion processes ultimately led to wetlands that could not be used. These deserted wetlands neither generate any economic benefits, nor can they be converted back to their original state. Thus the basic idea of economic development has not been fulfilled. Moreover, degradation of valuable natural resources has occurred. As a result an asset for the society is lost forever, posing a burden on future generations.

Table 2: Benefits Obtained from Different Types of Manmade Coastal Wetlands in Medinipur District

Converted Wetlands	Total Surveyed Area (ha.)	Benefits per Hectare (Rs.)	Standard Deviation
Traditional Aquaculture	279	5625	354
Mixed Aquaculture	215	13750	707
Prawn Culture	4.4	175000	42427
Salt Pan	600	9625	495
Infrastructure Development for Marine Fishing	36	694600	72238

The Environment Protection Act,. 1986 [No. 29 of 1986J) and its amendment in March 1992 led to the declaration of Coastal stretches as Coastal Regulation Zones [CRZ] and to a regulation of activities in the CRZ. In spite of all these governmental policies, the major part of the area under study has been converted for economic purposes. This has adversely affected the ecology of the Digha-Contai coastal stretch. For example, with the introduction of aquaculture including prawn culture, salt production and other developmental activities in and around the coastal region, the biodiversity has reduced substantially. It is also found that biodiversity loss is maximum in case of infrastructure development for marine fishing as compared to other activities. (Here, biodiversity loss implies reduced sighting of birds and aquatic animals, and non-availability of certain types of fishes in a particular wetland in the survey period.) In this region, water quality measured in terms of DO varies with types of activities being carried out. It has been found from the water analysis that the damage of the water quality is least if the economic activity is aquaculture. That the loss of biodiversity in traditional aquaculture practices is least also supports this finding.

Policy Recommendations

In spite of all these regulations and proceedings of the Court in other cases, it has been found that saltpans are being converted to prawn culture ponds in Digha-Contai coastal stretch for better economic gain. Along with it, a reverse trend has also been observed in a few cases of conversion from prawn culture to aquaculture ponds during the period 1995-2000. On the other hand, the infrastructure development for marine fishing in this coastal region is an activity that generates short-term benefits surpassing those from all the available alternatives. It is interesting to note that the benefits of all sorts of aquaculture practices can be well availed of from marine fishing, even if it is run alone. But from the perspective of biotic diversity, infrastructure development for marine fishing has the most disastrous effect. Next to it is prawn culture. However, the area-wise extent of damage is lower in the case of infrastructure development, as a larger area has to be converted to get the equivalent monetary benefit from prawn culture or commercial aquaculture.

Again, prawn culture requires collection of seedlings of prawn from seawater that affects offshore marine fishing within a few kilometers from the shoreline. This process disturbs the marine biological chain as the undesired species are thrown away by the collectors. The method of prawn seed collection has, to a large extent,

inflicted irreparable damage on faunal lives of Digha-Contai coastal area of Medinipur district. The activity of prawn culture also did not sustain itself, and defunct prawn cultivation ponds left behind non-reusable, non-productive wetlands. So the activity of prawn culture is ruinous as it depletes marine resources on one hand, and causes ecological imbalance on the other.

If conversion should be permitted to a limited extent, then infrastructure development for marine fishing seems to be the best alternative among all types of conversion made on coastal wetland. However, care should be taken that it should not intensify marine fishing so much, that it might aggravate the problem of over-exploitation of marine resources. As far as employment opportunities and economic returns are concerned, this developmental activity to facilitate marine fishing is considered to be sustainable in nature. Also, this coastal development is in accordance with the Environmental Protection Act. Once an infrastructure for marine fishing is set up, it is expected that investments will be channellised in favour of marine fishery rather than for further conversion of coastal, wetlands. This will eventually preserve a larger area of coastal wetlands. For the saltpans it can be said that their product is unique in this state. Moreover, a saltpan generates fishery income mainly to the people working there, during the lean seasons. This income is generated from the naturally grown sea fish that enter the ponds through in-flowing seawater. This provides a two-fold benefit: salt production and aquaculture. Also from both the environmental and ecological perspectives saltpans do not produce hazards as great as compared to others. Thus the saltpan in this region should be allowed to continue their operation, at least from the developmental point of view. Furthermore, any conversion from the sustainable state like saltpan to undesired state like prawn culture should be strictly restricted.

- A comprehensive policy should be framed for preservation and better maintenance of existing wetlands.
- If all the anthropogenic activities cannot be curbed due to economic pressure, only those activities should be encouraged which cause the least damage.
- The maximum sustainable level (such as maximum sustainable yield in the case of fishery) of those activities should be determined.
- Over fishing in wetlands should be stopped, water lifting for irrigation purposes should be restricted to a pre-determined level for the sustenance of existing species habitat, and seasonal draining should not be encouraged.
- The beneficiaries who suffer from such actions may be compensated by alternative employment opportunities like animal husbandry, multiple cropping and food for work programmes.

To conclude, conversion of wetlands cannot be stopped totally due to developmental pressures. But some physical components may restrict the long-term functioning of some of these converted wetlands. Hence, conversion should be made from a rational and realistic standpoint so that “better and more efficient utilization of the converted wetlands can be carried out which is sustainable in nature and eco-friendly”.