CONSERVATION OF WETLANDS

An Economic Assessment of Lake Chilika (Orissa)

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I hereby affirm that the research for this dissertation titled '**CONSERVATION OF WETLANDS - An Economic Assessment of Lake Chilika (Orissa)**' being submitted to the Jawaharlal Nehru University for the award of the Degree of Master of Philosophy was carried out by me at the Centre for Development Studies, Thiruvananthapuram.

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Certified that this dissertation is a bonafide work of Kumari Lopamudra Patnaik and has not been considered for the award of any other degree by any other University. This dissertation may be forwarded for evaluation.

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INTRODUCTION

A recognition of the complex linkages between environment and development and the concern over a steadily deteriorating natural resource base have preoccupied current rethinking on alternative approaches to development. The `integrative' approach incorporating environmental considerations into development planning is seen to have several advantages over the `add-on'approach by which environment is introduced as a peripheral consideration after the mainstream development decisions are made. One such advantage is the creation of necessary and sufficient conditions for sustainability of growth rates of countries with differential resource endowments. In the past environmental considerations were narrowly viewed as either relating to the control of industrial pollution and/or protection of nature. While these do enter into environmental analysis, they do so as a part of the larger issue of `environment (resource) management' for development - a development which while satisfying human needs is in harmony with the environment.

Amongst the most productive as well as the most threatened of all natural ecosystems today are the wetlands, an interface between terrestrial and aquatic ecosystems, comprising of estuaries, flood plains, lakes, marshes, mangroves, etc. which directly and indirectly provide an enormous range of products and services free - staple food plants, fertile grazing land, support for coastal and inland fisheries, flood control, feeding habitats for waterfowl, etc. However, worldwide they are facing threats from an ongoing process of overexploitation and/or conversion into other uses - industrial, agricultural or residential - leading to their degradation or depletion. Yet, it is increasingly being recognised that these wetlands are more valuable when retained in their natural state. This is critical not only from the environmental point of view but also from the socio-economic viewpoint, particularly so in the case of the developing countries where a significant proportion of the population is both directly and indirectly dependent on the resource base of these wetlands for livelihood. Conservation of wetlands, therefore, becomes a priority for sustaining long term development efforts.

India, being one of the largest and most populous developing countries, is not free from the problems associated with the appropriation of wetlands. Undoubtedly, this issue needs a closer examination in the Indian context where the sustenance of a sizable population depends on wetland resource based activities, like flood plains agriculture and fishing. In particular, Lake Chilika in the state of Orissa, is the largest brackish water wetland in India as well as Asia. It is one of the first two wetlands from India to find a place in the map of Wetlands of International Importance as `Ramsar sites' in 1981. In fact, it was in response to this international commitment to the protection of such habitats that wetland conservation and management was incorporated into development planning at national as well as state level. However, despite this commitment that Chilika Lake presumably warrants, it is obvious from the recent concern expressed by natural scientists over its ongoing degradation that efforts at managing or protecting a `valuable' natural asset have been inadequate or lacking altogether. Here, the term `valuable' is taken to characterise the intrinsic values of the multiple benefits that such an ecosystem provides for human welfare. This issue, therefore, necessitates a closer examination from a regional development perspective, which would facilitate drawing some policy implications for better management of the Lake.

The present study, however, confines itself to an economic assessment of the `benefits' from conservation of the Lake. In other words, it attempts an indirect assessment of the consequences of degradation of the Lake on socio-economic development in the region. The approach is essentially `economic' and fundamentally anthropocentric in so much as the assessment is in terms of the benefits that the Lake provides to man, thus ruling out bio-centric or moral/ethical values, which by no means, may be equally significant too. However, to the extent that the Lake is looked at in its totality as an ecosystem, the ecological dimension is integrated into the approach. In this sense it differs from the conventional `economic' approach and by doing so, the study attempts to explore the various dimensions of conserving a natural ecosystem.

The study is based on secondary information culled from various sources. The Lake has been the subject of many reports and studies, but these have invariably been for a narrow and specific purpose. An attempt has been however, made in the present study to draw the relevant materials from these studies to understand the issues involved therein. Given the particular approach this study adopts, the information/data base was seen to have several weaknesses either in terms of discontinuities which do not allow any rigorous analysis to be done and/or an absolute lack of information on certain aspects which limit the assessment of certain benefits. Further, discrepancies are galore which indicate that the raw data may not have been systematically checked. Only recently with increasing awareness of the different dimensions of the problem and the media attention on its degradation, attempts are being made to make the information base more comprehensive and systematic. Undoubtedly, a multidisciplinary effort is required to do justice to the issues involved. In the above context, the present study is restricted in its scope and coverage, limited to being more of a qualitative nature at certain points. However, it may be taken only as a preliminary effort towards putting the issue of conservation of a natural ecosystem in the broader context of resource management for sustainable development.

The present study is organised into three chapters. In the first chapter a review of the conceptual issues in the ongoing debate between environment and development is made. It introduces the issues of wetland conservation in general and the current status of Lake Chilika as an ecosystem in the international context. The second chapter makes an overview of the pace and pattern of development in Orissa as a necessary preliminary towards assessing the `macro' implications of the conservation of wetlands like Chilika Lake from a regional perspective. In the third chapter, assessment of the Lake is taken up in detail from macro economic as well as ecological perspectives. The last chapter summarises the main strands of theoretical issues regarding wetland conservation, in particular and resource management in general and raises issues for further research.

CHAPTER 1

ENVIRONMENT AND DEVELOPMENT
A Review

Recent years have witnessed a spate of concern over the deteriorating state of the environment[1] in both the developing and developed countries. Issues ranging from widespread deforestation in Brazil and Indonesia, soil erosion and land desertification in Sahel, Africa, water scarcity in Ethiopia, depletion of fisheries in Thailand to 'acid rains', global warming, loss of biodiversity, and 'the ozone holes' over large parts of USA and Europe have drawn international attention to the complex linkages between environment and development. The environmental as well as the socio-economic ramifications of such issues have gained ground since the Stockholm Conference in 1972, which first put environment on the international agenda to the latest 'Earth Summit' held in June 1992 at Rio de Janeiro, Brazil.

These issues can be largely traced to the pattern of development which is based on the appropriation of natural resources for maximising growth or net returns without a long term perspective, termed in environmental literature as the 'conventional exploitative development strategy'. This stems from the view that economic development and environmental considerations are mutually exclusive and that environmental degradation is a recurring cost of rapid economic growth. But the fact that such an approach may no longer be economically nor ecologically sustainable has led to an alternative unified approach towards economic growth, natural resource use and environmental protection, which has been connotated in recent literature as 'sustainable development'. It is recognized now that

> "...it is impossible to separate economic development issues from environment issues; many forms of development erode the environmental resources upon which they must be based and environmental degradation can undermine economic development..."[2]

However, `sustainability' of development has been a contentious issue, especially with respect to its relation with economic growth and its operationalisation. The concept has been variously interpreted. Perhaps the broadest definition of it is given as development "...that meets the needs of the present without compromising the ability of future generations to meet theirs..."[3] This is based on the principle of inter-generational equity. An intuitive idea of an economic definition of the concept is given as follows.[4] If `development' is defined as increasing per capita well-being or welfare, then sustainable development is simply non-declining welfare over time. A path of development that makes, say, this and the next two generations better off but imposes costs on the third generation to come such that their welfare falls below current levels is a non-sustainable path.

A similar concept is that of `eco-development' defined as "an approach to development aimed at harmonizing social and economic objectives with ecologically sound management in a spirit of solidarity with future generations."[5]

Keeping aside the contentious nature of its definition, what is implicit in the concept of sustainable development is that economic development is ultimately dependent on the environment and that economic development can be sustained only if development is modified to take into account environmental considerations. And environmental considerations do not merely mean the control of pollution or the protection of nature as an end in themselves, but the maintenance of the environmental quality and long run productivity of the natural systems so as to sustain the increases in welfare derived from them. In this sense, environment becomes a dimension of the development process. By incorporating environmental considerations into development planning, in what is referred to as the `integrative approach' rather than introducing it as a peripheral ex post consideration, termed as the `add-on approach', conditions are created for sustainability of the growth rates.[6] Combined with the basic needs strategy, it creates conditions for an improvement in both the growth rates as well as income distribution.

The principle of sustainability is therefore relevant for the `management' of the natural systems. This is especially so in the context of developing countries where the linkages between environment and development are all pervasive. Sustainability of development here implies providing means for accomodating a growing population and economy while maintaining environmental quality and productivity of the natural systems. It is not merely a question of economic growth versus environment, nor simply a question of trade-offs --- whether, inter-generational, inter-regional, or inter-sectoral. It encompasses an alternative pattern of development which while satisfying the basic human needs is in harmony with the environment. Sustainable resource use for the present, and not, preservation per se is the fundamental condition for sustaining long term development efforts.

Sustainable resource use implies using them in " a manner which does not eliminate or degrade them, or otherwise diminish their usefulness for future generations..."[7] In other words, the appropriation of the resources for development needs should be `conservation-based', that is, there should be an integration of conservation and development so as `to optimise ecological and economic systems.'[8] Conservation of the natural systems is therefore the key element of their `sustainable utilisation'. Obviously, "...development depends upon conservation and conservation ... depends equally upon development."[9] However, conservation and development, not so long ago were seen as incompatible with each other and their champions were always in opposite camps. They were seen to be mutually exclusive. But there is increasing appreciation of the fact that both are `mutually reinforcing in the long run'. The World Conservation Strategy emphasising the interdependence of conservation and development, was launched in the early 80's by the International Union for the Conservation of Nature (IUCN) together with World Wildlife Fund, UNEP, UNESCO and FAO. It has essentially three primary objectives___ (1) to maintain essential ecological processes and life support systems, (2) to preserve genetic diversity, and (3) to utilise species and ecosystems in a sustainable environment. A National Conservation Strategy on the lines of the World Conservation Strategy has been formulated and adopted by India too.

A section of opinion however still sees conservation as one of preservation alone. It is not so. What is at stake is the wise management of natural systems on a sustainable basis. Another segment views conservation as a delusion of naturalists, or as an elitist pursuit contrary to the interests of a developing country. This cynicism perhaps can be traced to the fact that the conservation movement was a take-off from that of the developed countries __ it started with the protection of `endangered species of animals', such as the Project Tiger. Sunil Roy points out a cartoon response in an Indian newspaper which showed two old farmers sitting smoking their hukkas with the caption, "We wish we were endangered species".[10] This illustrates the sentiments of the majority, a substantial percentage of whom live below the poverty line. But what needs to be emphasised here is that the poor are indeed `endangered' and degradation of the environment or the natural systems on which they depend directly can only `marginalise' them further. It is a moot point that poverty and environmental degradation work in a vicious cycle, but "economic growth, the alleviation of poverty and sound environmental management are in many cases mutually consistent objectives".[11]

Environmental degradation, though analytically may not be different in a developing country than those faced in a developed one, it differs with respect to the degree and intensity of its impacts and implications for development. This is essentially because of the fact that developing economies are more directly dependent on the environment for food, shelter and employment. Their development is inextricably tied to the productivity of the natural systems. A developing country therefore, cannot afford to overlook the importance of the environment dimension in formulating its development strategy.

In the case of the Indian economy, given the conditions at the time of Independence such that the primary sector supported the livelihood of almost 70% of the population and contributed nearly 60% to the national income, the development strategy pursued so far seems to have overlooked the environment dimension. Indiscriminate overlogging (deforestation) in the catchment areas of rivers in the Himalayas leading to changes in the water regime, increasing the rate of soil erosion and the intensity of floods downstream in the fertile Gangetic plains causing extensive damage to life and property is one such instance. Lack of soil moisture retention measures resulting in land desertification, have reportedly led to drought like conditions in Rajasthan and Western Madhya Pradesh and to unfavourable changes in the cropping pattern in North Arcot (Tamil Nadu). Overlogging of bamboo forests in Karnataka, Madhya Pradesh and Kerala leading to raw material scarcity for the paper industry have necessitated either a closure of paper mills or the import of paper pulp to meet the requirements. Dumping untreated industrial effluents of domestic sewage into water bodies beyond their absorptive capacity leading to increased incidence of human diseases; overfishing leading to depletion of fisheries and reduction in animal-protein intake; inadequate drainage and inefficient planning of irrigation systems leading to waterlogging and salinisation in the Eastern Plains; among others have been documented in various studies.

The studies may be more fact-oriented than analysis-oriented but they bring out the wider implications and criticality of the 'conventional' development process. Not only there is a reduction in the productivity of the natural systems reducing long-term growth prospects, but also welfare losses and a decline in the productive effort of individuals by affecting their health. It also results in decreasing returns from the major investments made in development projects, as in the case of siltation of the reservoirs in hydro-electric projects reducing their capacity, or in the loss of croplands to waterlogging and salinisation in case of irrigation projects. Evidently these are the 'externalities' which may or may not be captured by the market, but lead to increasing social and economic costs over time.

This is further apparent from India's development experience that growth achieved so far has not been able to generate employment opportunities and a broad based demand for industrial products; rather, it has given rise to imbalances across sectors, regions and classes. This development strategy induced imbalances have further exacerbated the imbalances due to inequalities which were already there in terms of physical endowment and appropriation of the resources. This point (spatial dimension) has been recognised in the development strategy since the 70's but the strategy pursued so far does not seem to have succeeded in overcoming the regional imbalances. In fact, studies show that regional imbalances have been increasing. In the agriculture sector, for instance, whereas the green revolution succeeded in certain regions (and that too was confined to certain crops and certain seasons of the year), it failed in other regions, thus aggravating the inequalities. Similar argument can be placed in the case of industrial growth too. It follows that regional imbalances have been reinforced, or remained unchanged at the least. This has led to a growing literature on regional development issues.

It is seen from an overview of such studies that Orissa has one of the highest poverty ratios and has remained structurally backward since Independence. Its economy is largely primary sector-based which is directly dependent on the appropriation of the natural systems, but despite being richly endowed with natural resources -- in terms of fertile land, abundant water, dense forests, rich deposits of minerals as well as a long coast line -- the growth performance of the resource based activities has been sluggish and/or negligible. At the same time, the state is not free from problems of environmental degradation. Soil erosion, waterlogging, etc. are reportedly on the increase. An explanation for this apparently paradoxical situation may be found in the pervasive linkages between resource management and development strategy.

Therefore, underlying the concern for environmental degradation is the wider dimension of incorporating environmental considerations into development strategies. This is especially relevant in a rural economy which is directly dependent on the natural systems. The analytics of the `integrative' approach towards environment and development is dealt with in the following section.

ANALYTICS OF THE INTEGRATIVE APPROACH

The linkages between environment and development can be seen in terms of three interactive flows. First, environment provides resources that become the material and energy inputs into the economic process. Resources are conventionally defined as non-renewable (exhaustible) resources and renewable resources. Non-renewable resources includes the fossil fuels and all minerals which have taken millions of years to form and from a human perspective are fixed in supply. The utilisation of non-renewable resources by definition is therefore, largely constrained by their availability. Resource management in this case is essentially determining the rate of their use over time and ensuring their 'efficient' (in the sense of not being wasteful) use in the development process. The operation of market forces and technology in general have been favorable towards preventing their complete exhaustion. The fear of an 'oil crisis' or 'energy crisis', for instance, have so long been averted by the innovation of substitutes through appropriation of technological advances and the operation of market forces, though perhaps with increasing costs. The major characteristic of renewable resources on the other hand, is that they are naturally renewed within a sufficiently short time span to be of relevance to man. In other words, these are capable of regenerating themselves as long as the environment in which they are nurtured remains favourable. These include resources like fish, forests, animals, soils and water aquifers. These can be exploited to extinction or exhausted if the rate of use exceeds the rate of natural replacement/regeneration, termed as the 'threshold level'. Overfishing leading to the depletion of fisheries, overlogging wiping out forests altogether, overgrazing leading to soil erosion, inefficient irrigation systems resulting in waterlogging and salinisation leading to a loss of croplands, are cases in point. It is evident that the renewability of these resources is meaningful only in terms of the level or intensity of use, it is a relative and not an absolute concept.[12] Their availability therefore depends on the demand for such resources, and hence all those factors which influence their allocation over time and space.

Second, environment assimilates the waste products generated by the economic process. This function usually occurs outside of market exchange relationships, so the 'conventional' approach takes this for granted. This is despite the fact that the assimilitative capacity is limited. For instance, the dumping of industrial/domestic sewage into waterbodies beyond their absorbing capacity results in their pollution. Increasing levels of carbon-dioxide emission into the air leading to `global warming' by the `greenhouse effect' and the emission of chloroflurohydrocarbons (CFCs) by the industrial countries leading to the depletion of ozone layer have been the latest of such concerns.

Third, environment provides a flow of `natural' or `environmental' services ranging from recreational, health, cultural, educational and aesthetic values to the maintenance of essential climatic and ecological cycles. This function is essentially non-marketable, but crucial for supporting economic production and human welfare. Unlike the first two functions which involve the direct physical interchange of materials and energy between the environment and the economic process, this function relies on the protection of the environment and the maintenance of in situ natural resources and stable ecological relationships. Deforestation in critical watershed areas of rivers leading to disruptions in the hydrological cycle and hence on the supply of water downstream is well documented.

Together, these three sets of interaction bring out the physical dependency of the economic structure and human welfare on the environment. Environment is thus, not `external' to the development process, but is an integral part of it. The principle of sustainability, therefore, necessitates `managing' the use of the non-renewable resources, conserving the renewables for present and future use, and regulating the discharge of residuals so as to sustain the flow of benefits and services from the environment.

The conservationist stance, therefore essentially reflects a shift of the environmentalists from a protectionist to a productionist approach and the economists from resource use to sustainable resource use.[13] In a sustained resource use concept, a distinction is made between an `effective' supply of resources and a `physical' supply of resources.[14] Physical supply of a resource, refers to its manifest availability, say, the extent of forests, the deposits of minerals, the extent of croplands, etc.. Physical supply of a resource may not be entirely available, because, if it is used to the point of exhaustion or used at a given rate, or used in a certain way, then a continued availability of the resource is not ensured. Effective supply refers to this 'continued' availability of the resource, incorporating maintenance of the resource with its use.

Environment, seen as a dimension of development planning in resource management, therefore, encompasses within its scope, three basic processes - resource use, resource maintenance, and resource restoration.[15] "The optimal use of resources alongside sustained maintenance of future resource levels is then foundational and common to the purposes of both environment and development planning."[16] Thus, the foregoing discussion amounts to highlighting the undercurrent that resources are no longer the gifts of nature but more of natural capital assets having capability of rendering invaluable services to the society. And such perceptions have led to characterisation of benefits from the environment in terms of stock and flow concept.

Total capital may be defined as the sum of man-made capital, human capital (knowledge and skills) and natural capital. However, natural capital may be distinguished from man-made assets in two crucial ways. First, the regeneration/ renewability of natural capital is essentially determined by nature and not man. Second, the cumulative degradation of natural capital is marked by uncertainty and irreversibility. These two aspects emphasise the need for sustainable utilisation and conservation of the resource base. This is referred to as the 'constant endowment' approach in environmental literature, which has its analogy in business. "No businessman survives or prospers by running down capital. His sustainable income is what he can take from the company without running assets down. Societies are no different. Capital depreciation now impairs the next generation's capacity to achieve the same level of welfare as this generation has...".[17]

If there is to be a trade-off between natural capital and other forms of capital, it is important to know what it is that is being traded off. If the natural capital is being 'run down' deliberately or as unintentional spillover effects of human activities, then it is important to know the costs of such degradation so that they can be 'internalised' into the economic system.

This has led to the development of the concept of 'natural resource accounting' in environmental literature. It has been theoretically shown (Maler, 1990) that if environmental damages could be accounted for in the national accounts and if the net changes in natural capital could be appropriately included in the accounts, then Net National Product (NNP) would measure sustainability in the sense that it would give the maximum constant consumption path that would not impair the possibilities for well-being for future generations. Though this awaits empirical estimation, it has been shown that even a partial reform of the existing accounting system by including environmental degradation that can be estimated in monetized form and the net changes in the stocks of natural capital can give a better idea of the growth of the economy. A study on Indonesia by Repetto et al including the depreciation of three stocks of natural capital - oil, timber and top soil - into the national accounts found that the official annual growth rate of about 7% between 1971 and 1984 should be reduced to 4%."[18]

Conservation however, is not merely a reflection of the concern over the physical changes in the environment per se but more significantly with respect to their implications for output, income, employment, consumption and other socio-economic variables. It has two components - the physical (ecological) dimension and a socio-economic dimension. An integration of the two is essential to arrive at 'socially optimal' resource utilisation as different from a 'financially optimal' one. This often entails making difficult choices under increasing demographic and development pressure and too often, development investments have ignored the environment dimension. Yet, well managed, the natural systems can continue to yield benefits, to help meet the needs for sustainable development.

Therefore, "economists have long sought to identify a value for the environment and the services it provides."[19] This approach has received mixed 'reactions', and it is criticized as being unduly 'economistic' or 'reductionistic' in valuing environment which is "priceless", and that economics can never account for the "true" value of the environment. However, the objective of the valuation process is "to facilitate responsible social choice rather than to value the environment per se."[20] And the fact remains that overexploitation/degradation of the environment has been more where the true 'values' have been omitted, downplayed or disregraded. The case for conservation or management of the natural systems, therefore, cannot be based on sentimentality but on real ecological and economic benifits. So, elaborating and understanding the structure of these systems and their links with the wider environment - both natural and socio-economic - is a rational option. "We need to stop thinking of economics, engineering, ecology and environment as separate entities. Instead, we need to start seeing them as aspects of a single ecosystem which has to be properly managed to ensure long term stability and sustained resource availability."[21]

Further, valuation methods have evolved over time to incorporate the 'total' value of the natural systems to as large an extent as possible -- not merely those values which have 'markets' but also the 'non-market values' using both qualitative and quantitative techniques. Values have been classified differently by different authors as direct/indirect (Barbier 1989), tangible/intangible, use/non-use (Stone 1991), functions/products/attributes (Dugan 1990), etc.. Evidently, it has not been easy to capture the intrinsic values of the environment, but their recognition gives a more 'holistic' perspective of the issue.

A review of the literature on the valuation of natural systems show two types of studies - in monetary and non- monetary terms. In the first type of studies, the methods used are most often the extended Cost-Benefit Analysis and Cost-effectiveness Analysis using travel cost, opportunity cost, replacement cost, hedonic pricing or contingent valuation techniques.[22] Earliest attempts may be traced to Ciriacy Wantrup and Phillips (1970) - on the value of California tule elk, Helliwell on amenity value of wild life and Gosselink et al on value of tidal marshes.[23] The tangible benefits and costs were assessed directly and the intangibles indirectly on the basis of what they called their scarcity, diversity and accessibility. To the extent that intangibles cannot be established properly, the final value tended to be an underestimatiom. Tobias and Mendelsohn used 'travel cost method' in their valuation of tropical rainforests in Costa Rica.[24] Peters, Gentry and Mendelsohn (1989) examined the value of non-timber products (minor forest produce) as compared to commercial timber harvesting in the Amazonian rainforests. They showed that by clear cutting, net revenue of about 1000 dollar/ha was earned, whereas net benefit from fruit and latex collection was established at over six times the amount. Since the minor forest products could be harvested on a sustained yield basis, they showed that the basic forest ecosystem could be preserved while yielding monetary returns.[25]

The other method of valuation is in energy terms - based on the fact that all ecosystems carry on energy transfer processes, so that energy flows can be used as a common denominator to assess interactions of all kinds. These energy values may then be used to arrive at monetary assessment of the value of natural ecosystems. This method was developed by Odum(1971). The limitation of this method is that it is relevant to those ecosystems with clear energetic functions.

The above mentioned methods are seen to be heavily dependent on a well-researched data base on the nature of the resources themselves and on the environmental impacts of human decisions. With the latter often lacking or incomplete, results are often based on uncertainty. Another method used in the literature is the 'flow diagrams' or use of 'formal models' for a reasonably comprehensive description, analysis and prediction of environmental impacts. To analyse the effects of human activity on the environnment - use is often made of environmental impact matrix.

However, most of these techniques owing their origin to developed countries are limited in their application to a developing economy -- mainly for two reasons - lack of data base, and second, the valuation of natural systems or environment cannot be done in isolation from the socio-economic dimension of resource utilisation. Further, the way in which society values any one benefit may change from place to place or over time. It is the interaction between the ecological and socio-economic components which is central to the pattern of resource utilisation.

From an ecological perspective, therefore, `characteristics' of the natural systems yield `benefits' which may be in the form of `functions', `uses' or `attributes'.[26] `Characteristics' include those properties which describe the system - size, shape, location, species present, soils, geology, water flow, water depth, altitude, slope, nutrient cycles, vegetation structure, biomass production/export, drainage pattern, pH, dissolved Oxygen, water balance, etc. These characteristics singly or in combination give rise to `functions', `uses' or `attributes'. A function is some aspect of the resources/ecosystem which "potentially or actually supports or protects a human activity or human property without being used directly." It is also referred to as the "indirect use value" (Barbier 1989). For example, the flood control function of a lake which protects downstream activity or property from the damages due to flooding; the acquifer recharging function and soil erosion control function of forests in the catchmnet areas of rivers; the pollutant absorption function of air; the micro-climate stabilisation of big waterbodies and forests; the shore-line protection function of coastal forests, the nutrient export function of mangroves supporting off-shore fishery etc. These are the `benefits' which people get without necessarily having to go to the resource. A `use' is "some direct utilisation of one or more of the characteristics" of the resource. For eg., the extraction of timber (which depends on such characteristics as the tree species, their girth and height, etc.) and other minor forest produce; extraction of drinking water from the aquifers; using waterbodies for waste-disposal; fishing from lake/rivers; extraction of plant products; etc.. These `benefits' are also referred to as the "direct use value" (Barbier 1989). An `attribute' is "some characteristic or combination of characteristics which does not necessarily provide a function or support a use, but which is valued by a group within society"; it is also referred to as "non-use value" or "preservation value" (Barbier 1989). Examples include the landscape, richness or diversity of flora and fauna (biological diversity), aesthetic /cultural values associated with the resource; a site valued as an educational, social or spiritual place by a group, etc..

The 'value' of a natural system is therefore, a measure or expression of the worth placed by society on the function(s), use(s) or attribute(s) of the particular system. This may be expressed in monetary or non-monetary terms. It may be expressed in comparative terms too - high, medium or low -- as a score on a defined scale in terms of local, regional, national or international significance.[27]

However, not all ecosystems possess equally valuable structural aspects or are equally productive. At the same time there are ecosystems which yield a wide range of 'benefits', and which form a major resource base for a majority of the rural population world wide, like the wetlands. It is by virtue of the multi-functional nature of the ecosystem, which makes their management a critical issue. A review of wetland issues is made in the following section.

WETLAND ISSUES AND CONCERNS

Wetlands have been variously defined by authors. It groups together a wide range of inland, coastal and marine habitats. It is seen as "a collective term for ecosystems whose formation has been dominated by water, and whose processes and characteristics are largely controlled by water. A wetland is a place that has been wet enough for a long enough time to develop specially adapted vegetation and other organisms."[28] They have also been defined as

> lands transitional between terrestrial and aquatic ecosystems, where the water table is usually at or near the surface or the land is covered by shallow water. For purpose of this classification wetland must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate [sic] is predominantly undrained hydric soil; and (3) the substrate is non soil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin 1979).[29]

The above definition emphasises three key attributes of wetlands -- (1) hydrology - the degree of flooding or saturation; (2) wetland vegetation (hydrophytes) and (3) hydric soil.[30]

It is evident that, wetlands can be of diverse types. They have been classified differently by different authors. One such classification is given in Appendix 1.1. It is seen that there are about thirty categories of natural wetlands of salt water and fresh water type and nine man-made ones. By location, they are often classified into inland, coastal or marine type also.

Depending on the particular type and site characteristics, wetlands provide a wide range of 'benefits' which can be in the form of functions, uses/products and /or attributes as described earlier. The different types of wetlands and the type of 'benefits' they provide in general is given in Appendix 1.2. It is evident that whereas products like agricultural and forest resources and fisheries directly support production and consumption, generating income and employment opportunities, supporting human livelihoods, the functions and attributes provide the 'environmental services' which are crucial for the ecological support that they provide. Wetlands therefore, provide benefits which are transsectoral. It may be noted that the high level of productivity of the wetlands is largely due "to their occurrence at the margin between truly terrestrial ecosystems as forests and grasslands and truly aquatic ecosystems such as rivers, deep lakes and oceans..."[31]

However, not all wetlands possess equally valuable structural aspects or are equally productive. On the other hand, there are wetlands which are multifunctional and their benefits as 'life support systems' extend well beyond their natural boundaries and sometimes across continents. It was this aspect in fact, which led to the 'Convention on Wetlands of International Importance

Especially as Waterfowl Habitat' at Ramsàr, Iran in 1971 popularly known as the Ramsar Convention.[32] "The main aim of the convention is to halt the decline of wetland habitats and maintain their ecological functions and wildlife. Contracting parties agree to include wetland conservation in national planning, to promote sound utilisation of wetlands, to create properly wardened nature reserves, and to develop management research and training facilities."[33]

Historically, wetlands worldwide have been drained/filled for other land uses or overexploited leading to their degradation. To quote,

> The temperate wetlands in developed economies have long suffered significant losses and they continue to face an ongoing conversion threat from industrial, agricultural and residential developments, as well as from hydrological perturbation, pollution and pollution-related effects. The extensive tropical wetland resources in developing economies are also undergoing increasing change as a result of improved access to wetland zones, the pressures of population growth and economic development. Many wetlands have and are being degraded because of unsustainable levels of grazing and fishing activities... Mangrove swamps, for example, are rapidly disappearing throughout Asia and Africa, because of land reclamation, fishpond construction, mining and waste disposal.[34]

Wetlands in general are therefore subject to a wide range of threats on account of both human interventions - direct and indirect - and natural causes. These are shown in Appendix 1.3.

The overutilization of wetlands may be traced to a combination of economic growth, population pressure and 'intervention'/'information' failure.[35] Information failure refers to the general indifference/ignorance about the 'real' value of conserved or sustainably managed wetlands and 'intervention failure' to market failures as well as the failure of policies directed at the use of wetlands. However, there is a growing awareness of the fact that wetlands are more valuable resources when retained in their natural state in course of their use. In fact, as Turner (1991) puts it,

> Conversion or degradation of such natural capital assets will therefore often not represent an increase in resource-use efficiency. Social inefficiency in wetland use is connected to the fact that wetlands are multifunctional resources and that, under heavy utilization pressure, some of the multiple uses conflict with each other. The inefficiency is not a consequence of the multiple-use conflict itself, but of the fact that not all the uses are properly evaluated and accounted for.

Wetlands are therefore amongst the most productive and also simultaneously the most abused of all natural systems. "The marshes, swamps and floodplains upon which were founded the great civilizations of ancient Egypt, Mesopotamia and Indo-China, and which continue today to support rural communities throughout the world, are menaced by drainage, reclamation and pollution. Many have been already lost. ... It is sadly ironic that as we have sought to exploit the riches of these habitats, we have unwittingly destroyed them. Unconscious of their fragility we have in our attempt to increase productivity, so disturbed the natural system that productivity has declined in several places. Yet if we are to feed our growing population we must try again to utilise these resources. ...But ... we should approach these questions in a way which takes account of the complexities and value of the ecosystems which we seek to exploit. Development should take account of the ecological structure of these systems if we are to continue to reap benefits from them on a sustainable basis."[36]

This is especially relevant in the case of the developing countries where a sizable population depend directly on the appropriation of wetland resources for their livelihood and basic needs. Fisheries, for example, not only provide income and employment opportunities, but is also a primary source of animal protein intake of the people. Rice, which is a wetland plant, is the staple food for over half of the world's people. The forage resources provided by the wetlands support the pastoralists. And, indirectly, the `functions' provide the ecological foundation for the socio-economic structure dependent upon them. The flood-control function, for example, prevents not only damages to agricultural activities but also to life.

Further, given the inherent nature of the ecosystem which makes it attractive for a diverse range of activities, (aquaculture, for instance) often in conflict with the traditional use of the resources on which the rural communities depend for
livelihood, the pressures on such resources is bound to be high in the developing economies.

> Undoubtedly the most important fact to emerge from the Asian Wetlands Inventory is that the great majority of natural wetland ecosystems in southern (the Indian Subcontinent) and eastern Asia are under threat.[37]

In many of the countries, deforestation, overgrazing and shifting cultivation have led to severe soil erosion, increasing the silt load of rivers and hence the intensity of flooding. Shrinkage of lakes due to siltation and reclamation has lowered flood reduction capacity, increasing the threat of flooding downstream. Mangroves have been destroyed by non-sustainable timber exploitation and intensive aquaculture activities.

The area of wetlands as described in the Directory of Asian Wetlands and the proportion under protection is given in Appendix 1.4. It is seen that 14.8% of the area is under some form of protection and 10.3% is totally protected. The frequency of occurrence of the major threats to Wetlands of International Importance in the three subregions of Asia is given in Appendix 1.5. It is seen that the most widely reported threats are human settlement and agricultural encroachments (27%), drainage and reclamation for agricultural purposes (23%), pollution, particularly from domestic sewage, industrial waste,and pesticides (20%), overexploitation of fishery resources and associated disturbance (19%), commercial logging and other forestry activities in mangrove and forest and freshwater swamp forest (17%), and degradation of watersheds resulting in increased soil erosion and siltation (15%). The table also shows the regional differences in the frequency of occurrence of particular types of threat. These may be related to the types of wetland present and the type of resource utilisation pattern depending on the nature of the economy. The severity of the threats to these wetlands is given in Appendix 1.6. It is seen that nearly 50% of the sites are under moderate to high threat.

India being one of the fast growing countries is not free from the wetland problems described above, particularly so when its economy is primarily rural, with a majority of the population dependent on wetland resources for meeting basic needs. It has been estimated that there are some 17 million hectares of wetlands, excluding the permanent rice fields, in India ranging from the high Himalayan lakes in the north to the salt flats of Kutch, the mangroves of Bay of Bengal to the innumerable small water tanks of the Deccan.[38] The natural and man-made wetlands (excluding mangroves) in terms of area in the different states of India is given in Appendix 1.7.[39] A list of the important wetlands in India, the habitat types, the protection status, the degree of threat and the conservation values is also given in Appendix 1.8.[40]

India acceded to the Ramsar Convention in 1981 and the first two wetlands from India designated as 'Ramsar sites' in the List of Wetlands of International Importance included Chilika Lake in Orissa and Keoladeo National Park in Bharatpur, Rajasthan. In response to the international commitment to the protection of such habitats, wetland management was incorporated into national planning. A National Wetlands Committee was established by the Department of Environment, Government of India, to lay down broad policy guidelines for implementing programs of conservation, management and research of wetlands.[41] In turn, State Steering Committees on Wetlands were set up at state level to prepare management plans for important wetlands.

Now, Chilika Lake in Orissa is the largest wetland of its type not only in India but also in Asia. Notwithstanding its size and international profile as a 'Ramsar site' the Lake has been an integral part of the socio-economic fabric of the region since centuries as a source of fisheries generating income and employment opportunities. It reportedly supports the livelihood of about one lakh population directly and indirectly, residing on its shores. Presently, it is in the news[42] as a 'dying lake' "showing all the symptoms of environmental degradation."[43] Natural scientists have expressed concern over the physical changes in the Lake's ecology brought about in the wake of developmental activities in and around the Lake. Siltation of the Lake, for instance, is seemingly delinking the connection with the sea, slowly altering the ecology causing a proliferation of weeds. Studies are currently going on to estimate the extent and intensity of the degradation that has set in. It has been listed as one amongst the most seriously threatened wetlands of Asia.[44] It may be noted from Appendix 1.8 that it is coded as being 'under serious threat from several sources' and that most, if not all, of the wetland habitat is likely to be lost or major ecological changes are likely to occur unless some immediate remedial action is taken. In terms of protection status, it has been listed as fully protected, but it is not so. A part of it is protected as a bird sanctuary since 1973. In terms of conservation values, it is reported as a site which is a good representative example of a specific type of wetland habitat, which has considerable socio-economic or cultural values, which supports populations of one or more threatened or endemic species of plant or animal, which is of special value for maintaining the genetic or ecological diversity of the region in which it is situated and which is of considerable importance for waterfowl.

Therefore, by virtue of the multi-functional nature of wetlands in general, the degradation of the Lake necessitates a closer study. However, underlying the issue of its degradation is the broader question of the relevance of the sustainable use of the Lake's resources or, in other words, the conservation of the Lake from the perspective of regional/local development. Before going on to an assessment of the benefits from the Lake, it is therefore, essential to understand the structural conditions of the economy in the region which largely determine the nature of demands made on such natural systems. This has been taken up in the following chapter to highlight how environment and development is interdependent by making an overview of the pace and pattern of the development process in Orissa.

Notes and References

1. Environment here refers to natural systems and environmental quality. Natural systems refer to ecosystems of various types - aquatic and terrestrial - in various types of uses - croplands, forests, fisheries, grazing lands, etc.. Environmental quality refers to the state of the air, water, land and human artifacts as affected by human activities.

2. WCED (1987).

3. Ibid.

4. Pearce and Maler, `Environmental Economics and the Developing World' in Ambio, Vol XX, No. 2, April 1991, p.52.

5. Definition by Sachs (1979) cited in Adams (1990).

6. The two approaches so termed are used by Bharadwaj (1979).

7. Goodland & Ledec (1987) cited in Pezzey (1989), p.65.

8. Adams (1990).

9. Allen (1980) cited in Pezzey (1989), p.70.

10. Roy in Southgate et al.(1987).

11. World Bank (1988).

12. Rees (1985).

13. Suriyakumaran (1979).

14. Ibid.

15. Bharadwaj (1979).

16. Suriyakumaran (1979), op. cit., p.54.

17. Pearce and Maler, loc. cit.

18. Ibid. p.53.

19. Alison Stone, `Economic Evaluation of Wetlands' in Donohue and Phillips (ed.) (1991).

20. Donohue and Phillips (ed.) (1991).

21. Maltby (1986).

22. A review of these methods given in Hufschmidt et al. (1983) and Stone, op.cit.

23. Cited in Rees (1985).

24. Travel cost method measures the extent to which an individual is prepared to spend time and incur costs travelling to a site. The study is cited in Ambio, Vol XX, op.cit. p.21.

25. Cited in Ambio, Vol XX, No.3, 1991.

26. This terminology is by Claridge (1991), which has been adopted for the present study while assessing the 'benefits' from Lake Chilika.

27. Donohue and Phillips (ed.) (1991).

28. Maltby (1986).

29. Cited in Government of India (1990), Wetlands of India - A Directory, Ministry of Environment and Forests, New Delhi.

30. Ibid.

31. Issues in Wetland Management, Department of Water Resources (1970), Water Board, Sydney.

32. Wetlands are the only particular ecosystem type to have their own international convention.

    The Convention defined wetlands in the broadest terms as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

33. Maltby (1986).

34. Turner (1991).

35. Ibid.

36. M.S.Swaminathan in his foreword to 'Waterlogged Wealth' by Maltby (1986).

37. Scott and Poole, op.cit.

38. Ibid.

39. Government of India (1990), Wetlands of India - A Directory, op.cit.

40. Scott and Poole (1989), A Status Overview of Asian Wetlands : Compiled for the Asian Wetland Bureau (AWB) and World Wide Fund for Nature (WWF).

41. Government of India (1990), op.cit.

42. (1) Uday Shankar (1992), 'Chilika: A lake in limbo' in Down to Earth, August 31st, 1992; (2) Usha Rai (1992), 'Will Grand schemes save Chilika' in Indian Express dated 17th January, 1992; (3) 'The Chilika Tangle' - editorial in Indian Express, 5th August, 1992; and (4) 'Chilika Project: Patnaik denies report' in The Hindu, 2nd August, 1992.

43. Senapati (1991).

44. Scott and Poole, op.cit.

CHAPTER 2

PACE AND PATTERN OF DEVELOPMENT IN ORISSA
An Overview towards Resource Management Approach

The present chapter makes an overview of the pace and pattern of development in the state to assess the significance of `resource management' in the development process. Further, the degradation of natural systems, Chilika Lake in particular, and the `benefits' from its conservation cannot be seen in isolation from the larger socio-economic structure which determines the nature of demands made on the natural resource base of the state. This chapter therefore attempts to unravel certain dimensions of the development process in the state which would aid in assessing the `macro' implications of the `benefits' from the Lake in the following chapter.

Historically, Eastern India comprising Orissa, West Bengal, Bihar and East Uttar Pradesh formed the most prosperous agricultural tract in the country, given the rich endowment of natural wealth in the form of fertile soil, good rainfall, and abundant surface and groundwater resources. Even at the time of Independence, its agriculture maintained a lead over other regions in the country. The trends in foodgrains yield analysed by the Sen Committee on Agricultural Productivity in Eastern India[1] is shown in Table 2.1.

It is observed that during the triennium ending 1950-51, the Eastern Region had recorded highest foodgrains yield. However, since then and especially after the introduction of the new HYV seed and fertiliser technology in the country, the region with the exception of West Bengal, has steadily lost its

Table 2.1: Trends in Foodgrains Yield

(kg/ha)

State/Region	Triennium Average			
	1950-51	1960-61	1970-71	1980-81
West Bengal	916	949	1170	1290
Orissa	540	758	839	779
Bihar	513	714	820	914
East Uttar Pradesh	673[5]	694	822	957
Eastern Region[1]	644[6]	765	897	970
Western Region[2]	390	524	551	649
Southern Region[3]	554	731	897	1149
Northern Region[4]	608[7]	788	1150	1493
All India	541	671	820	975

Notes: 1 Includes West Bengal, Orissa, Bihar and East Uttar Pradesh
2 Includes Maharashtra, Gujarat, Madhya Pradesh and Rajasthan
3 Includes Andhra Pradesh, Tamil Nadu, Karnataka and Kerala
4 Includes Punjab, Haryana and Uttar Pradesh (excluding East Uttar Pradesh
5 For U.P. as a whole
6 Includes entire U.P. as separate data for East U.P. are not available
7 Excludes U.P.

Source: RBI (1984), Report of the Committee on Agricultural Productivity in Eastern India, Volume 1.

relative position. The Northern Region crossed the foodgrains yield level of the Eastern Region by early 1960s and the Southern Region in the 1970s. "It appears ironical that programmes and policies during the planning era, which have induced an acceleration in the pace of agricultural development in other regions, could not make sufficient impact in the Eastern Region which was agriculturally so prosperous in earlier times."[2]

Orissa, in terms of geographical area, occupies 4.7% of the country's area and 3.9% of the population (1981 Census). A profile of the state's population is given in Table 2.2. It is seen from the table that the decennial

Table 2.2: A Profile of Orissa's Population Trends

Population Characteristics	Census			
	1961	1971	1981	1991(P)
Total Population (in lakhs)	175 (4 %)@	219 (4 %)@	264 (3.9 %)@	315 (3.7 %)@
Decennial growth rate of population (%)		25.1 (24.8)	20.2 (24.6)	19.5 (23.6)
Population Density per Sq.Km	113 (142)	141 (177)	169 (216)	202 (267)
Urban Population [as % of total population]	6.3 (18.0)	8.4 (19.9)	11.8 (23.3)	13.4 (25.7)
Rural Population [as % of total population]	93.7 (82.0)	91.6 (80.1)	88.2 (76.7)	86.6 (74.3)
SC & ST Population [as % of total population]		38.2 (22.0)	37.1 (23.6)	22.4
Working Population [as % of total population]			38.1 (36.7)	37.5 (37.7)
Main Workers [as % of total population]		31.2 (33.1)	32.8 (33.5)	32.7 (34.1)

Notes: (1) Figures in parentheses with `@' are percentages to All India
(ii) Figures in parentheses refer to those for All India.

Source: The Census data for All India and Orissa for the years 1961, 1971, 1981 and 1991 (Provisional)

growth rate of population for Orissa has declined from 25.1% in 1961-1971 to 19.5% in 1981-1991 and it has remained below the national average for the last two decades. At the same time, it may be noted that the population density per sq.km in Orissa has been steadily increasing. In fact, it has almost doubled within a span of 30 years, from 113 in 1961 to 202 in 1991.

Moreover, the table reveals that a sizable proportion of the population consists of the scheduled castes and scheduled tribes comprising about 37.1% as compared to 23.6% for India (1981 Census). Further, about 88% of the population (1981) is rural as compared to about 77% for India. The working population is however, only about 38%, with 33% as main workers (1981 Census definition). Hence, it is imperative now to have a look at the occupational classification of the workers. This is shown in Table 2.3.

It is seen that more than 70% of the main workers (1981) are engaged in agriculture as cultivators and agricultural labourers. Taking the allied activities into account nearly 80% depend on the primary sector. Looking across the inter-censal figures, it is seen that the employment structure has virtually remained unchanged. It may be noticed further from the table that a significant proportion of the sizable SC and ST population in the state remains in agriculture. It is therefore apparent that a majority of the population is directly dependent on the primary sector activities which are by definition based on the direct appropriation of the natural resource base.

Table 2.3: Economic Classification of Workers, Orissa

Sl. No.	Occupational Categories	1971 Census			1981 Census			1991 Census		
		% to Total workers	% to Total ST workers	% to Total SC workers	% to Total Workers	% to Total ST workers	% to Total SC workers	% to Total workers	% to Total ST workers	% to Total SC workers
1.	Cultivators	49.2	52.4	27.5	46.9	52.2	28.9	44.2	- Not Available -	
2.	Agricultural labourers	28.3	36.7	49.2	27.8	36.2	47.4	28.9		
(1+2)	Agriculture	77.5	89.1	76.7	74.7	88.4	76.3	73.1		
3.	Livestock, Forestry, Fishing, Hunting, Plantations, Orchards & Allied Activities	2.1	1.9	2.5						
4.	Mining & Quarrying	0.8	1.3	0.7						
5.	Manufacturing & processing, Servicing & Repairs									
	(a) Household Industries	3.6	1.2	5.4	3.3			3.5		
	(b) Other than Household Industries	2.3	1.2	1.5						
6.	Construction	0.6	0.2	0.5						
7.	Trade & Commerce	3.3	0.6	1.6						
8.	Transport, Storage & Communication	1.5	0.7	1.6						
9.	Other Services	8.4	3.8	9.5						
	Other Workers*				22.0			23.5		

Notes: 1. * as indicated for 1981 Census and 1991 Census includes categories 3, 4, 5(6), 6, 7, 8 and 9.

2. Inter-censal data is not strictly comparable due to changes in the definition of 'Workers' amongst Census

Source: Economic Survey of Orissa, 1977 & 1983/84

Now, in terms of per capita income, the position of the state is shown in Table 2.4.

Table 2.4: Per Capita Income in Orissa and All India
(Rs. at 1970/71 prices)

Reference Years	Orissa	All India	Gap	Gap as % of All India
1960/61	236	559	323	57.8
1965/66	358	559	201	36.0
1970/71	478	633	155	24.5
1975/76	475	664	189	28.5
1980/81	477	698	221	31.7
1985/86	551	798	247	31.0

Source: Chandhok & the Policy Group (1990), India Database: The Economy, Volume 1.

It is seen that the per capita income of Orissa has been increasing, but at the same time since the 70s there is a widening gap with respect to that of the national average which indicates growing regional disparity. It may be interesting in this context to find out the extent of poverty in the state. Estimates of the population below poverty line in Orissa made by the Planning Commission is given in Table 2.5 below.

It is seen that the poverty ratio has been declining but as in 1987-1988, about 45% of the population is still below poverty line. In terms of rural-urban divide, about 48% of the rural and 24% of the urban population is below poverty line in 1987-88. The 38th Round of NSS Data gives still higher figures for Orissa based not merely on calorie requirements but access to basic needs of food, clothing and shelter. A major factor for the high incidence of poverty is seen to be the widespread unemployment and underemployment in the state.[3] In other words, this reflects the failure of the economy to generate employment opportunities for broad based development. This calls for a closer examination of the productive sectors of the economy.

Table 2.5: Incidence of Poverty in Orissa

(in percent)

Reference Years	Rural	Urban	Total
1972/73	71.0 (54.1)	43.3 (41.2)	68.6 (51.5)
1977/78	67.9 (51.2)	41.8 (38.2)	65.1 (48.3)
1983/84	44.8 (40.4)	29.3 (28.1)	42.8 (37.4)
1987/88(P)	48.3 (33.4)	24.1 (20.1)	44.7 (29.9)

Note: Figures in parentheses refer to those for All India.

Source: Planning Commission, Government of India in Statistical Outline of Orissa (1991), Directorate of Economics and Statistics, Orissa.

It is seen from Table 2.6 (p.37) that the primary sector including agriculture and animal husbandry, forestry and logging fishing, mining and quarrying accounts for more than 60% of the state's income and its share has declined only marginally since the 60s. At the same time, the share of secondary sector has also gone down, while only that of the tertiary and the services sector have gone up. Further break up of the primary sector's share in state income is given in Table 2.7. It is seen that agriculture is the major component of the primary sector. It alone contributes nearly 60% of the state income, and with almost 70% of the population engaged in it as seen earlier in Table 2.3 , it is evident that agriculture is the mainstay of the economy.

It can be also seen from the same Table that there has been a decline in the share of agriculture, though marginally. The share of forestry and logging has also declined while only that of fishing has picked up. The share of mining and quarrying, on the other hand has almost remained unchanged. This appears paradoxical in light of the favourable endowments of natural resources that the state has.

Table 2.6: Sectoral Contribution to Orissa's Net State Domestic Product at factor cost at 1970-71 prices

(in Percent)

Reference Years	Primary Sector[1]	Secondary Sector[2]	Tertiary Sector[3]	Services[4]
1960/61	64.6	11.7	8.3	15.4
1965/66	63.8	13.5	9.9	12.7
1970/71	67.3	10.4	11.2	11.2
1975/76	66.7	9.9	11.2	12.1
1980/81	63.5	10.6	11.2	14.7
1985/86	63.2	8.9	10.9	17.0
1987/88	62.1	9.5	10.9	17.5

Source: Same as in Table 2.4

Notes: 1 Includes Agriculture, Forestry & Logging, Fishing, Mining & Quarrying

2 Includes Manufacturing - registered & unregistered, Construction, Electricity, Gas & Water Supply

3 Includes Transport, Storage & Communication, Trade, Hotels & Restaurants

4 Includes Banking & Insurance, Real Estate, Ownership of Dwellings & Business Services, Public Administration, and Other Services

Table 2.7: Contributions within the Primary Sector to Orissa's Net State Domestic Product at factor cost at 1970-71 prices

(in Percent)

Reference Years	Agriculture	Forestry & Logging	Fishing	Mining & Quarrying
1960/61	60.0	2.1	0.6	1.9
1965/66	59.7	1.6	0.6	1.9
1970/71	63.2	1.4	0.8	1.8
1975/76	62.6	1.0	0.9	2.1
1980/81	59.5	1.1	1.1	1.8
1985/86	58.9	0.9	1.5	1.9
1987/88	57.6	0.8	1.8	1.9

Source: Same as in Table 2.4

It is thus evident from the occupational structure as well as the sectoral contribution to state income that the basic structure of the economy has remained virtually the same since the 60s. This `impasse ' confirms our earlier scepticism that development planning has hardly made a dent on the regional development of Orissa. The sectoral income per worker is given in the following Table 2.8

Table 2.8: Per Worker Sectoral Income*

(Rs.)

Sectors	1970-71	1985-86	Absolute Change
Agriculture & allied activities	1246	1407	+ 161
Mining and Manufacturing	2554	1645	_ 909
Services	2566	3126	+ 560

Note: * worked out by dividing the total income originating in the sector by workers in the respective sectors, as per the 1971 and the 1981 Census.

Source: CMIE (1989), cited in Bansil (1990), Agricultural Statistical Compendium, Vol.1, Foodgrains, Part 1.

Thus, it is seen that in terms of output, income and employment, the primary sector activities, and especially agriculture, is the dominant economic activity in the state. It follows therefore, that for a broad based development which can meet the needs of a growing population in terms of food and employment, the economy is dependent directly on the growth performance of agriculture/the primary sector. However, despite the favourable natural endowments in terms of the land and water resource base, the productivity of this sector has remained low. The Sen Commmittee in its analysis of agricultural productivity in Orissa since the 60s noted that it is very low and much below its potential.[4]

Now, one explanation for the low productivity in agriculture may be found in the 'environmental factors' influencing the agricultural performance in the state. In other words, given the institutional, socio-economic and organizational features which have created bottlenecks in improving the productivity of the region,[5] the environment dimension with respect to the management of the resource base cannot be less significant. This may be seen in the 'type' of agriculture done, the cropping specificity, the cropping intensity, as well as the recurring natural calamities in the state, which to anticipate makes agriculture largely dependent on an effective management of the resource base.

Agriculture in Orissa, in the first instance, is largely rainfed. Orissa lies in the zone of medium to heavy rainfall and receives almost 75% of the rains on account of the South-West monsoons during the months of June to September. However, the rainfall being largely erratic and uneven, agriculture in the state is virtually a gamble on the monsoons. In addition, the development of irrigation facilities in the state as a safeguard against the erratic supply of water has been rather tardy both for historical and topographical reasons. By 1989-90 total irrigation potential created from all sources was 19.68 lakh hectares which constituted only about 31.2% of the net area sown in the state. The Central Water Commission has estimated that 59 lakh hectares out of the net cultivable area of 65.59 lakh hectares in the state can be brought under irrigation through different sources. Further, the main source of irrigation in the state is canal irrigation (51% in 1986 -87), which depends on the river waters. And these rivers being rainfed, the irrigated areas are still vulnerable to the vagaries of the monsoons.

The onset, pattern and distribution of rainfall therefore significantly affects the agricultural economy of the state. Invariably, years of good (normal) monsoon have been accompanied by good agricultural production and years of abnormal rainfall, either, deficient or excessive, have been trying times in the nature of droughts and floods. This may be seen from Table 2.9 below which

Table 2.9: Pattern of association between Monsoon and Foodgrains Production

Years	Monsoon	Foodgrains Production in Lakh Tons	Years contd.	Monsoon	Foodgrains Production in Lakh Tons
1964/65	N	49.24	1973/74	N	52.75
1965/66	A^{S}_{D}	36.85	1974/75	$A_{SD,F}$	39.71
1966/67	A_{D}	42.31	1975/76	N	55.70
1967/68	A_{MF}	41.35	1976/77	A_{SD}	40.75
1968/69	A_{MF}	47.21	1977/78	N	55.61
1969/70	A_{MF}	47.28	1978/79	N	57.65
1970/71	A_{MF}	48.63	1979/80	A_{SD}	38.72
1971/72	A_{SF}	43.54	1980/81	N	59.77
1972/73	$A_{D,F}$	48.60			

Note: N - normal monsoon; A - Abnormal year -- due to drought (d); mf - mild flood; sf - severe flood; sd - severe drought; c - cyclone

Source: Modified from Mishra (1983).

gives the production of foodgrains (which constitute about 70-75% of the agricultural production in the state) from 1964-65 to 1980-81 along with the years of abnormal and normal monsoons.[6]

It is seen that there is a sharp fall in foodgrains production during the years of natural calamities. It is estimated that during the period 1951-52 to 1965-66, 40% of the variation in agricultural production was accounted by erratic monsoon, whereas during the period, 1957-58 to 1977-78, 60% of the variation was accounted by the same and despite the improvement of technology in the latter period, the yield rate was low because of the hazards of the monsoon.[7]

Further, the water regime also infuences the cropping pattern and cropping intensity, and thereby shaping agricultural productivity of the region. For instance, certain crops which could have been grown otherwise may not be grown because of the uncertain water supply. The cropping pattern of major crops in the state is given in Table 2.10.

Table 2.10: Cropping Pattern of Principal Categories of Crops in Orissa

(%)

Year	Rice	All Cereals	Pulses	Food grains	Oil seeds	Fibres	Other Crops
1950-51	64.4	67.1	0.6	67.7	3.0	0.9	28.0
1960-61	61.9	64.4	8.1	72.5	3.6	0.9	22.4
1970-71	66.1	72.4	12.5	84.9	4.9	1.2	8.1
1980-81	47.9	59.3	19.7	79.0	8.4	1.1	10.6
1984-85	49.1	56.9	18.9	75.8	10.5	1.1	11.8
1989-90	46.5	52.5	21.3	73.8	11.9	0.9	12.6

Source: Agricultural Statistics of Orissa, Directorate of Agriculture & Food Production, Government of Orissa (1987) for the years upto 1984-85, and data pertaining to the year, 1989-90, is collected from Chandhok & the Policy Group (1990).

It is seen that more than 60% of the cultivated area is under foodgrains and among the foodgrains, more than 50% of the area is under paddy cultivation. Lately, there has been some shift in favour of pulses and oilseeds. However, paddy is still the dominating crop. It may be noted that paddy is one of the most water-intensive crops and also the only crop which can withstand swampy conditions for a prolonged period of time.[8] Given the onslaught of the monsoons and the lack of irrigation facilities, it is not surprising that the cropping pattern and cropping intensity is limited. This may also explain the persistence of traditional methods of agriculture in the state, despite the low yield rate., since it has been observed that modern agricultural practices like the HYV package, for instance, places greater demands on the availability of water in the right amounts at the right time.

It is thus seen that the rainfall regime has been a significant factor influencing agricultural performance in the state. An analysis of the changes in the rainfall pattern in the state from 1901-86 by Pujari (1991) and Lenka (1991)[9] shows that the quantum of precipitation has declined and it is declining but with higher intensity (that is, there are lesser number of rainy days with more concentrated distribution). They also showed that the floods in the later years have been caused with rainfall below normal indicating that the natural drainage system system has lost its natural carrying capacity of rainwater, and this, they have attributed to the loss of canopy cover in the catchment areas of the rivers, the increased rate of soil erosion and increasing siltation of the river beds.

In addition, Orissa is one of the five `chronically flood affected' states of India.[10] Floods inflict not only direct, tangible damages in the form of damages to crops, properties and livestock caused by the direct contact or submergence from the floodwaters, but also intangible and indirect damages caused by the cessation of normal economic activities, the mental agony and anxiety, the health hazards, the loss of human lives etc. which affect the productivity of the people. Apart from this, it is also subjected to what is referred to as the `damage of underdevelopment'and `damage due to wasted opportunities'.[11]

> "A chronically flood affected region suffers from the actual occurences or the threat of occurrences of recurrent floods. Consequently, the economic activities which are likely to be interfered with, interrupted or disrupted by such occurrences are perpetually carried out in low gear. The investment of money, materials and manpower into essential or otherwise possible economic activities such as agriculture or some agro-based industries is kept at low level in order to minimise damages to be sustained in the eventuality of flood occurences ... the economic potential of this region remains far from realized or developed ... "[12]

While floods signify damages, destruction and devastation, they also contain opportunities of use and benefits. The volume of water that floods contain, the energy that provides them with destructive capability and the silt that they deposit can be all harnessed to productive purposes. This is referred to as the flood damages attributable to `wasted opportunities '. Therefore, these `benefit prevented ' damages are over and above the direct damages caused by floods which is not captured by the usual methods of flood damage assessment but which as seen above is significant in the context of a chronically flood affected region.

By prevailing methods of flood damage assessment, the share of the major states in flood damages for the period 1970-85 is given in Appendix 2.1. The share of Orissa is 7.26%, the highest being for Uttar Pradesh at 26.37%. In terms of the area which is liable to floods in the different states of India, the estimates by the National Flood Commission (1980), are given in Table 2.11. It is seen from the table that in case of Orissa, the maximum area affected by flood in any year between 1953-85 is 3.34 million hectares; area liable to floods is 1.4 million hectares and area protected from floods till 3/1985 is 0.45 million hectares. This is only 32% of the area liable to floods. Flood prone area of the state according to the Eighth Plan estimates is 41,000 sq.km and it is proposed to provide protection measures to different degrees to an area of 28,210 sq.km by the end of March 1992.[13]

The recurrence of floods, therefore, entail the allocation of economic resources in monetary and physical terms year after year as relief and protection measures. In fact, the outlay on flood control (together with irrigation) has increased sharply from Rs. 807.45 crores during the 7th Plan to Rs. 2369.34 crores during the 8th Plan. This has been a major component of the state's budget accounting for about 24 percent of the total outlay.

Table 2.11: Areas Liable to Floods in India

(million ha)

S. No.	State	Max. area affected by flood in any year between 1953-1985	Area liable to floods as indicated in RBA Report	Area protected till 3/1985
1.	Andhra Pradesh	1.45	1.39	0.99
2.	Assam	3.15	3.15	1.53
3.	Bihar	4.26	4.26	1.84
4.	Gujarat	1.39	1.39	0.43
5.	Haryana	1.00	2.35	1.62
6.	Himachal Pradesh	0.23	0.23	0.01
7.	Jammu & Kashmir	0.08	0.08	0.06
8.	Karnataka	0.26	0.02	neg.
9.	Kerala	2.00	0.87	0.02
10.	Madhya Pradesh	0.43	0.26	neg.
11.	Maharashtra	0.23	0.23	neg.
12.	Manipur	0.08	0.08	0.08
13.	Meghalaya	0.02	0.02	neg.
14.	Nagaland	0.008	-	-
15.	Orissa	3.34	1.40	0.45
16.	Punjab	1.73	3.70	2.65
17.	Rajasthan	3.26	3.26	0.04
18.	Sikkim	0.02	-	-
19.	Tamil Nadu	0.85	0.45	0.08
20.	Tripura	0.33	0.33	0.03
21.	Uttar Pradesh	7.34	7.34	1.37
22.	West Bengal	3.08	2.65	1.62
23.	Union Territories	0.13	0.06	0.08
	ALL INDIA	34.668	33.52	13.00

Note: neg. indicates negligible

Source: Rashtriya Barh Ayog: RBA (National Flood Commission), Government of India, New Delhi, March 1980.

Now, floods cannot be eliminated altogether but the extent and intensity of their damage can be minimised. Flood control measures in the state are essentially of the protective type in the form of flood embankments downstream and construction of dams in the upper reaches of the rivers, like the Hirakud Dam on Mahanadi, Rengali Dam on River Brahmani, etc.. However, these have not been very effective in minimising the damages in absolute terms.

downstream and construction of dams in the upper reaches of the rivers, like the Hirakud Dam on Mahanadi, Rengali Dam on River Brahmani, etc.. However, these have not been very effective in minimising the damages in absolute terms. Estimates of damages caused by floods and other natural calamities in the state are given in the table 2.12.

It is apparent that natural calamities, floods in particular, pose the single biggest constraint for the state - both in terms of the physical dimension, that is, the magnitude and intensity of the floods as well as the socio-economic dimension.

Predictably, the regional variation in terms of both physiography and socio-economic factors makes certain regions more `sensitive' to such natural calamities, which therefore require special attention. By physiography, the coastal plains, for instance, are the most fertile region anywhere. They have always attracted human settlements and invariably these have been the site of all civilizations, often growing into centres of flourishing trade and economy. Consequently, the plains are also most subject to stress - from demographic and development pressures as well as from environmental factors such as its location and topography, which make it vulnerable to influences from the sea on one side and the upland activities on the other.

In case of Orissa, physiographically, it is divided into four zones -- the Northern Plateau, the Central Tableland, the Eastern Ghats and the Coastal Plains as shown in Figure 2.1 (p.47). Roughly, the thirteen districts of the state can be divided into four categories on this basis. A brief sketch of each of the zones is presented in Appendix 2.2.

Table 2.12: Properties damaged, Deaths and Injuries caused by Flood, Drought and Cyclone in Orissa

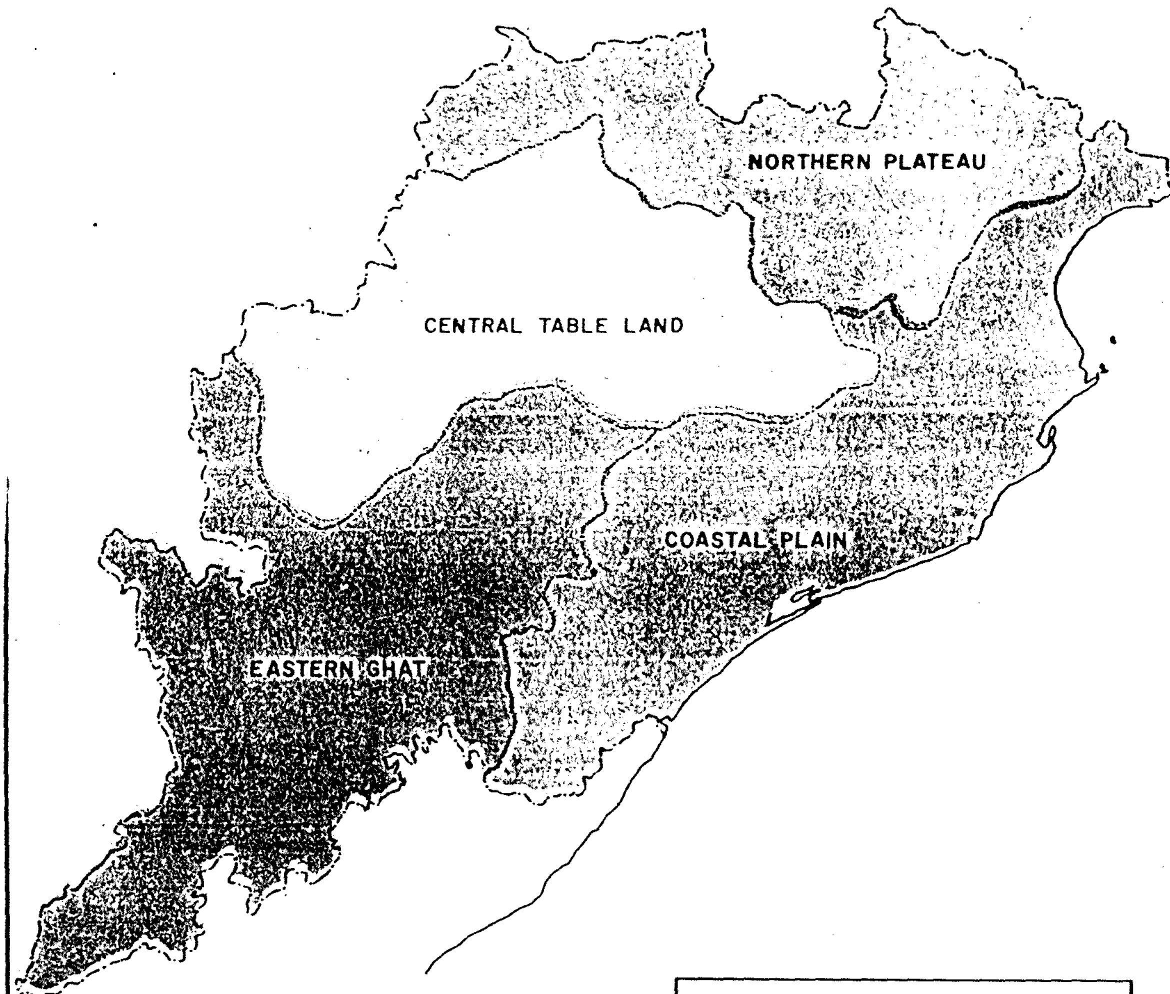
Year	Types of Calamity	No. of Persons involved in the calamity ('000)	No. of human beings lost	No. of human beings injured	Value of property lost & damaged (Rs.lakhs)
1972	Fl, Cy, D, T	475	139	2	1289
1973	Fl, Cy, D, F	435	17	11	291
1974	D, Cy, Fl, F, S & T	1072	24	5	1289
1975	Fl, F, Cy	433	45	7	344
1976	D, Fl, S & T, F	2859	65	14	1791
1977	Fl, D, F, Cy, L	1195	71	8	922
1978	Fl, D, S & T, F	1530	101	383	959
1979	Fl, Cy, Dr, S	6323	51	11	3257
1980	Fl, Dr, F, L	2443	136	53	3054
1981	Fl, D, F, L	617	109	966	1256
1982	Fl, Dr, F, L, Cy	18183	416	450	10711
1983	Fl, Dr, F, L, Cy	2103	119	29	4938
1984	Fl, Dr, F, L, Cy	7829	140	75	11448
1985	Fl, Dr, F, L, Cy, S	7082	194	557	13887

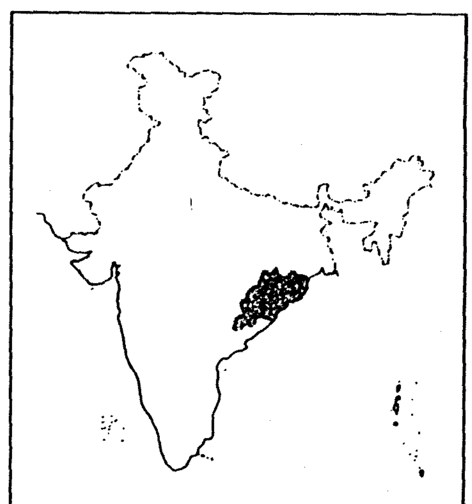
Note: Fl - Flood; Cy - Cyclone; Dr - Drought; F - Fire; S - Strom; L - Lightning

Source: Statistical Abstract of Orissa, Various Issues, Directorate of Economics & Statistics

It is seen from the Appendix 2.2 that the Coastal Plains zone or in other words, coastal Orissa comprising of the four districts of Balasore, Cuttack, Puri and Ganjam is the most densely populated and the most intensely cultivated region in the state. It may be noted that Chilika Lake lies in this zone in the district of Puri, partly extending into Ganjam district.

2.1 Orissa: Physiographic Zones





1 Based upon Survey of India map with the permission of the Surveyor General of India.

2 © Government of India Copyright 1985.

3 The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

4 Responsibility for the correctness of internal details shown on the maps rests with the publisher.

It is also noticed that the Coastal Plains have a population density higher than the state's average, with 48% of the state's population living in these four districts. Further, it is seen that 71% of the population is dependent on agriculture. The net area sown comprises about 53% of the area, which is 34% of the state's area. In other words, it is this zone which forms the major agricultural belt of the state.

It may be further noted that the coastal districts are distinct from the hilly, inland districts both in terms of population and the resource base. The tribal population is more concentrated in the inland districts than in the coastal districts. Further, the productive base in the inland districts comprises mainly the minerals and forests, whereas it is largely wetland-based in the case of the coastal districts - agriculture and fisheries.

The share of the coastal districts in agriculture by area and production to the total for the state is given in Table 2.13 below. It is seen from the table that in 1979-80, coastal Orissa accounts for 41% of the total area under foodgrains in the state, 39% under paddy and 55% under pulses. With respect to non-foodgrains, its share was 34%, including 32% of the oilseeds (60% of the groundnuts, in particular), 60% of the fibres (95% of the jute) and 40% of the sugarcane area in the state. In terms of production, its share in foodgrains was 51%, with 54% of the rice and 60% of the pulses. In case of the non-foodgrains, it accounted for 45% of the oilseeds. Evidently, the favourable agro-climatic conditions in terms of the fertile soil and the abundant supply of water from the rains in the kharif season and from canal irrigation in the rabi season supports the diversified agriculture noted in this zone. However, in terms of productivity, it is much below its potential.[14] Further, it is also observed that the relative contribution of the coastal districts to total has declined both in terms of area and production implying that agricultural

Table 2.13: Relative Shares of Coastal Orissa in Orissa Agriculture by Area and Production of Major Crops for 1979-80 and 1984/85

Crops by Area/Production	Relative Share@ (%)	
	1979/80	1984/85
AREA UNDER MAJOR CROPS		
I. Foodgrains	40.95	36.92
(i) Rice	38.89	38.36
a. Autumn	*9.49*	*10.59*
b. Winter	*47.56*	*47.04*
c. Summer	*32.24*	*35.97*
(ii) Pulses	54.62	39.77
II. Non-foodgrains	34.40	31.48
(i) Oil seeds	31.27	29.27
(ii) Fibres	59.88	58.33
(iii) Sugarcane	39.74	32.60
PRODUCTION OF MAJOR CROPS		
I. Foodgrains	51.10	38.61
(i) Rice	53.85	40.17
a. Autumn	*36.76*	*15.08*
b. Winter	*57.60*	*45.56*
c. Summer	*29.02*	*37.76*
(ii) Pulses	59.62	42.29
II. Non-foodgrains		50.35
(i) Oil seeds	44.68	44.13
(ii) Fibres		18.45
(iii) Sugarcane		38.38

Note: @ - the ratio of Coastal Orissa to Orissa State.
Source: Statistical Abstract of Orissa (1981, 1985), Directorate of Economics and Statistics.

activities in the zone appears to have slackened.

In fact, a district wise analysis of flood damage data for three flood years, 1964, 1980 and 1982, showed that 82.5%, 82% and 70% of the damage for the state as a whole in the respective years with respect to the cropped area affected occurred in the districts of Cuttack and Puri which lie in the deltaic plains of River Mahanadi.[15] This corroborates the earlier point that the slow down in agricultural activities may be attributed to the occurrence of floods. Hence, it becomes imperative to understand the intensity of flood occurrences in Mahanadi delta.

Mahanadi is the largest river system in Orissa (its river basin is the third largest in India) and like other major rivers of India carries a high discharge during the South West monsoons when heavy and widespread rainfall occurs. It experiences floods almost every other year. The Hirakud Dam on the upper reaches of the river in the district of Sambalpur, commissioned in 1956 had the triple objectives of irrigation, flood control and power generation. The Sivaraman Committee in its report on the Benefits due to Complete Flood Protection by the Hirakud Dam Project, by analysing the annual peak discharge data for Mahanadi over a period of 80 years upto about 1954, noted that a "normal flood " averages once in 3 years, a fairly "heavy flood" once in 5 years and an "abnormally heavy flood" once in 12 years. With respect to the floods in Mahanadi in the pre-dam period and the post dam period it was shown that there has been no declining trend in the extent of flood damage in the delta in the post-dam period. Not only the average extent of cropped area affected by floods has increased in absolute terms but also as a proportion of net sown area. In terms of physical dimension, it was observed that though the frequency of large and very large floods had come down in the post-dam period, that of small and medium floods have gone up. In other words, the average magnitude of floods in the Mahanadi has gone down in the post-dam period, but the average extent of damage has not declined. Three reasons have been advanced -an increase in the average duration of floods, an increase in the flood level because of siltation of river beds and an increasing occupation of the earlier flood-prone areas.[16]

It is thus seen that, floods in Mahanadi tend to be a major calamity for the zone and the state as well. And considering the fact that they continue to wreak havoc with a notorious regularity, it calls for a fresh look into the flood management strategy of the state. In this context, the role of Chilika which lies at the tail-end of the river system in the south-eastern periphery of Mahanadi's delta and which is one of the major outlets for the flood waters of Mahanadi cannot be overlooked. This aspect will be taken up while assessing the `benefits' from the Lake in the next chapter.

It may be further noted that the extent of damages caused by floods in the rivers of the state has been acute in the deltaic plains partly due to certain natural factors and partly due to the man-made systems, like the irrigation and drainage structures. The flat topography of the Plains, for instance, with very little slope which characterises this particular part of the Eastern Plains creates problems of natural drainage. This when added to the faulty designing and maintenance of the drainage structures and flood embankments in this region intensifies the damages. This has also resulted in the additional problems of waterlogging and soil salinity observed to be increasing along this coast. The extent of waterlogging in the state is given in ~~the~~ table 2.14.

It is seen that the coastal districts have the maximum area under waterlogging. It is estimated that in the delta of Cuttack, Puri and Balasore, for every 100 acres which have come under irrigation about 8 acres have gone out of cultivation due to over-irrigation.[18]

Moreover, the percentage of waterlogged area in relation to irrigated area in the coastal districts and one inland district is given in Table 2.15. It is seen that Balasore, with 17% of irrigated area has almost 9% area waterlogged. Ganjam has the least waterlogged area with respect to irrigared area. Cuttack and Puri have more than 8% area waterlogged. The inland district, Sambalpur has about 6% waterlogged area in relation to the irrigated area. It may be noted that this district has the Hirakud Irrigation System. It has therefore, been suggested that the irrigation system and drainage structures have been responsible for the increasing waterlogging observed in the state.

Table 2.14: Distribution of Waterlogged Area in Orissa

('ooo ha)

Districts	Waterlogged Area
Balasore	6.36
Cuttack	21.36
Puri	13.95
Ganjam	5.86
Bolangir	3.36
Dhenkanal	0.87
Kalahandi	6.32
Keonjhar	0.99
Koraput	3.82
Mayurbhanj	1.21
Phulbani	1.12
Sambalpur	7.73
Sundergarh	1.81

Source: ORSAC (undated), Waterlogging in Orissa.

Table 2.15: Percentage Distribution of Irrigated and Waterlogged Area by Coastal Districts

Coastal Disticts	Net Sown Area (1)	Irrigated Area (2)	(2) as % of (1) (3)	Water logged Area (4)	(4) as % of (2) (5)
Cuttack	705	242	34.32	21.36	8.82
Puri	466	169	36.26	13.95	8.25
Balasore	424	71	16.74	6.36	8.95
Ganjam	501	226	45.10	5.86	2.58
Sambalpur	622	140	22.50	7.73	5.52

Source: Same as in Table 2.14.

Further, the cyclonic rainfall associated with depressions over the Bay of Bengal adds to the fury of the monsoons and the rivers carry a heavy discharge by the time they reach the plains, which intensifies the `magnitude' of the floods. The `intensity'is made further worse by the increasing silt load of the rivers which reduce the natural carrying capacity by raising the river beds. The presence/absence of `flood moderating factors' which hold the precipitation where it falls and thereby control not only the rate of river flow but also the silt load of the rivers therefore become very significant in a chronically flood affected state. These `factors' include conditions like the forest cover, the land use practices, the wastelands, etc. in the critical watershed areas of the rivers at the upper end as well as in the deltaic region at the tail end. In other words, the conditions of the land resource base inluence the water resource base too; both are inextricably interlinked. It is in this context that land degradation, deforestation, soil erosion, etc. have become major `environmental issues' with widespread ramifications.

The estimates of land degradation in the state vary, but the end result of it, the wastelands, have recently been identified and classified in six districts of Orissa by ORSAC in line with a nation-wide project by the National Wasteland Development Board. The estimates are given in Table 2.16.

Table 2.16: Nature and Intensity of Land Degradation in Selected Districts of Orissa.

Characteristics	Ganjam		Cuttack		Puri		Dhenkanal		Sundergarh		Balangir	
	% to Geog. Area	% to Waste land	% to Geog. Area	% to Waste land	% to Geog. Area	% to Waste land	% to Geog. Area	% to Waste land	% to Geog. Area	% to Waste land	% to Geog. Area	% to Waste Area
AREA OF WASTELAND (SQ.KM)	35.0		6.9		17.2		14.2		11.8		14.3	
1. Gullied/Various land	0.5	1.4	0.1	0.9	0.3	1.7						0.5
2. Upland with or without Scrub	1.5	2.4			1.7	9.7	1.4	9.9	2.8	23.3		20.6
3. Surface Waterlogged Land & Marsh	0.2	0.6	0.8	11.6	1.7	10.0						
4. Salt Affected Area			0.01	0.1	0.2	0.9						
5. Shifting Cultivation Area	0.4	1.1										
6. Degraded Forest Land	24.2	70.4	3.9	56.8	10.1	58.8	11.4	80.4	7.9	66.7	10.0	69.7
7. Degraded Pastures/ Grazing Land	0.01	0.02							0.6	0.5		
8. Degraded Non-forest Plantation Land	0.2	0.6			0.9	5.1			0.1	0.9		0.5
9. Sands	0.2	0.5	0.7	10.0	0.6	3.3					0.1	0.8
10. Barren Rocks/Stony Wastes or Sheet Rock Areas				6.7					0.5	4.0	1.0	6.8
11. Steep Sloping Area					0.1	0.3					0.1	0.9
12. Mining/Industrial Wasteland												
Geographical Area of District	12531		11142		10189		10835		9675		8916	

Source: ORSAC (1988), Wasteland Maps of Orissa.

It is seen that degraded forest land is the major wasteland category in all the districts, followed by waterlogged lands and salt affected lands in the coastal districts. However, Orissa is considered to be one of the states still with a significant forest cover, but the extent of deforestation in the state as estimated by the National Remote Sensing Agency (NRSA) is given in Table 2.17.

Table 2.17: Deforestation in Orissa

Area in sq.km	1972-75	1980-82
Total geographical area	155780	155780
Closed forests	37320	28812
Open degraded forests	10829	10386
Mangrove forests	234	227
Total forest area	48383	39425
% of forest area to total geographical area	31.06	25.31

Source: NRSA in 'Proceedings of the Seminar on Environmental Aspects of Land Use in Orissa', October 30, 1990.

It is seen that the percentage of forest area has declined from 31% in 1972-75 to 25% in 1980-82. Further, the deforestation is reportedly more in the strategic areas like the watersheds and along the coast.[19] Shifting cultivation practiced in the hilly upland districts of the state is seen as the major factor underlying deforestation in the hilly upland districts.[20]

In addition, deforestation in the periphery of the multi-purpose river valley projects in the state is seen to be widespread. This is given in Table 2.18.

The extent of soil erosion in the state is given in Table 2.19. It may be noted that soil erosion can be critical for both the drier, inland districts as well as for the coastal districts. In the first case, it leads to what is termed as 'desertification' which results in drought like conditions. And in the latter case, it leads to an aggravation of the damages due to floods

Table 2.18: Changes in the Composition of Forests by Multi-purpose River valley Projects

(area in sq.km)

Multi-purpose River valley Projects	Open Forests Degraded		Closed Forests		Total Forests	
	72-73	80-82	72-75	80-82	72-75	80-82
Hirakud	303	462	709	581	1012	1043
Machkund	475	513	795	696	1270	1209
Rengali	195	274	655	488	850	762
Salandi	321	...	1037	...	1358	1294

Source: Same as in Table 2.17

Table 2.19: Soil Erosion in Orissa, 1990-91

Sl. No.	Type of Erosion	Area (in lakh ha)
1.	Sheet erosion	38.22
2.	Rill erosion	25.49
3.	Gully erosion	9.32
4.	Ravinous erosion	1.15
5.	Erosion due to shifting cultivation	1.84
6.	Stream bank erosion	2.00

Source: Eighth Plan 1992-97 and Annual Plan 1992-93, Orissa, Vol. I & II, Government of Orissa, November 1991.

by raising the beds of the rivers as well as adding to the problems of waterlogging as mentioned earlier. Further, it also results in the siltation of reservoirs, hampering both irrigation and power generation. In particular, the increasing rate of soil erosion is seen to be the major factor in the increasing rate of siltation of Lake Chilika at the tail-end of Mahanadi, thereby affecting the fisheries of the Lake.

It is thus observed that in terms of the high population density and in terms of the area under agriculture which supports the livelihood of a sizable chunk of the population and which contributes a major portion to the state's total food production, environmental degradation has a significant socio-economic content in the coastal plains.

Fisheries

In addition to agriculture which is the dominant economic activity in the state and particularly in the flood plains of the coastal districts, the other wetland based activity is fishing. Having a long coast line of 480 km (8.5% of India's) along with the inland water resources like the rivers, ponds, estuaries and lakes, both marine and inland fishing have been a traditional and caste based occupation in the state. Inland fishing is done in all the thirteen districts and marine fishing in the four coastal districts. Inland fisheries includes both fresh water and brackish water fisheries. A profile of the fishing sector at two different time points, 1982-83 and 1990-91 is given in Table 2.20.

It is seen from the table that the fisheries support the livelihood of more than 6.6 lakhs fishermen population (2.5 % of the state's population, 1981 Census) with 81% of them engaged in inland fishing as in 1990-91. The annual per capita income has been estimated as Rs.7363. The active fishermen

Table 2.20: A Profile of the Fishing Sector in Orissa

Characteristics	1982-83			1990-91		
	Inland	Marine	Total	Inland	Marine	Total
1. Fishermen Population	395304	126135	521439	529187 (80.8)	126135	655322
2. Active Fishermen		50207		134769	48769	183538 (28.0)
3. Number of Fishing Villages	8464	329	8793	6889	329	7218
4. Number of Landing Centres		62			62	
5. Number of Mechanised Boats		630			1802	
6. Number of Traditional Crafts		7549			13488	
7. Annual Per capita Income of Fishermen (Rs.)				7128	7363	
8. Fish Production (tons.)	32530 (45.7)	38700	71230	80758 (50.8)	78192	158950
(i) Fresh Water	22030 [67.8]			58720 [72.7]		
(ii) Brackish Water	10500 [32.3]			22038 [27.3]		
9. Value of Fish Production (million Rs.)	258.8	241.6	500.4	1449.1	859.8	2308.9
(i) Fresh Water	158.5 [61.2]			1031.0 [71.1]		
(ii) Brackish Water	100.3 [38.8]			436.1 [30.1]		
10. Local Consumption (tons.)	23530 (60.0)	14700	39230	61959 (66.5)	31277	93236
(i) Fresh Water	19030 [80.9]			50499 [81.5]		
(ii) Brackish Water	5500 [23.4]			11460 [18.5]		
11. Export of Fish Outside State & Abroad (tons.)	8000 (25.0)	24000	32000	18799 (28.6)	46915	65714
(i) Fresh Water	3000 [37.5]			8221 [43.7]		
(ii) Brackish Water	5000 [62.5]			10578 [56.3]		

Notes: ( ) indicates % to total and [ ] % to inland respectively.
Source: Orissa Fisheries at a Glance, various issues, Directorate of Fisheries, Cuttack, Orissa.

constitute about 28%, with 81% in the inland subsector. In terms of fish production and local consumption too, it is seen that the share of inland sector is relatively more than the marine sector. Evidently, inland sector predominates the fishing scenario in the state in contrast to the other maritime states of India. However, as far as exports are concerned, the marine sector appears to dominate. It has been observed that the poor performance of the marine sector is due to a lack of attention to the development of the marine fisheries potential in the state.[21]

In terms of fish production, Orissa's share in India's fish production is seen to be only about 4.3% (1987). The share of the two sub-sectors to fish production from 1985-86 to 1990-91 is shown in Table 2.21. It is seen that fish production in the two sub-sectors - inland and marine - is more or less equal. However, the percentage share of inland and marine fish to total fish production has almost remained stagnant. Within the inland sector, the production of fresh water fish is more than the brackish water. It may be noted that a major component of freshwater fish production in the state is through fish culture.

It is also seen that the relative share of brackish water fish production to total inland fish production and also to the total fish production in the state has been going down (columns 6 and 7). This may be related to what is happening in Chilika, since it is the single largest source of brackish water fisheries. Further, it is seen from column 8 of the table that the percentage share of marine and brackish water fish together has also been consistently going down. It may be noted that brackish water fisheries are linked to the sea, and

Table 2.21: Trends in Fish Production in Orissa

(in '000 tonnes)

Year	Inland			Marine	Total (3 + 4)	Brackish as % of Inland Total	Brackish as % of Total	Brackish + Marine as % of Total	Marine as %of Total
	Fresh	Brackish	Total						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1985-86	31.22	23.91	55.13	53.58	108.70	43.4	22.0	71.2	49.2
1986-87	32.79	24.21	57.00	55.32	112.32	42.5	21.5	70.8	49.3
1987-88	41.00	23.50	64.50	59.96	124.46	36.4	18.9	67.1	48.2
1988-89	45.37	24.50	69.87	60.12	129.99	35.1	18.8	65.1	46.3
1989-90	50.50	25.37	75.87	77.90	153.77	33.4	16.5	67.2	50.7
1990-91	58.72	22.04	80.76	78.19	158.95	28.3	13.9	63.1	49.2

Source: Same as in Table 2.20

the declining trend may be related to the factors common to both of them. This, to a certain extent, indicates the interdependence between the brackish water and marine fisheries. However, in the absence of catch and effort data for different crafts/gears combinations and other more specific information, it is difficult to discern the causes for these trends.

A closer examination of the marine fisheries sector as from Table 2.22 below showing the operation of boats and the marine fish landings reveals that the number of mechanised boats have more than doubled in the same period, and the traditional crafts have also increased but in relatively less numbers.

Table 2.22: Operation of Boats and Marine Fish Landings in Orissa

Years	Mechanised Boats operated (Nos.)	Fish Landing by mechanised boats (%)	Non-mechanised Boats (Nos.)	Fish Landing by non-mechanised boats(%)
1985-86	674	47.49	10550	52.50
86-87	724	46.25	10653	53.75
87-88	891	42.63	12019	57.37
88-89	1099	39.70	13470	60.30
89-90	1263	40.61	13488	59.39
90-91	1802	48.77	13488	51.23

Source: Directorate of Fisheries (1991), A Handbook of Fisheries Statistics, Orissa.

It may be noted that despite the tremendous increase in the number of boats, the fish landings in either case have remained almost stagnant. The fisheries not only provide a source of livelihood, but also have nutritional value as a source of animal protein. The average per capita expenditure on different groups of food items in India and Orissa for 1988-89 is given in the table 2.23. It is seen that the average per capita expenditure on animal protein rich food like meat, fish and eggs in Orissa is higher than than the all-India average for both rural and urban regions.

Table 2.23: Average Per Capita Expenditure on Selected Food Items
(Rs.)

Food Items	Rural		Urban	
	Orissa	India	Orissa	India
Cereals	58.00	45.55	59.27	41.27
Pulses & pulse products	4.52	7.14	0.03	0.19
Milk & milk products	3.71	15.65	14.29	26.74
Edible oils	4.89	7.59	10.62	12.61
Meat,fish,eggs	**6.65**	**6.12**	**13.41**	**10.59**
Vegetables	10.84	9.32	16.53	13.75
Food - total	101.59	111.80	153.99	152.49
Non-food total	45.75	63.30	102.37	114.36
Total Expenditure	147.34	175.10	256.36	266.85
Av. household size	4.99	5.17	4.63	4.87

Note: Data based on NSS 44th Round (July 88 - July 89)
Source: Sarvekshana, Vol. XIV No.3 Issue No.46, NSSO, cited in Bansil (1990).

In fact, it is estimated that nearly, 80% of the population in the state take fish.[22] The per capita availability of fish is 6.31 kg (1991)[23] in comparison to all India figure of 3.6 kg (1985) per year.[24] The consumption of fish within the state is given in Table 2.24.

It is seen that the consumption of inland fish is more than that of marine fish, which may be related to the distinct consumer preference for inland fish in the Eastern belt. Within the inland sector, the consumption of fresh water fish is observed to be increasing (column 6), while the percentage share of brackish water and marine fish is seen to be largely fluctuating in nature.

It may be noted that inland fish is almost always sold fresh, whereas the bulk of the marine landings is salted and dried. It is estimated that 71% of the catch is marketed fresh, 22% dried and salted and 7% frozen.[25] Whereas, the first preference of the consumers is for fresh fish, the interior places, dried fish meets the demand. Further, dried fish which is cheaper, is more popular with the lower income groups as well as in the rural areas.

The average annual per capita fish consumption in Orissa is estimated at 3.87 kg (1991)[26]. There is no survey of the demand-supply situation yet, but it may be safely assumed that there is a high demand for fish in the state.[27]

The fisheries, therefore, provide a cheap and easily accessible source of high quality animal protein in the form of fish and fish products. It may be noted that protein deficiency is a major factor underlying the widespread malnutrition problem in the country.[28] It is estimated that in both the rural
62
and urban areas, nearly 20% of the population in Orissa fall below the ICMR recommended intake of protein intake.[29] It is interesting to note from the same

Table 2.24: Trends in Local Consumption of Fish in Orissa

(in '000 tonnes)

Year	Inland			Marine	Total (3 + 4)	Frsesh as % of Inland Total	(2 + 4) as % of (5)	Percapita annual consumpt-ion (kg)
	Fresh (1)	Brackish (2)	Total (3)	(4)	(5)	(6)	(7)	(8)
1985-86	27.04	12.91	39.95	21.43	61.38	69.7	56.0	2.85
1986-87	28.40	13.09	41.47	22.13	63.60	68.5	55.4	2.91
1987-88	35.57	12.69	48.26	23.98	72.18	73.7	50.8	3.23
1988-89	39.01	12.74	51.75	24.05	75.80	75.4	48.5	3.35
1989-90	43.43	13.19	56.62	41.16	97.78	76.7	61.9	3.76
1990-91	50.50	11.46	61.96	31.28	93.24	81.5	45.8	3.87

Source: Same as in Table 2.20.

Table 2.25: Trends in Export of Fish from Orissa to outside state and abroad

(in '000 tonnes)

Year	Inland			Marine	Total (3 + 4)	Marine as % of Total	Brackish + Marine as % of Total	Brackish as % of Total
	Fresh (1)	Brackish (2)	Total (3)	(4)	(5)	(6)	(7)	(8)
1985-86	4.18	11.00	15.18	47.33	62.51	75.7	93.3	17.6
1986-87	4.39	11.14	15.53	48.72	64.25	75.8	93.2	17.3
1987-88	5.49	10.81	16.30	52.28	68.58	76.2	92.0	15.8
1988-89	6.35	11.76	18.11	54.18	72.28	75.0	91.2	16.3
1989-90	7.07	12.18	19.25	65.99	85.24	77.4	91.7	14.3
1990-91	8.22	10.58	18.80	65.71	84.51	77.8	96.3	12.5

Source: Same as in Table 2.20

study that Kerala, one of the highest fish producing states in the country, has the largest population in the protein deficiency. Evidently, it has nothing to do with fish production per se, but the per capita domestic consumption of fish and accessibility to other sources of protein as well.

An explanation for this ma be found in the export oriented nature of the sector. Fish and fish products have been a traditional item of exports from India accounting for 3-4% in terms of value and particularly to the developed countries, which includes USA, Japan, Australia, the West European countries in addition to other developing countries as well, such as Nepal, Sri Lanka, Malaysia, Singapore, etc.. Orissa's share to the marine exports from India comprise about 3.7%(1981).[30] It is estimated that out of the total fish production in the state, only half is consumed within the state , while the other half is marketed outside the state, in particular, Calcutta which is the major wholesale fish marketing centre in that part of India.[31] Visakhapatnam, Madras and Cochin are the other centres where fish is sent to. The export of fish outside the state and abroad is given in Table 2.25(p.64).

It is seen that marine fish forms the major component (more than 75%) of the exports. Including brackish water fish, the share goes up to more than 90%. Evidently, it is the marine sector which meets the external demand, with inland sector catering to domestic needs. However, it may also be noted from column 8 that the share of brackish water fish to the total exports has been declining. And as noted earlier, Chilika Lake being the single largest brackish water source of fisheries, the conditions in the Lake may significantly explain the trends observed in the case of brackish water fisheries in the state. This will be analysed in the following chapter.

It is thus seen that fisheries constitute an important resource base for the state - as a source of livelihood, as a source of low-cost high quality animal protein, as well as a source of foreign-exchange earner. Both in light of the increasing pressures of the population dependent on it for livelihood as well as the increasing demand for fish due to easy affordability and fish products for domestic consumption and in the export markets, it becomes imperative that the resource base be conserved so as to sustain these benefits. To the extent that the fisheries are renewable by defination as long as their exploitation remains within the 'threshold level', and they remain productive as long as their 'environment' remains favourable, there is a need for their conservation.

TOURISM

If sustainable development is taken to mean the improvement in the quality of life as well as the living conditions of the population, then leisure is as important to life as work. In fact, 'visiting' places/monuments/sites of cultural/historical/spiritual importance or relaxing amidst the aesthetic beauty of natural scenic spots is as old an habit of man as his desire to 'live' life. If earlier, this used to be a part and parcel of life, now its blown up into a full-fledged economic activity under the services sector in terms of both creating employment oportunities as well as earning foreign exchange. In fact, the National Development Council has given tourism the status of an industry since 1984. Currently, it is India's largest domestic generator of foreign exchange and it is estimated that this sector has generated directly and indirectly employment to nearly 1.3 million people in the country.[32]

Now, tourism is largely a diffused activity in Orissa. Not much information is available on its socio-economic dimensions. However, it may be noted that it is one of the few states to declare hotel as an industry to develop tourism. With its rich cultural, spiritual, architectural and natural heritage, the state receives a fair share of tourists from outside the state as well as from abroad. Estimates of tourist traffic in Orissa are given in Table 2.26.

It may be noted that the above figures represent only the tourist traffic to `ticketed' spots, therefore, they might be taken only as indicative of the increasing trend observed in the flow of both the domestic and international tourists. It is also seen from Table 2.26 that domestic tourists constitute the majority (more than 90%) of the tourist flow into the state. Also, the growth rate is observed to be faster in the case of the domestic tourists.

Table 2.26: Tourist Traffic in Orissa (in '000)

Year	International	Domestic	Total
1980	24	190 (88.8)	214
1985	26	671 (96.3)	697
1987	27	1044 (97.5)	1071
1988	30	1108 (97.4)	1138
1989	33	1132 (97.2)	1165
1990	32	1212 (97.4)	1244
1991*	14	563 (97.6)	577

Note: * - data upto end of June `91
Figures in parentheses indicate percentages to the total

Source: Economic Survey of Orissa (1991-92), Directorate of Economics and Statistics, Orissa.

Estimates of the earnings from tourism are given in Table 2.27 below. It shows that they have nearly doubled within a decade. Now, among the major tourist spots in Orissa is the 'Golden Triangle' consisting of Puri, Konarak and Bhubaneswar, famous for the temples, the beaches and the natural scenic spots. It may be noted that this is located in the coastal part of Orissa. Further, Lake Chilika close to Puri is considered an extension of this 'Triangle'. Its assessment as a tourist spot will be taken up in the next chapter. It is thus seen that apart from the agriculture and fisheries sectors, another sector which benefits from the conservation of the natural assets is 'nature-tourism'.

In fact, during the Seventh Plan, the Department of Tourism, Government of India had commissioned FORE[33] to undertake a study on the tourist profile in Orissa with a view to ascertaining the impressions of the tourists visiting, especially the tourist belt of Konarak, Puri, Bhubaneswar, Cuttack and Chilika. The study in its report observed that Orissa has tourist attractions for all categories of tourists, both foreign and domestic, those interested in

Table 2.27: Earnings from Tourism in Orissa

(Rs. lakhs)

Year	International	Domestic	Total
1980	122 (33.1)	247 (66.9)	369
1985	187 (12.0)	1369 (88.0)	1556
1987	309 (11.6)	2350 (88.4)	2659
1988	345 (11.6)	2626 (88.4)	2971
1989	377 (8.2)	4245 (91.8)	4622
1990	406 (7.5)	4982 (92.5)	5388

Note: Figures in parentheses indicate percentages to the total
Source: Same as in Table 2.26

holidaying at beaches; cultural haeritage and fine arts, dances, sculptures, paintings; wildlife, trekking, sight seeing, visits to historical and archaeological places, handicrafts and artefacts; religious tourism; as well as special interest tourism such as research into tribal culture, archaeology and architecture. It noted that Orissa is a rich ground for development of leisure tourism, cultural tourism, wildlife tourism, adventure tourism, ethnic tourism and religious (pilgrimage) tourism.

At the same time, like the other activities, tourism can damage the very base on which it rests unless properly managed. " An almost total reliance on tourism may not be a sensible approach , not only because tourist facilities can encroach on wetlands [natural resources], but also because, the tourist industry is very sensitive to short term economic fluctuations."[34] In this context, the concept of `eco-tourism' has come up which reconciles the economic activity with environmental sensitivity. In this way tourism could be a tool for sustainable development and used to promote further conservation of the natural heritage.

Conclusion

It is seen from the above discussion that the economy of the state is primarily rural in nature, with a significant proportion of the population directly dependent on the natural resource base, mainly land and water, for agriculture which is the dominant economic activity. However, the economy has remained structurally backward despite decades of regional planning and a major factor is the low productivity of the agriculture sector which has failed to create a broad based development. It was seen that floods pose the single largest constraint, and with the dominance of paddy cultivation which is a water-intensive crop, and the rain-fed nature of cultivation, water management becomes a prime requisite for improving the agricultural productivity. This when seen in the context of land degradation prevailing in the state which is seen to further aggravate the problems, makes the management of land use equally significant. Further, in light of the fisheries and tourism sectors which are increasingly becoming more important as sources of alternative employment as well as raising the nutrition status and level of human welfare, it follows that there is a need for a fresh look into the resource management strategy of the state.

A better management of the resource base would not only directly ensure conditions for improving the agricultural productivity in the state, but through inter-sectoral linkages and inter-resource linkages, such as in the improvement of fisheries, forestry and tourism, the rest of the economy too. This would create conditions for 'sustainable development' in the state. In this context, an assessment of the need for conservation of Lake Chilika is taken up in the following chapter.

Notes and References

1. RBI (1984), Report of the Committee on Agricultural Productivity in Eastern India, Volume 1, p.23.

2. Ibid.

3. See Mishra (1983).

4. RBI (1984), op. cit.

5. The Sen Committee gives an account of these constraints in its analysis of agricultural productivity in Orissa.

   The dynamics of interaction between the `institutional' or social organisation aspects of production (mode of production, its appropriation and utilisation) in an agrarian system and technological change in agriculture from a comparative historical analysis of agrarian transition in Orissa is given in Padhi (1986).

6. Mishra (1983).

7. Cited in Mishra (1983).

8. Rice is therefore considered a wetland crop.

9. Proceedings of the Symposium on Environmental Aspects of Water Resources of Orissa, 30th July 1988.

10. It is the frequency of recurrence of floods over the years in a region which qualifies it to be a `chronically flood affected' region. Other chronically flood affected states identified by the National Committee on the Development of Backward Areas, 1981, include Bihar, Uttar Pradesh, West Bengal and Assam.

11. Prasad (1986).

12. Ibid.

13. Government of Orissa (November,1991), Eighth Plan (1992-97) & Annual Plan (1992-93), Orissa, Vol. I & II.

14. RBI (1984), Ibid.

15. This section is based on the findings of Satapathy (1987).

16. Ibid.

17. ORSAC (undated), <u>Waterlogging in Orissa</u>.

18. Ibid.

19. Proceedings of the Seminar on Environmental Aspects of Land Use in Orissa, October 30, 1990.

20. ~~MPEDA (1976)~~ Ibid.

21. MPEDA (1976)

22. Directorate of Fisheries (1991), A Handbook on Fisheries Statistics, Government of Orissa, Cuttack.

23. Ibid.

24. CMIE (1985), Standard of living of the Indian people, Feb.1985, cited in Agarwal et al. (1986), p.50.

25. Estimate by the Directorate of Fisheries, Orissa, quoted in BOBP (1984), p.6.

26. Directorate of Fisheries (1991), Ibid.

27. BOBP (1984), Ibid.

28. Gupta,S.(1987), Inter-state Variations in Food Consumption, Nutritional Adequacy and Levels of Poverty, US AID/India Occasional Paper No.4, June 1987. Cited in Bansil (1992), Part 2, p.897.

29. Ibid. Here, protein intake includes both animal and vegetable protein.

30. BOBP (1984), Ibid.

31. Estimate by the Department of Fisheries, Orissa, quoted in BOBP (1984).

32. Cited in Manorama (1992).

33. FORE stands for Foundation for Organisational Research & Education. The study cited in Government of Orissa (November, 1991), Eighth Plan, op. cit.

CHAPTER 3

AN ECONOMIC ASSESSMENT OF LAKE CHILIKA

The review of literature on environment in general and on wetlands in particular in the first chapter has highlighted Lake Chilika as one of the Wetlands of International Importance. The subsequent chapter while making an overview of the development process in Orissa brought out the significance of the environmental dimension in the regional context. Against this backdrop - that is, the multi-functional nature of wetlands in general and the location of Chilika in a structurally backward rural economy, the present chapter makes a case for the conservation of the Lake from an economic perspective. It also assesses the Lake from an ecological perspective in terms of the 'benefits' (as defined earlier in chapter 1) derived from it. In other words, an attempt is made to indirectly assess the consequences of environmental degradation of the Lake on socio-economic conditions.

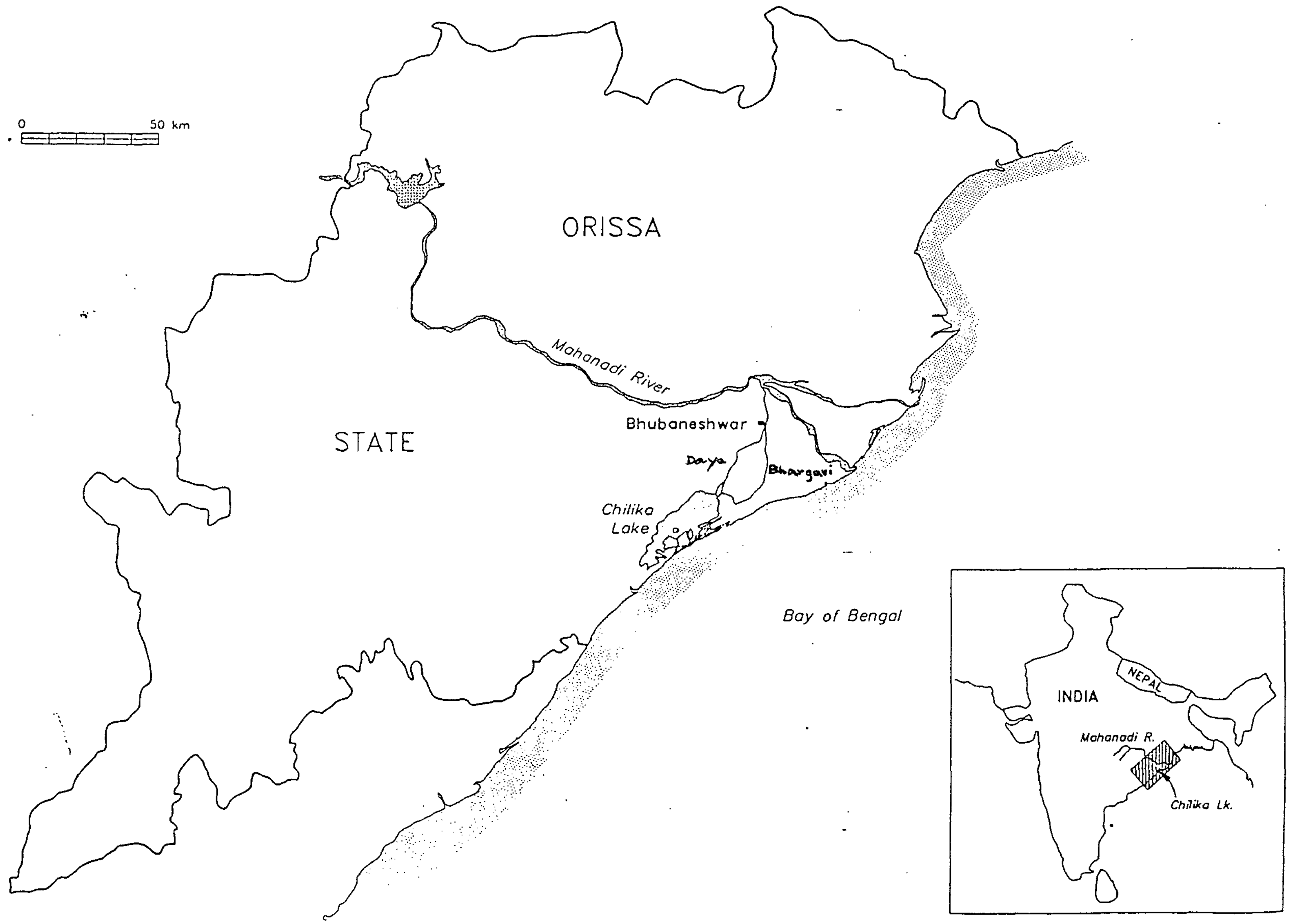
The present chapter is organised into four sections. Section 1 introduces the setting -- it gives a profile of the Lake. Section 2 makes an overview of the changing conditions in the Lake. Section 3 makes an assessment of Chilika as a flood outlet mechanism, as fisheries and as a tourist spot -- the most direct and tangible 'benefits' from the Lake which follow from the overview of the state's economy in the earlier chapter. In section 4 an attempt is made to improve the assessment by analysing the more indirect and intangible 'benefits' from the Lake. The last section makes the concluding remarks.

The Setting

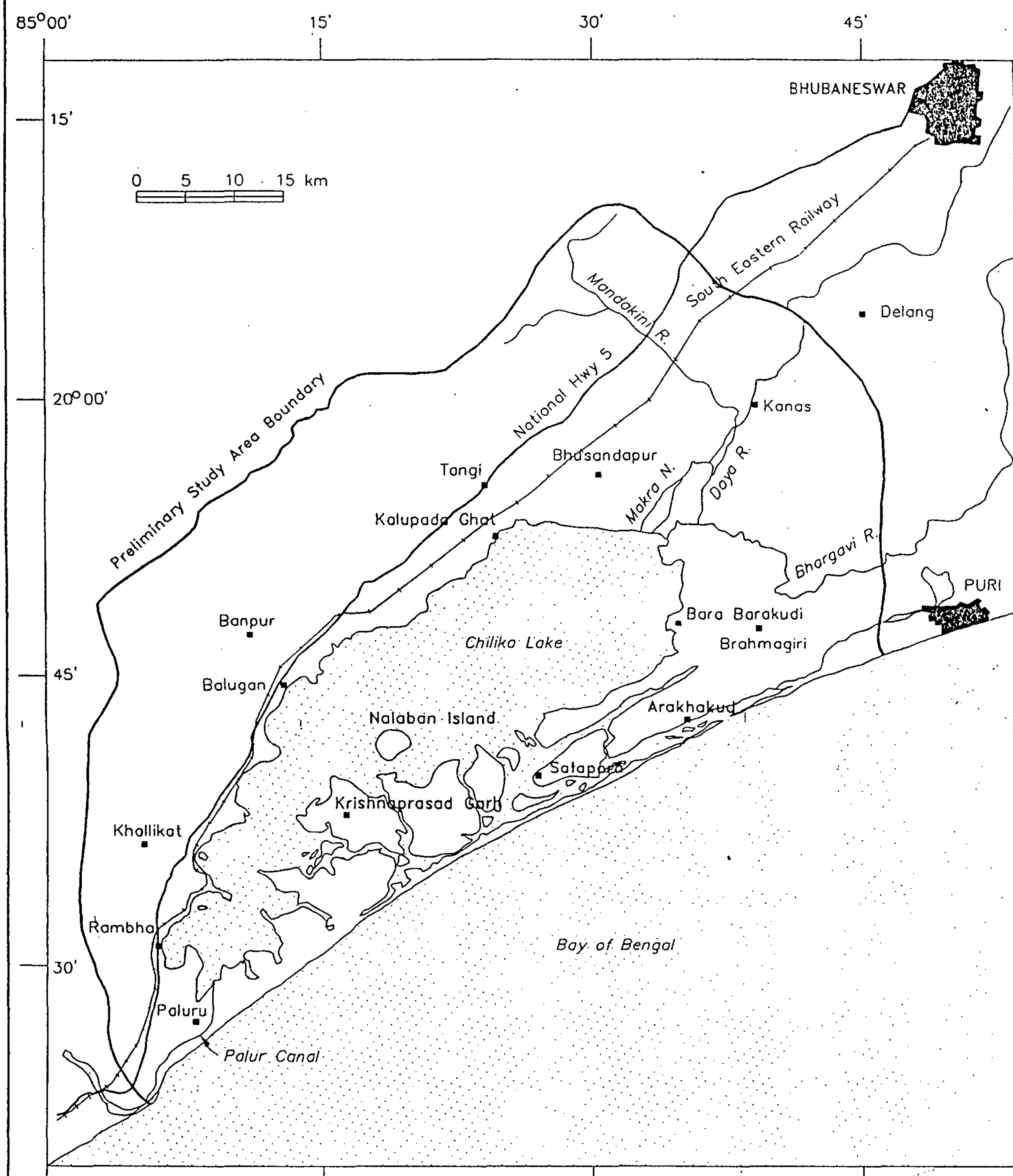
Chilika Lake lies in the coastal zone of Orissa, arching across the districts of Puri and Ganjam between latitudes 19° 28′ N and 19° 54′ N and longitudes 85° 06′ and 85° 35′E. Figure 3.1 gives the location map. It lies at the tail end of Mahanadi river system. The dissected hills of the Eastern Ghats anchor its south-western limits, the deltaic plains of River Mahanadi lie to its north and the Bay of Bengal to its east. It spreads over an area of 1165 sq.km in the monsoons shrinking to 906 sq.km in the summer.[1] It is pear-shaped, with the greater part of it lying in Puri district. It has a maximum length of 64 km along the axis of the main water body oriented along North East and South West and a maximum breadth of 16 km in the north eastern extremity.[2] In terms of size therefore, it is the largest of its type in India and Asia.

As a wetland, it occupies 40% of the total wetland area (excluding mangroves) in Orissa.[3] In terms of the classification used in the first chapter and given in Appendix 1.1 it is a coastal, natural wetland of the brackish, lagoonar type.[4] It is "a classical tidal lagoon, created by a beach barrier berm developed by the accretion of coastal sediments following the stabilisation of sea levels some 3000 - 4000 years ago."[5] As seen from Figure 3.2 the Lake is connected with the Bay of Bengal by a channel which opens out into the sea through a narrow mouth. The channel is about 35 km long and the mouth about 300m width.[6] On the northern side, the Lake receives inflow of fresh waters from the deltaic distributaries of River Mahanadi. It is this blend of saline waters from the sea which flushes into the Lake through the channel and the influx of fresh water from the watershed which gives the unique brackishness to the Lake.

3.1 Location Map of Lake Chilika



3.2 Lake Chilika

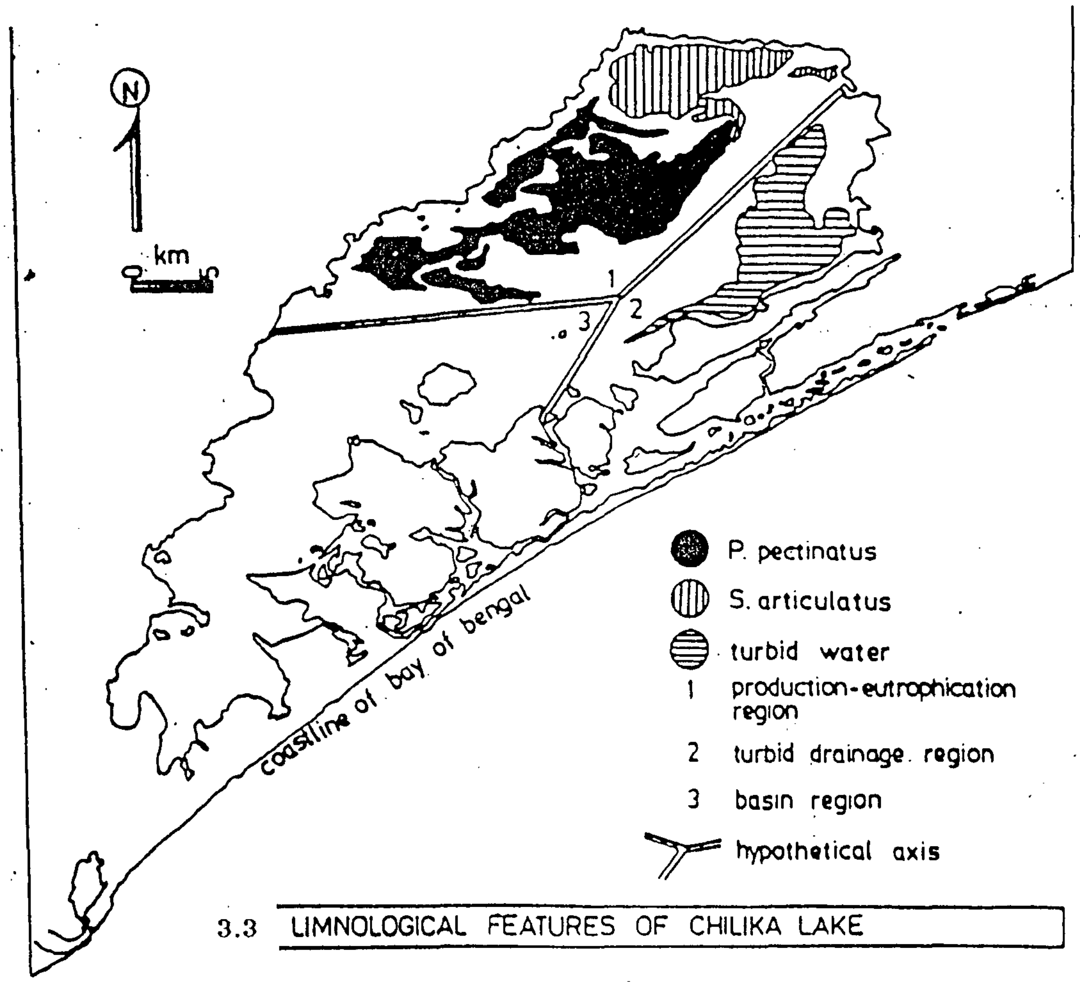


Source: ORSAC

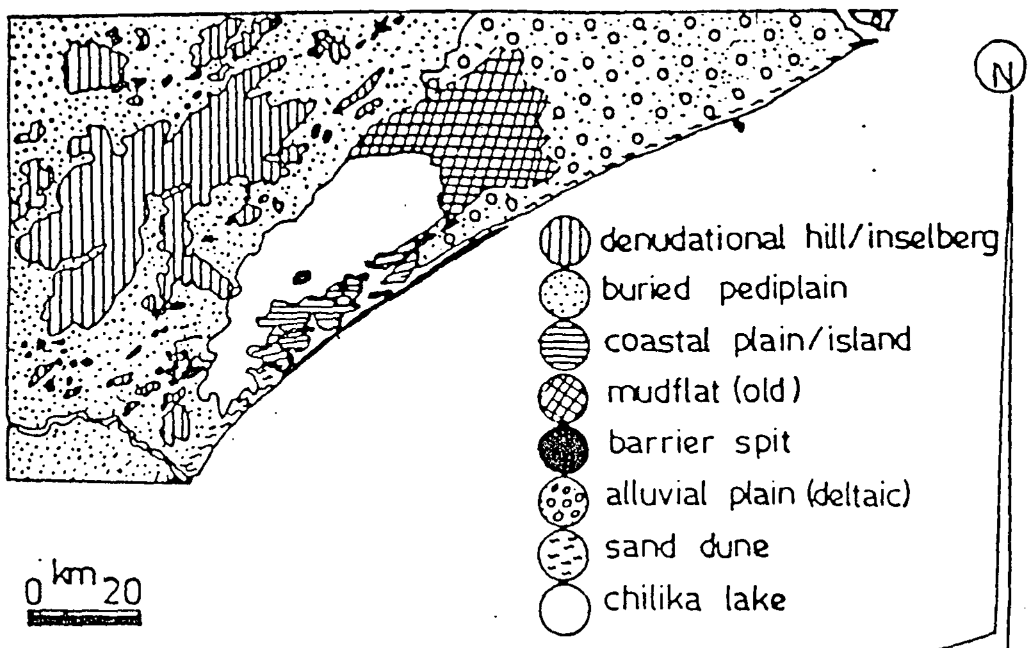
The physical, hydrological and limnological characteristics of the Lake such as its waterspread, depth, salinity, pH value, alkalinity, nutrient concentration, dissolved oxygen, transparency, turbidity, temperature, etc. vary seasonally as well as spatially. The predominant seasonal influence on the Lake's limnology is due to the monsoons when fresh water flows into the Lake. It is apparent that like in other wetlands, it is the hydrological regime which drives the dynamics of the Lake.

On the basis of hydrobiological variability, the waterbody of the Lake has been broadly divided into three regions -- the production-eutrophication region (Region 1), the turbid-drainage region (Region 2) and the deep water region (Region 3) as shown in Figure 3.3.[7] Region 1 is the zone of profuse biological production dominated by macrophytes. Region 2 is the region of drainage of the deltaic distributaries of River Mahanadi, mainly Daya and Bhargavi. The waters are shallow, vegetation free and grossly turbid. Region 3 is the deepest, with a placid and tranquil expanse of waters, vegetation free except in the banks which harbour some macrophytes. Some authors have divided the Lake into the Northern sector, the Central sector, the Southern sector and the Outer sector (the channel).[8]

Further, by virtue of its location in the coastal zone, the Lake is subject to influences from three fronts simultaneously -- from the sea (marine/coastal action), from the rivers (fluvial action) and from the winds (aeolian action), singly or in combination. This is seen in a geomorphic analysis of the area around Chilika using remote-sensing data which shows the four types of geomorphic units -- denudational, marine/coastal, fluvial and aeolian, as shown in Figure 3.4.[9] The hills and inselbergs bordering mostly south-west and west-north-western part of the Lake and the buried pediplain extending beyond the hills right upto the western shores of the Lake are the



3.3 LIMNOLOGICAL FEATURES OF CHILIKA LAKE



3.4 GEOMORPHOLOGICAL UNITS AROUND CHILKA LAKE denudational forms. Lithologically, the denudational hills comprise of khondalites and gneissic rocks of Eastern Ghats and are covered with fairly thick vegetation. The pediplain is generally marked by a rolling topography and is covered with sediments by both fluvial and marine action, so known as buried pediplains which is good for agriculture. The coastal plains on the south eastern part of the Lake which is in the form of small sandbar islands and the barrier spit which separates the Lake from the sea are the marine landforms. The deltaic alluvial plains extending between River Daya and the coast, to the north of the Lake constitute the fluvial landforms. It includes the 'active' deltaic land formed by the constant deposition of silt by the rivers and the mud flat over which the Daya and Bhargavi river system has been entrenched. Drainage pattern is intricate and the river beds are generally at higher elevation than that of the Lake which is contained by constructing embankments along the river banks. The aeolian landform includes the coastal sand dunes which lie all along the northern part and southernmost part of the coast, discontinuous and parallel.

Another conspicuous feature of the Lake is its shifting mouth. It is observed that the mouth of the Lake tends to shift in a north-easterly direction as a result of the littoral drift along the shore of the Lake. The factors involved in the stability or shifting of the Lake mouth have been identified as the influence of wave action, the influence of longshore currents in the form of littoral drift and the influence of freshwater discharge and tidal current near the Lake mouth.[10] This in turn brings about resultant changes in the tidal effects felt by the Lake.

It is thus apparent that the Lake's ecosystem is inherently a dynamic and complex one. Given this inherent complexity, and the 'openness' of the ecosystem by virtue of its location right at the coast, the Lake's ecology is vulnerable to activities in the watershed and along the coast in addition to the activities internal to the Lake. In other words, both offsite and onsite factors have a significant influence on the Lake's environment. And given the interdependence of the various units/components of a natural ecosystem, the activities which superimpose changes altering the ecology of the Lake is bound to have widespread ramifications, affecting the entire ecosystem. Obviously, the impact of the activities would depend on the nature, extent and intensity of the changes vis a vis the inherent resilience/stability of the ecosystem. But, given the irreversibility and uncertainty which marks the process of environmental degradation, such degradation may entail heavy losses. The physical changes lead to changes in the biological processes and these in turn by affecting the productivity of the Lake's resources on which the resident community depends affect output, income, employment, consumption, etc. thereby affecting the socio-economic structure.

Historically, the Lake has been an integral part of the socio-economic fabric of the region. In ancient times, as way back in the sixth century B.C., the Lake "served as Orissa's window to the rest of the world, it being used as a port by the sea going vessels" [11] At a time when, water transport was predominant, the Lake served as a gateway not only for the far-off places in South-East Asia with which Orissa had trade and cultural links but also for many places along the coast-line of the country. Ancient literature presents a glorious account of the Lake as a centre of trade and commerce and as a witness to "the lofty military achievements, political victories and cultural assimilations" which marked the history of the state.

However, its cultural and commercial importance seems to have declined over time, apparently coinciding with the general deterioration of the state's position under political subjugation by the Marathas, Mughals and the British in succession.[12] However, the Lake's fisheries continues to be the main economic base of the region, supporting the livelihood of a significant proportion of the population residing along its shores and on the islands on its eastern side. Prior to independence, the Lake was a part of the Feudal Estates of Parikud and Khallikote. Since Independence the rights over the fisheries of the Lake virtually rest with the state government, which are `leased out' to the fishermen. Lately, the Lake has been the focus of sectoral development activities, mainly in the fisheries (prawn culture) sector and in the tourism sector aimed at maximising revenue from the Lake.

Against this setting the changing physical conditions in the Lake towards its degradation in the wake of human interventions necessitates a closer look. However, before making an assessment of the cost of such degradation in terms of the loss of actual and potential `benefits' from the Lake, it is essential to examine the nature of changes that have taken place. The next section makes an overview of the changing conditions in the Lake.

An Overview of the Changing Conditions

It may be recalled from the earlier chapter that both on account of physiographical reasons and the socio-economic pressures on the land and water resource base, the severity of environmental degradation is more in the coastal zone. The Lake, by virtue of its location right at the coast would therefore be particularly vulnerable to the impacts of activities in its watershed on one hand and along its coast on the other.

The major physical changes in the Lake seen as a threat to its ecology as highlighted by environmental studies on the Lake may be broadly categorised into the following --

(1) Siltation of the Lake ;

(2) Shrinkage of the Lake;

(3) Increasing shallowness and choking of the mouth;

(4) Reduction in salinity;

(5) Spread of aquatic vegetation; and,

(6) Pollution of the Lake;

Siltation of the Lake

Studies show that the Lake is getting silted up or that the silt load into the Lake has been increasing over the past few years. It has been estimated that within the period 1975-82, the light siltation zones have increased by 50.4 sq.km per year and heavy siltation zones by 2.3 sq.km per year on an average.[13] Siltation is not the same everywhere in the Lake. It has been observed to be the maximum in the northern sector of the Lake, including the outer channel and the mouth region of the Lake.

Silt deposition in the Lake is ascribed to two sources. First, the sediment load of the rivers and the surface runoff draining into the lake from the surrounding watershed. " The silt load can easily be seen on satellite imageries as it works its way through the Lake to the outlet channel. Although some fine suspended matter might be flushed out, it is safe to assume that all of the coarser sediments and most of the fine silt is deposited in the Lake; much of the latter flocculates and is deposited in the form of clays."[14] Second, the littoral drift along the coast which deposits sand on the eastern side of the Lake. Studies on sediment movement at Madras and Visakhapatnam indicate that about 1 million tons of sand per year moves past along the east coast of India in a northerly direction occurring mainly in the south-west monsoon season.[15]

It has been observed that the increased rate of siltation is due to an increasing rate of soil erosion in the watershed. This may be related to the fact that soils of the region are easily erodible, especially when stripped of vegetative cover. And it is estimated that approximately 460 ha of land in the catchnment area of the Lake is critically eroded.[16] It may be also recollected from the earlier chapter that River Mahanadi carries a high silt load when it is in spate and as distributaries, Daya and Bhargavi carry some of the silt into the Lake. Estimates of the sedimentation rate in different parts of the Lake by ORSAC[17] corroborate this fact. The rate of sedimentation was estimated to be 1159.92 gm/day in the Daya-Bhargavi confluence region, 70.8 gm/day at Magarmukh (the outer channel area) and 14.4 gm/day at Bhusandpur (on the western shore).[18] Further, it has been observed that,

> Erosion due to water and wind appears to be very much spectacular in the catchment of Lake Chilika. Some of the important criteria that contribute to the progress of accelerated erosion are overgrazing, illicit felling and ruthless cutting, cultivation up and down the slope, clearance of vegetation over large areas for rehabilitation and agriculture, ... these have led to devastating effects downstream, causing heavy siltation in the Lake. No systematic erosion assessment survey has been taken up in the past to assess the exact degree as well as extent of erosion in the catchment.[19]

It is thus apparent, that soil erosion from the watershed is largely responsible for the siltation of the Lake. This has led to further changes in the Lake's basic ecology - mainly, a reduction in the size and depth of the Lake.

Shrinkage of the Lake

"It was reported by Anandale and Kemp(1915) to be 350 sq.miles (896 sq.kms). Landsat Imagery of 1987 indicates the waterspread area of 790 sq.kms only. So, it is clear that there is a gradual shrinkage of waterspread at the rate of 1.45 sq.kms per year for the last 73 years."[20] Indirect evidence is in terms of increasing encroachments into the peripheral areas of the Lake's shores by the people for farming, as grazing lands and also for prawnculture operations. By one estimate, the Lake's shores have receded by as much as 12 kms.[21]

Increasing Shallowness of the Lake and Choking of the mouth

The Lake is essentially shallow in nature. Like other limnological features, the depth varies from region to region and at different times of the year. A bathymetric map of the Lake as in September 1987 is given in Figure 3.5. It shows the shallow depth profile, particularly in the Northern sector, where it is less than 1.5 m. More than half of the area is less than 2 m. Maximum depth occurs in the Southern sector. It may be noted that the figures correspond to the post-monsoon situation. Much lower depths would occur in the drier period.

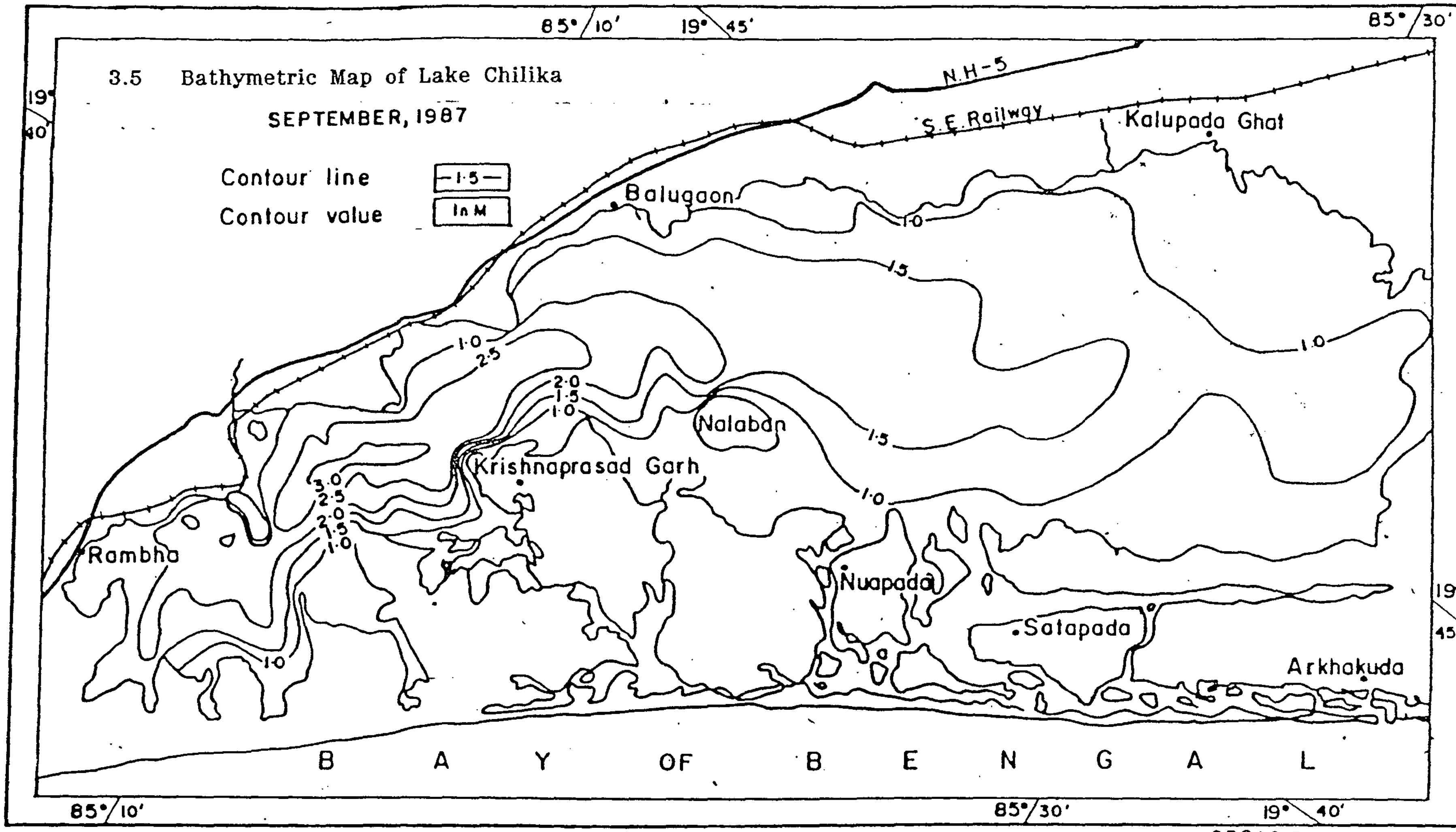
Studies suggest that the Lake is increasingly becoming shallower, or that the average depth of the Lake has declined, particularly, in the northern sector and in the outer channel area. This has further, led to the problem of choking of the mouth, restricting the flow of water in and out of the Lake.

Reduction in salinity

As noted earlier, the uniqueness of the Lake lies in its brackish nature, brought about by the mix of freshwater and sea water inflows. Salinity of the lake is seen to vary along a north-south gradient, lowest in the north and generally increasing in the south-easterly direction. This is due to the influence of the fresh water contributions in the Northern sector. The outer

3.5 Bathymetric Map of Lake Chilika

SEPTEMBER, 1987



ORSAC, Bhubaneswar.

channel has the highest salinity. " The lagoon is brackish over most of its area and varies from freshwater (zero salinity) adjacent to the Daya river mouth, to a hypersaline (higher salinity concentration than full-strength sea water) level ... in the outlet channel during the dry period."[22] Further, there are large seasonal effects on salinity distribution.[23] And it is this variation in salinity which is a major factor in stimulating fish spawning migrations.

The concern expressed over this aspect is that the average salinity of the Lake has declined and it is declining. Indirect evidence of this is provided by "the recent spread of fresh water macrophytes, the recent detection of fresh water leeches and the recent use of lake water by both humans and cows in the northern sector of the lake."[24]

The major reason advanced for the declining salinity of the Lake is the silting up of the outer channel and choking of the lake mouth which inhibits the inflow of sea water. Another reason suggested is the diversion of the river waters in the watershed for irrigation and other purposes. This has reportedly slowed down the rate of discharge of fresh water, allowing it to flow into the Lake over a larger period of time than under the normal seasonal run off pattern. The fresh water flowing into the Lake long after monsoon continues to dilute the salinity.

Spread of Aquatic Vegetation

Aquatic vegetation is an integral part of a wetland ecosystem. Region 1 as shown earlier in Figure 3.3 is dominated by macrophytes. The vegetation is of two types -- temporary and permanent, the former occurring seasonally, particularly, in the post-monsoon phase. The rapid spread of this vegetation over larger areas of the Lake has been of concern lately. It is estimated that the general growth of aquatic vegetation is at the rate of 14.6 sq.km per year.[25]

Table 3.1: Spread of aquatic vegetation (sq.km)

Year	Area
1973	20
1977	60
1982	100
1985	200

Source: ORSAC (1989), Report on Status Survey & Environmental Monitoring of Chilka.

Further, there has been a change in the type of vegetation. In the 60's vegetation was dominated by the submerged macrophyte, Potomogeton pectinatus -- approximately, 78% of the Lake's biomass -- and the emergent macrophyte, Scirpus articulatus.[26] Potomogeton is a naturally established species in the Lake, commonly referred to as 'weed'. However, recently freshwater type floating vegetation, especially water hyacinth (Eichornia crassipes) has reportedly spread to form solid mats, particularly in the northern portion of the Lake, and in the outer channel, very close to the lake's outlet.

This proliferation of the vegetation is believed to be instrumental in slowing down the movement of water out of the Lake, further increasing the rate of sedimentation in the Lake. A rapid spread of vegetation increases the loss of water through transpiration and adds more organic matter to the ecosystem too.[27] Further, it also affects the fishing activities. The impact on fish production is however not clear. It has been observed that the dramatic increase in the vegetation in the 70s was also accompanied by a spurt in the fish production in that period and there could be some correlation between the two.[28]

This is based on the observation that aquatic vegetation usually provides a good habitat for plankton and insects which is a source of food for the fish as well as the birds.

The reasons for the spread of aquatic vegetation is not clear yet. However, it is suggested that this is in response to the progressive reduction in salinity conditions as indicated by the growth of freshwater macrophytes. The alternative reason suggested is the surface runoff loaded with nutrients and agricultural chemicals from the surrounding watershed which stimulate the growth of vegetation in the Lake.

Pollution of the Lake

The increasing level of activities -- agricultural, industrial and domestic -- in the surrounding watershed have led to the pollution of the Lake. Though industrial activities in the immediate watershed of the Lake are hardly present, the pollution load of the upper reaches of the rivers draining into the Lake is unloaded into the Lake along with the sediments. No accurate estimates of pollution levels in the Lake has been estimated yet. However, traces of mercury in the south-western part of the Lake has been recorded.[29] This is apparently due to the effluent discharges of a caustic soda plant on the banks of River Rushikulya in Ganjam district, to the south of Chilika, a portion of which found its way into the Lake through the Palur canal.[30]

Further, the fish plants and chicken farms in the adjoining areas dispose their wastes into the Lake. The use of chemicals, like food additives, antibiotics, etc. in the expanding aquaculture and prawn culture operations in the periphery as well as the oil and oil distillates from increasing use of mechanised waterboats for fishing and tourism in the Lake are the other sources of pollution in the Lake.

Pollution from agricultural sources is traced to the use of fertilisers and pesticides in the watershed. Though the use of such chemicals is limited in the region as a whole, it is likely that the frequent occurrence of floods washes them off the lands adding to the pollution load of the surface runoff.

With respect to domestic pollution, it is reported that there are no sewerage treatment facilities in the area.[31] Consequently, untreated domestic wastes of the entire drainage basin find their way into the Lake. Further, because of Chilika's convoluted connection to the sea which does not provide adequate flushing, and the high degree of evaporation[32] from the Lake's surface, the pollutants tend to accumulate, thus heightening the risk of pollution.

Pollution, as elsewhere, is seen as a threat to the biotic community of the Lake, which through the food chain, such as in the consumption of fish, would affect human health. It may be noted that the high demand for Chilika's fish and fish products in the international market is because of its low degree of pollution.

It is evident that the physical changes examined above pose a threat to the Lake's ecology. Given the inherent complexity and dynamics of the ecosystem, the `uncertainty' and `irreversibility' of these changes may have far-reaching effects on the Lake's ecosystem as a whole. This is particularly due to the fact that the changes act in a `synergistic' way.[33] For instance, a certain amount of siltation is natural to the Lake as a part of the coastal dynamics of the region, but the higher rate of siltation in the watershed combined with the reduction in salinity is seen to be changing the `brackish' characteristic of the Lake and thereby the biotic life adapted to it.

It may be recalled from the first chapter, that it is the `characteristics' of the natural ecosystems which form the ecological base for the `benefits' accruing from the particular ecosystem. And if these `characteristics' are being altered by human interventions, either as a conscious decision or as `spill-over' effects from other activities, then the `cost' of such changes must be accounted for. Given the fact that wetlands are a unique ecosystem by themselves (from the first chapter) and this particular Lake lies in a rural, backward primary-sector based economy (from the second chapter), the `costs' of the above mentioned changes needs to be looked into. An indirect assessment of the costs of the degradation of the Lake can be made by assessing how `valuable' as a `natural asset' it is. In other words, this calls for an assessment of the `benefits' from the Lake. This is attempted in the following section.

An Assessment

Since, the Lake cannot be seen in isolation from the socio-economic structure which is directly dependent on it and also which in turn determines the nature of demands made on the Lake's resources, it is essential to have an idea of the socio-economic environment first. In the absence of exact information on the watershed boundaries of the Lake, an area based on the administrative divisions of the police stations adjoining the Lake's boundaries can be taken as a provisional indicator of the level of socio-economic development in the immediate environs of the Lake.[34]

The study area comprises of five police stations as given in Table 3.2 below and shown in Figure 3.6.

3.6 Study Area Around Lake Chilika

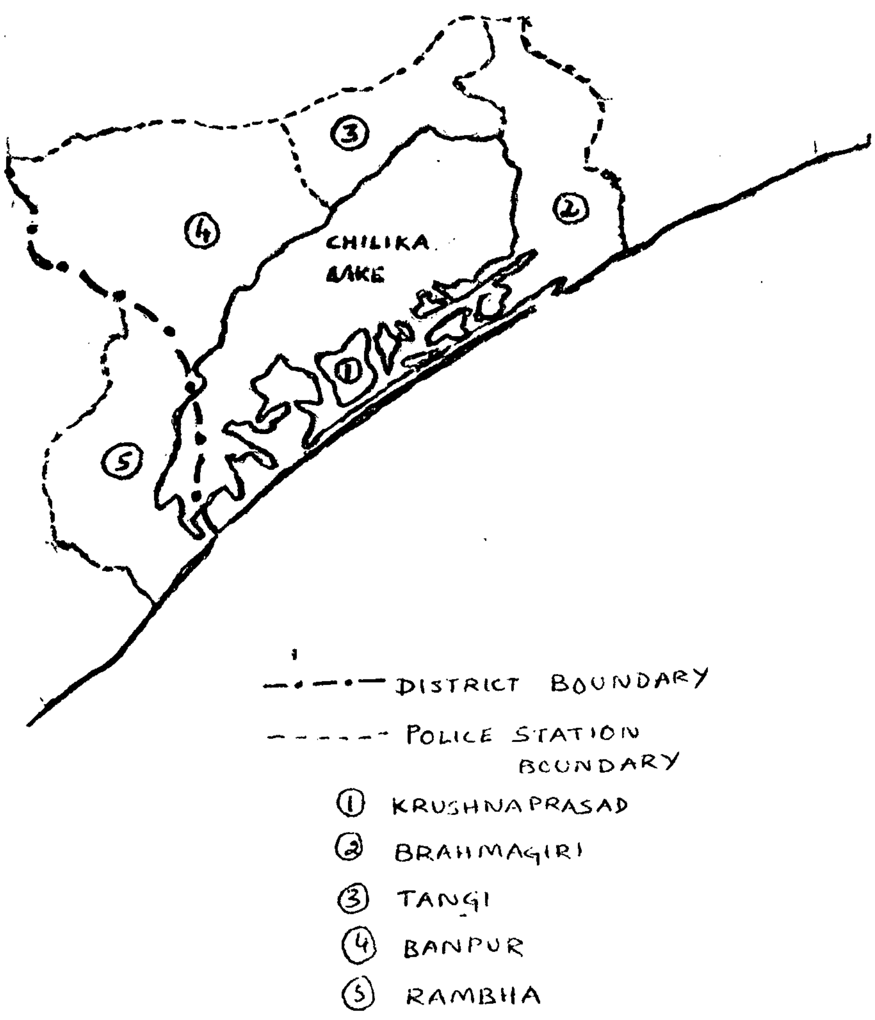


Table 3.2: The study area around the Lake

DISTRICT	*Tahasil*	Police station
PURI	*Krushnaprasad* *Puri* *Banpur*	1. Krushnaprasad 2. Brahmagiri 3. Tangi 4. Banpur
GANJAM	*Chatrapur* *Khàlikote*	5. Rambha

It is seen that the first four police stations lie in three Tahasils of Puri district and the fifth one is spread over two Tahasils in Ganjam district. It may be noted that Krushnaprasad comprises of the islands on the eastern side of the Lake, Brahmagiri lies in the deltaic plains, Tangi is to the west of the plains, Banpur is on the western side, and Rambha is to the south of the Lake.

A profile of the above study area is given below in Table 3.3. It is seen that the study area comprises a total area of 2332 sq.km having 1165 villages and a total population of 5.5 lakhs (1981 Census). About 29% constitute the working population, out of which 69% are engaged in agriculture and allied activities, 29% as `other workers' and a mere 2.2% in household industries. It is evident that the socio-economic structure is not unlike the rest of the state, it is primarily rural, dependent on pr imary sector activities. Further, a survey conducted by Tourism and Country Planning Organisation (TCPO) in 1988, observed a striking contrast between the settlements on the eastern and western shores of the Lake.[35] Whereas the former were isolated, lacking commercial and social facilities, like educational, health, etc. with the communities eking out a subsistence level of living, in case of the latter, they were more developed, with major market and commercial centres located along the shores and the communities economically better off.

Table 3.3: The Study Area around Chilika - A Profile as on 1981

Police Station	Krushna-prasad	Brahmagiri	Tangi	Banpur	Rambha	Total
Total Area (Sq.Kms)	258.5	728.5	316	600.9	428.1	2332
No. of Villages	100	237	201	355	272	1165
Total Population	33395	125749	116144	140749	137041	553078
SC Population	4900 (14.7)	11928 (9.9)	6338 (5.5)	11988 (8.5)	25059 (18.3)	60213 (10.9)
ST Population	6	333 (0.3)	2079 (1.8)	6530 (4.6)	3985 (2.9)	12933 (2.3)
Literate	11112 (33.3)	49458 (39.3)	42402 (36.5)	53976 (38.3)	38621 (28.2)	195569 (35.4)
Total Main Workers	9782 (29.3)	35276 (28.1)	30454 (26.2)	36877 (26.2)	45893 (33.5)	158282 (28.6)
Cultivators	5401 (55.2)	21548 (61.1)	12959 (42.6)	17708 (48.0)	22532 (49.1)	80148 (50.6)
Agricultural Labourers	1409 (14.4)	4425 (12.5)	5224 (17.2)	7084 (19.2)	10935 (23.8)	29077 (18.4)
Other Workers	2786 (28.5)	8370 (23.7)	11770 (38.6)	11311 (30.7)	11315 (24.7)	45552 (28.8)
Household Industry	186 (1.9)	933 (2.6)	501 (1.6)	774 (2.1)	1111 (2.4)	3505 (2.2)
Marginal Workers	784	1914	1372	2655	8434	15159
Non-Workers	22829	88559	84318	101217	82714	379637

Note: Figures in parentheses are relative proportion to total.

Source: Primary Census Abstracts, District Census Handbook, Puri & Ganjam, 1981.

It may be recalled from chapter 1 that 'benefits' from natural systems may be in the form of 'function(s)', 'use(s)' or 'attribute(s)'. These benefits include both the direct/tangible ones as well as the indirect/intangibles. They may/may not be priced in the market. As mentioned in the first chapter, the degradation of wetlands can be partly accounted for by the fact that the 'real' benefits from conserving such resources are underestimated, whereby the costs of conservation appear to be very large in comparison.

The first step in assessing the Lake would be to identify and analyse the 'benefits' which are most direct or tangible. It is seen from an overview of the state economy in the earlier chapter that the Lake is a flood outlet for the flood waters of Mahanadi; it is a major source of inland (brackish water) fisheries; and is a major tourist spot. It is also seen from the review of wetland issues in general (in chapter 1) that there are other 'benefits' which extend ecological support, often beyond the natural boundaries of the wetland. This section is therefore divided into two parts - the first looks at conservation of the Lake from an economic perspective. The second part examines the other 'benefits, from an ecological perspective.

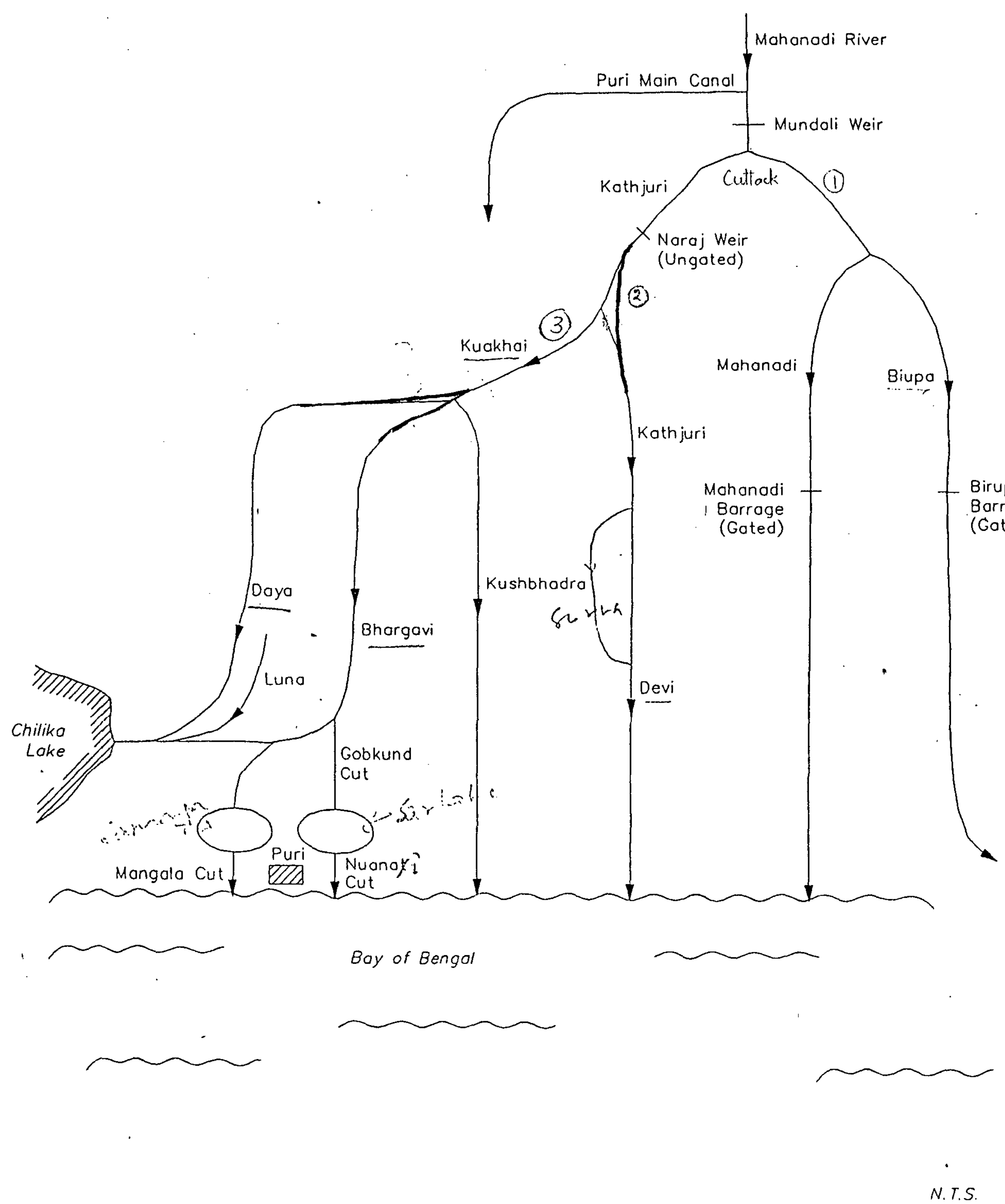
The Macro - Perspective

Chilika as a Flood-Outlet Mechanism

The Lake, as pointed out in the earlier chapter, lies at the tail-end of the Mahanadi river system, receiving influx of fresh water from its deltaic distributaries, mainly Daya and Bhargavi on the north-eastern side. Invariably, when there are floods in Mahanadi -- which as seen in the earlier chapter, is a recurrent calamity for the zone and the state -- a portion of the flood waters flow into Chilika through the distributaries.

A schematic diagram of Mahanadi's drainage system from the delta head is given in Figure 3.7. It is seen that the river trifurcates at Cuttack into three branches -- (1) a northern Mahanadi branch which flows to Paradeep and

3.7 Mahanadi River : Schematic Distributaries



carries about 28% of the flood flows. This branch is controlled by gates; (2) a central Kathjuri or Devi branch which is the main distributary, caries about 60% of the flows and is controlled by gates; and (3) a southern Kuakhai branch which breaks into three - the Kushabhadra, Daya and Bhargavi -- the latter two flowing into Chilika Lake. The Kuakhai branch takes about 12% of the flow during the floods and of which, Bhargavi and Daya take about 35% each.[36]

Clearly, the volume of flood water that flows into Chilika depends on the 'magnitude 'of the flood in Mahanadi. The exact mechanism thereafter is not known, but evidently, the Lake acts as a huge reservoir holding the waters and slowly releasing them through the outer channel into the sea. This is evident from the fact that during the monsoons, the water level in the Lake rises by 1 - 2 m[37] and the flow is generally from the Lake to the sea, whereas it is the reverse in the dry months.

The discharge of the three main distributaries, Daya, Bhargavi and Luna and 32 other small streams into the Lake as estimated by ORSAC for the year 1989-90 is given as follows.[38]

<u>Total Discharge of Water into the Lake</u>

From November 89 - October 90	-->	38.08 x 10 cu m
From July 90 - October 90	-->	34.62 x 10 cu m
During January - February 91	-->	7.0 x 10 cu m

It may be noted that nearly 91% of the inflow into the Lake was during July-October which are the monsoon months. Evidently, the Lake serves as a temporary natural storage reservoir for the inflow from the watershed during the monsoons. However, the volume of water retained in the Lake at any one time would depend on the 'water balance' of the ecosystem.[39] Whereas there are rough estimates for the inflow into the Lake, the 'outflow' mechanism has not been figured out yet. However, it is reported that the evaporation rate from the huge water surface is very high.[40] However, given the fact that the Lake is shallow, and the outer channel is rather long and convoluted with a narrow mouth, the rate of discharge from the Lake into the sea should be a critical factor in the water balance of the Lake. In this context, flooding due to 'backwater effect' of Chilika has been reported. On the other hand, opening up of new outlets under the pressure of flood waters has also been observed. Two new mouths opened in the Lake due to the devastating cyclone in September 1972 of which the one that exists today opposite Arakakhuda village is still open.[41] Historical records further indicate artificial cuts being made to discharge the flood waters of Mahanadi as in 1825 and 1907.

It may be noted that the Lake receives water from four sources - from precipitation directly, from the distributaries of Mahanadi on its north and north eastern side; from the local rivers, rivulets and streams on the western side, the surface run-off from the surrounding watershed; and tidal inflows from the sea. The immediate drainage area of the Lake is estimated to be about 3200 sq.km about three times the area of the Lake itself.[42] Total drainage area would be much larger since the Lake receives water from the Mahanadi.

The 'magnitude' of inflow therefore, largely depends on the precipitation in the region and the tides in the sea, given the size of the mouth. Rainfall as noted in the previous chapter, for the Coastal Plains zone averages around 1100 mm, 75% of which occurs in the monsoon months of June-September. It also receives rainfall from the cyclones and depressions formed over the Bay of Bengal. Tidal fluctuations in the Bay of Bengal are semi-diurnal, and their effects are reported to be minimal in the Lake.[43]

The `value' of the Lake as a natural flood outlet can be assessed in terms of the `damages prevented' benefits -- potential and actual -- by examining both the physical dimension (the magnitude and frequency of flood occurrences) as well as the socio-economic dimension of floods (the present and potential use of the areas affected) in Daya and Bhargavi.

At the outset, it is seen from the earlier chapter that damages caused by floods in River Mahanadi are most acutely felt downstream in the deltaic plains for reasons of both physiography worsened by ill-planned drainage systems as well as the high population density. The plains to the north east of Chilika comprising of the Daya-Bhargavi Doab are a part of these deltaic plains. Like the rest of the coastal plains, they are most densely populated and most intensely cultivated. The culturable command area (CCA) of this Doab comprises 16% of Mahanadi's deltaic plains.[44] Paddy is the dominant crop. Further, the low lying lands along the western boundary of the Lake as well as the islands on the eastern side are also used for cultivation purposes by the resident population.

The exact area which benefits from Chilika's function as a flood outlet has not been figured out yet. It can be safely presumed, however, that the favourable impacts of flood damage mitigation by Chilika are not only felt by the adjacent low lying lands, but they may extend upstream as well, beyond its natural boundaries. It would help therefore to assess this `benefit' by examining the pattern of land utilisation in the adjoining study area.

It is seen from Table 3.4 that nearly 53% of the area is used as agricultural land, of which 8.2% is irrigated land. Cultivable waste comprises about 15% of the area and the area not available for cultivation is 19%. Forests

Table 3.4: Land Utilisation Pattern in the Study Area, 1981

(in Hectares)

Land use	Krushnapra-sad	Brahmagiri	Tangi	Banpur	Rambha	Total
Reported Area	25656.74	46524.05	29955.73	51173.47	47862.29	201172.28
Forest	1775.34 (6.9)	1321.26 (2.8)	3406.25 (10.4)	15896.51 (30.8)	4036.34 (8.4)	26435.70 (13.1)
Agricultural Land						
Irrigated	219.35 (0.8)	NIL	NIL	NIL	8447.84 (17.7)	8667.19 (4.3)
Unirrigated	10098.96 (39.4)	27876.48 (61.0)	13574.84 (40.4)	20327.67 (39.4)	25223.63 (52.2)	97101.58 (48.3)
Cultivable Waste	3375.48 (13.2)	13963.94 (30.7)	5407.83 (18.1)	6947.99 (13.5)	1026.72 (2.1)	30720.96 (15.3)
Area not available for cultivation	10187.61 (39.7)	3363.37 (7.3)	7566.81 (25.3)	8001.30 (15.5)	9127.76 (19.1)	38246.85 (19.0)

Source: Same as in Table 3.3.

comprise about 13%. Further as seen earlier in Table 3.3, nearly 70% of the working population in the study area is dependent on agriculture, with 51% as cultivators.

It may be noted that Brahmagiri lying to the north of the Lake has 61% of land under agriculture, with nearly 74% of its working population engaged in agricultural activities. This is evidently because of the fertile alluvial soil of the region. However, agriculture is noted to be fully rainfed, which may partly explain the low yields of the region. Cultivable waste[15] is to an extent of 31%. This may be related to the unavailability of irrigation facilities as well as the increasing incidence of waterlogging and soil salinity in the coastal areas as mentioned earlier in the second chapter.

Rambha on the opposite side of the Lake has the highest percentage of land under irrigated (18%) and unirrigated (52%) agriculture with 73% of workers in that sector. Cultivable waste is 2% with 19% not available for cultivation.

Krushnaprasad comprising the islands on the east has 40% of land under agriculture with nearly 70% of the working population engaged as cultivators and agricultural labourers. Almost 40% of the agricultural land is unirrigated. Cultivable waste accounts for 13% and area not available for cultivation is almost 40%.

Banpur on the western shore has the lowest percentage of land under agriculture, with 67% of the working population engaged in it. 16% of the land is not available for cultivation. This is evidently because this area falls largely under the relict hills of gneissic rocks. The 14% culturable waste is presumably the pediplains, which extend from the hills upto the Lake's shores. Further, it also has the largest area under forests.

Tangi on the north western side has 40% land under agriculture, and 60% of the workers in that sector. Culturable waste accounts for 18% and 25% is not available for cultivation.

It is thus evident that the region around the Lake supports agricultural activities to a great extent. Rice is the major crop grown and it is reported that the yield rate on an average is a mere 3 quintals per acre.[46] Some other crops cultivated include pulses, oilseeds, coconuts and cash crops like cashew, polang seeds, and betel nut. There are no estimates of the income earned from agriculture in the region. In fact, there is very little information on the socio-economic life of the farming community of the region. However, it is known that they belong to socially and economically better off classes in contrast to the fishermen, the other major group in the region. They are also involved in money-lending and fish marketing. Further, with the boom in shrimp-export market, they are presently into prawn-culture operations in the shallow peripheral areas of the Lake, which has led to conflicts over the fisheries of the Lake.

Given the nature and extent of agricultural activities in the region supporting the livelihood of the local populace with no alternative means of livelihood, and the increasing population density in the area, it is evident that the damages due to floods in this region, in terms of losses to human lives and existing cropped area cannot be less significant than in the rest of the Plains. Further, indirectly, the inundation of the flood waters and their inefficient drainage from the lands, by increasing the waterlogging entails declining productivity. According to one report,[47] farmers on the western side have taken to fishing because of failure of crops due to flooding in the last ten consequetive years.

Further, the intensity of damages from the floods, as seen in the earlier chapter, depends on the magnitude and frequency of occurrence of the floods as well as on the absence/presence of 'moderating' factors, like the conditions in the catchment and in the deltaic areas. Since, about 12% of the floods in Mahanadi carried by the Kuakhai branch reach Chilika through Daya and Bhargavi, the magnitude and occurrence of floods in Mahanadi may be taken as a proxy for the magnitude of inflow into the Lake. It was noted in the earlier chapter that whereas the frequency of large floods has come down in the post-dam period, that of small and medium floods have increased and the extent of damage has also increased because of the absence of moderating factors.[48] Therefore, flood-control management continues to be a major concern for the region. In this context, ensuring the effectiveness of Chilika as a natural flood outlet becomes significant, especially in light of the increasing investments being made on structural measures to mitigate flood damages in the state.

In the above context, the silting up of the Lake may now be examined. The increasing shallowness of the Lake would significantly reduce the flood water retention capacity of the Lake and further, the choking up of the channel and mouth would be a deterrent to the outflow of floodwaters into the sea. This would definitely increase the risks of overflows from the Lake inundating the low lying lands and add to the problems of waterlogging and soil salinity. This not only reduces the effective cropped area but also results in declining productivity of the existing cropped area. It would also affect the other uses to which the lands are put to (such as grazing) or to which they can be put to. As mentioned earlier, consequent flooding of the adjacent areas has led many of the farmers to go in for fishing. Such a trend would obviously increase the demands made on the fisheries resources of a fast shrinking Lake.

It follows, therefore, that the siltation of Chilika cannot be seen as distinct from the flood management concern in Mahanadi's delta affecting the agricultural productivity of the region and thereby the economy. The cost of losing the flood outlet function provided naturally by the Lake should therefore be seen either in terms of the `damages prevented benefits' or in terms of the costs, both social and economic, of an alternative which would provide the same function. More importantly, the loss in terms of the `other' benefits from the Lake have to be accounted for, for it is not just a water reservoir to control/mitigate floods but it provides other equally important `benefits' too.

Chilika and Fisheries

As noted in the earlier chapter, Chilika Lake is the single largest source of inland (brackish water) fishery in the state. Further, it was also observed that the share of brackish water fish production in the state has been coming down. Since fisheries provide not only a source of livelihood but also a source of high quality animal protein, the fisheries of Chilika Lake, in this context needs to be studied.

The fauna of the Lake was first surveyed by the Zoological Survey of India in 1914.[49] Between 1957-1965, the Central Inland Fisheries Research Institute, Barrackpore, undertook extensive investigations on the fish population and the fisheries of the Lake. Chaudhuri (1916, 1917, 1923) and Hora (1923) who worked on the fish collection of the 1914 Survey described 118 species of fish from the Lake, and Kemp (1915) recorded 21 species of prawns. By 1957, the number of recorded species of fish rose to 152.[50] Subsequently, a total of 166 species of fish has been recorded which includes 8 species which have been introduced into the Lake during the past 50 years.[51]

Further, it has been noted that the fish community in the Lake is complex and includes fresh water, marine, brackish, catadromous and anadromous species.[52] The catadromous and anadromous species are migratory species -- the former live in the Lake and spawn in the sea; and the latter, live in the sea and come into the Lake to spawn. Out of the 158 native species in the Lake, 15 species are reported to be marine, 24 fresh water, and 119 brackish.[53] Further, several `marine' species on the other hand have established breeding populations within the lagoon and are capable of completing their life cycles within the brackish water of the Lake.[54]

It is clear therefore that the link to the sea is important for the fisheries of the Lake. In this context the silting up of the channel and the constriction of the mouth would directly affect the productivity of the fisheries in terms of yield as well as value. This is particularly so in light of the fact that a large percentage of the fish species which are commercially valued are migratory. It is estimated that 63-75% of the annual fish production in the Lake was contributed by migratory species.[55] More recently this has dropped to around 30% due to a relative increase of fresh water species within the Lake.[56] This obviously is related to the declining level of salinity of the Lake.

It has been further noted that most fish species of Chilika grow rapidly, achieving maturity within 2-3 years, and that a large percentage of the Lake's species are `consumers' feeding directly off plant material and decaying detritus. And because of this trophic characteristic, the Lake's fish populations are extremely productive relative to fish populations in other aquatic environments.[57] The annual fish yield for Chilika ranged between 65-122 kg/ha, with an average about 90 kg/ hectare during the 1980's.[58]

Therefore, in terms of diversity of the fish species thriving in the Lake and their productivity, the Lake may be seen as providing a rich habitat for fish production. Studies reveal the abundance of `primary producers' (phyto-planktons and macrophytes) and `secondary producers' (zooplankton and benthic organisms) in the Lake, which provide the `trophic links' for the diverse fish community natural to the Lake.[59] Further, it has been observed that the high nutrient concentration and an efficient nutrient recycling between the sediments and the water column in the lagoons makes them highly productive.[60] A comparison of productivity and biomass estimates for lagoons around the world by Barnes (1980) clearly indicates that lagoons are characterised by exceptionally high productivity and biomass, compared to other aquatic ecosystems. And this high degree of productivity is seen to support rich fisheries in the lagoons.

The diverse fisheries of the Lake also include a rich prawn fishery and a relatively minor crab fishery. Four species of penaeid prawns -- Penaeus monodon, Penaeus indicus, Metapenaeus monoceros and Metapenaeus dobsoni -- contribute to the commercial fishery in the Lake. The first two species have historically contributed over 70% of the total prawn catch.[61] "With historical acerage annual total landings above 1000 tonnes prawns have been the most important component of the commercial fishery within Chilika Lake, contributing 28% of the commercial landings during the years 1957-1965.[62] "In recent years (1981-1991), landings of clupeids and a miscellaneous group of fresh water species have surpassed those of prawns; however, with the current high prices obtained for landed prawns, they continue to maintain an important position in the commercial fishery within Chilika Lake.[63]

It may be noted that prawns are migratory species, they go to the sea for breeding and migrate inward into the Lake in the post larval stage. "Post-larvae of Penaeus indicus and Penaeus monodon recruit into the lagoon from the Bay of Bengal and complete their life-cycle within one year. While both species are capable of reproducing all year round,pulses of post-larval recruits enter Chilika Lake as juvenile "waves" which are subsequently harvested throughout the lagoon...Growth of both species is extremely rapid within the Lake..."[64] It is noticed that maintaining the link to the sea is important for the prawn fishery too.

The crab fishery is relatively minor, yet an important part of Chilika's fishery. Different species have been identified of which the mud crab (Scylla scerrata) is the most important and most abundant.[65] "Though these are caught throughout the year all over the Lake, the marketable catches come only from the southern and central sectors."[66]

Apart from the rich capture fishery discussed above, the Lake supports culture fishery too. Fish culture seems to have been practiced in the Chilika region since long as a method of supplementing income during the lean seasons. Prawn culture was introduced here in the early 80's and it may be noted that it was in Chilika where brackish water prawn culture was first successful in the country. However, this seems to have become its bane now.

Prawn culture is essentially of two types - extensive and intensive, the latter, being more capital intensive. The prawn culture followed in case of Chilika is essentially of the extensive type which requires dyking off ponds in the shallows along the periphery of the Lake, essentially carried out by the fishermen to supplement their incomes. It was also encouraged as a self employment program by the government for the unemployed fishermen youth. However, with the recent boom in shrimp-export market, significant changes have taken place - both in terms of utilisation of the Lake's resources as well as in the user groups. Prawn culture yields lucrative incomes. In terms of area an acre of prawn culture tank yields two good harvests and one relatively minor harvest in the course of a year. Each harvest yields at least Rs.15,000 per acre.[67] So, this has led to a proliferation of prawn culture ponds in the shallows around the Lake, thus clashing with the traditional fisheries.

Further, it has encouraged the entry of non-fishermen into fishing activities. This has led to a conflict over the fisheries resources of the Lake. This has been further compounded by the `leasing out' system of the fishing rights and the failure of the institutional agencies in protecting these rights. Consequently, this has resulted in conflicts between the fishermen themselves of different villages and different castes, between fishermen and the neofishermen (the non-fishermen by caste, essentially belonging to the socially and economically powerful component of the farming community). And the latest dimension added to this is the involvement of large private commercial firms in the undertaking of intensive prawn culture operations. The project by the Tata group, for instance has raised a lot of flak in the press. The major concern that has surfaced is that not only the extensive prawn culture operations have adverse environmental impacts, thus threatening the Lake's ecosystem, but they also result in the 'marginalisation' of the traditional users of the Lake's resources who have no alternative source of livelihood. With tacit government support for expansion of prawn culture as a prime source of foreign exchange, it has raised issues of both growth and equity. From the purview of the present study, this assumes importance in the context of integrating basic needs strategy with the environmental dimension in planning for sustainable reource management.

In fact, the traditional artisanal fisheries of the Lake form the main socio-economic base of the area. It is estimated that 70% of the population in the villages bordering the Lake depend on fishing as the source of livelihood.[68] It may be noted that the number of fishing villages around the Lake or the number of fishermen population directly dependent on the Lake is seen to vary between the different studies. However, according to the Directorate of Fisheries, Orissa, the number of fishing villages is reported to be 122, with a total population of 100,000 and 27,200 active fishermen.[69] Fishing in the Lake, like in the rest of the state, is caste-based and largely artisanal in nature. A profile of fishing in Chilika is given in Table 3.5. It is seen from the table that over a period of eight years, whereas the fishermen population has increased by 66.7% the active fishermen have increased by nearly 76%. The number of boats have increased by 1.7% and the total number of nets used by more than 50%.

Table 3.5: A Profile of Fishing in Chilika Lake

Particulars	1982-83	1990-91	Relative growth (%)
Fishermen Population	60000	100000	8.3
Active Fishermen	15500	27200	9.4
Fishermen Villages	122	122	
Types of Fisheries & Seasons			
'Jano' [Oct. to Feb.]	109	109	
'Bahan' [Round the Year]	33	33	
'Dian' [Oct. to Feb.]	88	88	
'Uthapani' [July to Oct.]	9	9	
Prawn [March to June, Oct. to Feb.]	77	77	
Total	310	310	
Total no. of boats	4325	4400	0.2
Total no. of nets	21065	31668	6.3
Fishing methods & Percentage of catch			
Bahan (Net fishing)	60	60	
Jano (Enclosures by bamboo screen)	15	15	
Traps (Prawn Fishing)	25	25	

Source: Orissa Fisheries at a Glance, 1984/85 & 1990/91, Directorate of Fisheries, Orissa, Cuttack.

Now, fish production from Chilika Lake in terms of the total tonnage landed and their value for the period 1981-91 is given in the following table 3.6. It is seen from the table that the total fish (and prawn) production from the Lake is largely fluctuating. From column 5, however, it is seen that the share of Chilika's fish production to that of total brackish water fish production in the state is declining. This may be related to the conditions prevailing in the Lake, given the fact that there has been no decline in the fishing effort as may be crudely assumed from the increase in the number of active fishermen as well as the fishing boats and nets. However, more information on different fishing gears-crafts combinations is necessary to assess

Table 3.6: Trends in Production and Value of Fish from Lake Chilika
(Qty. in tonnes; Value in Crores)

Year	Fish (1)		Prawn (2)		Total (3)		Crabs (4)		(3) as % of Total Brackish in State
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	
1980-81	5412	4.39	1101	3.43	6513	7.82	123	0.13	62.0
1981-82	5671	4.67	1927	5.58	7598	10.25	80	0.12	59.2
1982-83	5472	4.53	1434	4.28	6906	8.81	88	0.13	43.3
1983-84	6116	4.16	1344	2.95	7460	7.11	141	0.21	32.8
1984-85	5339	3.59	869	1.94	6208	5.53	90	0.22	28.9
1985-86	7446	5.18	1144	3.16	8590	8.09	79	0.20	35.9
1986-87	7283	5.41	1587	4.11	8872	9.35	54	0.16	36.8
1987-88	6863	4.62	1241	2.40	8104	7.05	39	0.13	34.5
1988-89	5211	N.A	917	N.A	6128	N.A	44	N.A	24.9
1989-90	5493	N.A	1177	N.A	6670	N.A	36	N.A	26.4
1990-91	3792	N.A	481	N.A	4273	N.A	24	N.A	19.5

Note: NA - not available
Source: Same as in Table 3.5.

the intensity of pressures on the fisheries of the Lake. In case of the crab fishery, the decline is more pronounced. It may be noted that since crabs are caught throughout the year, they provided an additional means of livelihood for a five month period after the main prawn fishing season.

In this context, a comparison of fish species composition in different time periods, by ranking the different fish groups in terms of their numerical abundance in the commercial landings as given in Table 3.7 provides more information.[70] It is seen that the relative abundance of both prawns and

Table 3.7: Changes in Fish Species Composition in Lake Chilika by Rank

Fish Species	1949/50 to 1954/55	1957/58 to 1965/66	1981 to 1991
Prawns	1	1	3
Mullets	3	2	4
Clupeids	4	4	1
Perches	5	5	5
Catfishes	6	3	6
Threadfins	7	6	7
Sciaenids	8	7	9
Beloniforms	9	9	8
Elasmobranchs	10	10	10
Miscellaneous	2	8	2

Source: Biswas (in prep.) from Feguson et al. (1992)

mullets has declined and that of clupeids and miscellaneous species has increased. It may be noted that the former group is currently highly valued in the market. Prawns, for eg. which had a low value historically and were even used to fertilise coconut platations, presently fetch a very high price. Penaeid prawns sell at the rate of Rs.100 - 150 per kg.[71] The species wise composition of fish and price per kg as in 1991 for instance is shown in Table 3.8.

Further, it is important to note that prawns and mullets in the above mentioned group is also migratory in nature, in which case their production depends on those factors which control their movement in and out of the Lake and also the extent and intensity of fishing activities in the adjacent sea-coast. Jhingran and Natarajan (1969) have noted that many of the marine species show high fecundities and produce planktonic eggs and larvae which develop in adjacent marine waters in the Bay of Bengal, close to the mouth of the Lake. Evidently, there are interlinkages between the Lake's fishery and the coastal off-shore fishery. The exact area of influence or the full extent of dependence between

Table 3.8: Species-wise composition of Lake Chilika Landings and Price per kg (1991)

Species	Composition (%)	Price per kg. (Rs.)
Prawns	11.25	
(i) Penaeid		100
(ii) Medium		40
(iii) Small		20
Mullets	12.57	20
Hilsa	1.20	20
Clupeids	14.37	12
Perches	5.57	15
Catfishes	17.78	10
Threadfins	5.34	12
Sciaenids	4.60	n.a.
Beloniforms	2.96	8
Etroplus	9.91	10
Miscellaneous	14.45	5

Note: n.a. - not available
Source: Handbook of Fisheries Statistics (1991), Directorate of Fisheries, Orissa, Cuttack.

the two has not been figured out yet, but it is well known that coastal wetlands provide support to off shore fishery as spawning and breeding grounds. The Lake therfore supports the coastal fisheries to some extent and the importance of this sector was highlighted in the earlier chapter. Likewise, it is seen that since the adjacent coastal habitat is used by the fish species of the Lake, and Chililka's fisheries is the single largest inland source in the state, inland fisheries are also linked to the dynamics of the coastal region. Perhaps this partly explains the fluctuations in the fish landings from Chilika.

However, it is estimated that Chilika alone meets 30- 60% of the state's consumption, which as noted in the earlier chapter has a large fish-eating population with a definite preference for inland fish. Therefore, it is a major source for fish protein, which is still the most affordable and easily accessible source of animal protein, notwithstanding the fact that the bulk of the fish/prawns is sold outside the state or abroad. The statistics for 1990-91 indicate that 40.8% of the total fish production from Chilika was consumed within the state, 5% by the local fishermen, 50% was exported outside the state and 4.2% was exported to foreign markets which comprised mainly of prawns.[72]

Now, the sale and export of dry and later fresh fish from Chilika has been an important item of trade right from the ancient times, with countries like China, Ceylon and the Far East and later to USA and the European countries. Within the country too, the fish finds a ready market in the neighbouring states of West Bengal and Bihar and also in the South. Within the state, the fish reaches the different corners of the hinterland. With the development of refrigeration and icing facilities around Chilika and the introduction of aquaculture, the exports have increased. It may be noted that the demand for the fish products from Chilika especially in the international market is influenced to a great degree by the low pollution content. The export of fish (and prawn together) from Chilika outside state and abroad is given in Table 3.9.

Table 3.9: Export of Fish and Prawn from Lake Chilika
(in tonnes)

Year	Total Export outside State & Abroad (1)	(1) as % of State Total (2)	(1) as % of Brackish Fish Export from State
1980-81	4366	13.6	87.3
1981-82	5128	14.3	85.5
1982-83	6697	18.8	90.0
1983-84	7250	17.1	69.3
1984-85	5999	14.4	60.0
1985-86	7961	12.8	72.7
1986-87	8163	12.8	73.6
1987-88	7345	10.6	67.5
1988-89	4843	6.6	40.8
1989-90	--	--	
1990-91	2314	2.7	21.7

Source: Same as in Table 3.6.

It is seen that the exports have been largely fluctuating. However, from 1986-87 onwards, they have been declining. From column 2 it is seen that exports from Chilika forms the major component of brackish water fish export from the state as a whole and it is, however, seen to be steadily declining in the recent years.

It is thus evident that the fisheries of the Lake is under stress. Depletion of fish stocks has been voiced by the local fishermen population, but there has been no study on this aspect yet. However, way back in 1975, the overfished state of the fisheries in terms of 'low mean age, low mean length and high rate of exploitation' had been pointed out.[73]

It is clear from the above discussion that in terms of its size, the productivity and the diversity of species that the Lake supports, the Lake has been a major source of capture and culture fishery. In addition, it provides breeding and spawning ground as support for the coastal fishery. Thus, it provides a source of income and employment directly in the inland sector and indirectly sustains the marine sector. With the low agricultural productivity that marks the region, the fisheries of the Lake constitute the most productive base. It therefore follows that this base be sustained to maintain the 'value' of the benefits accruing from it.

In this context, the physical changes in the Lake like the siltation, reduction in salinity, the growth of vegetation affect the biological production processes and hence the habitat for the fish. It was seen that the link to the sea is important for the productivity of the fisheries. Consequently, siltation, by blocking the channel and the mouth is a direct threat to the fisheries. Since, spawning runs are stimulated by salinity levels, the reduction in salinity affects the Lake's breeding and spawning grounds. The spread of aquatic vegetation hinders the fishing activities as such, but at the same time has reportedly favoured the fisheries by providing a rich source of food for the fish. Prawn culture, though a lucrative economic activity has reduced the shallows used as breeding and spawning grounds by the fish resulting in serious conflicts over the fisheries.

Though the concern over the depleting stocks of fish has not been proved, the fact that they are in an overfished state should be sufficient to make a reassessment of the fishery potential of the Lake in light of the current and projected rate of exploitation. In addition, the sustainability of the unscrupulous expansion of prawn culture operations, leading to 'marginalisation' of the traditional users and environmental degradation on one side and 'filling of the state coffers' on the other needs to be examined.

It may be noted that fisheries are renewable by definition only when its 'environment' remains favourable. 'Mining' them or degrading their habitat would render them 'non-renewable'. The loss of fisheries not only directly suggests a loss of income and employment for the fishermen population residing around the Lake, but has implications for the dietary intake of the people. This assumes significance in the context of the socio-economic conditions prevailing in the region.

Chilika and Tourism

In light of the growing emphasis on 'eco-tourism' especially in the coastal belt as a source of generating additional employment opportunities and earning foreign exchange, the actual and potential benefits from Chilika as a tourist spot needs a closer look.

The Lake has, since ancient times, enjoyed an unenviable position in the socio-cultural and historical map of the region. Hemmed in between the dissected hills of the Eastern Ghats and the Bay of Bengal, the Lake with its vast expanse of blue waters dotted with islands and with a varied picturesque scenery has long been a source of inspiration to poets, artists and philosophers. Oriya literature abounds in poems on the panaromic beauty of the Lake. Apart from its natural attractions, a large number of local legends drawn from history and mythology are associated with the Lake. The Kalijai island with a temple on it is a local pilgrimage site. And traditionally the banks of the Lake and the islands in it have been popular recreation/picnic spots for the younger folk.

Amongst its natural attractions which provide a veritable feast for the eye are the lakhs of birds that regularly flock to the Lake. "The bird fauna of Chilika Lake is diverse, and includes 151 species belonging to 26 families. The avifauna is predominated by 22 species of ducks and geese, 52 species of plovers and sandpipers belonging to 8 families, 14 species of gulls and terns, 13 species of eagles and 11 species of herons and egrets."[74] Acording to one report about 5 - 7 lakhs of migratory birds use the Lake as a wintering habitat from September to April.[75] In fact, its importance as a waterfowl habitat, as a resting/feeding site for birds migrating across continents led to its nomination as a 'Ramsar site' discussed in the first chapter. "Out of the 151 species, 92 species are considered as long-distance migrants and the rest are considered resident or local migrants."[76] Migratory birds largely come from Arctic and Central Asia -- the Caspian region, Siberia, Kazakh, Kirghiz steppes, the Urals, Lake Baikal, Yakut and Kiev regions, Pakistan, Iran as well as from the Himalayan region.[illegible] However, much before becoming a Ramsar site, the Nalabana island in the southern sector of the Lake which is a favourite haunt for the birds had been declared a bird sanctuary in 1973 under Orissa Wildlife Protection Act.

Apart from the fact that the spectacular flock of birds raises the 'tourism value' of the Lake, they may be seen as biological indicators of wetland ecology. The 'flushes' of productivity produced by the natural cycle of filling and drying up of wetlands provides rich feeding grounds for the birds. Further, the shelter of the island habitats and the shallows along the periphery of the Lake are used by the birds as feeding and resting habitat.

Further, by virtue of its location very close to the capital of the state, and the 'Golden Triangle' (mentioned in the earlier chapter) the flow of tourists to Chilika is largely related to the tourist flow to the 'Triangle'. And since the latter attracts people from far and wide, the potential flow towards the Lake is high. In fact, according to an estimate by the State Tourism Department, Chilika attracts a lakh of domestic tourists and 500 foreign tourists a year.[77] However, there are no estimates of the people engaged in tourist related activities with respect to the Lake or the income earned through tourism - mainly, because it is a very diffused activity. However, Rambha right on the southern banks of the Lake has lately emerged as a tourist resort.

In this context, the degradation of the island habitats through overgrazing and the removal of the shallows for prawn culture reducing the feeding grounds for the birds, which are the major attraction of the Lake reduces the tourism value of the site. The number of birds flocking to the Lake is reportedly on the decline. This would depress tourism related tertiary activities in the region.

It is thus evident that in terms of its religious and cultural significance for the local community, as well as in terms of the 'nature-tourism value' providing an alternate source of employment and income, the Lake's value is significantly high.

It is evident from the above section that the 'value' of the Lake's 'function'as a flood-regulating mechanism, its 'use' as fisheries and its 'attributes' as a tourist spot is significant. And, clearly, sustainability principle would demand conservation of the Lake's ecosystem in terms of resource use, resource maintenance and resource augmentation in the overall management strategy for the Lake.

The Ecological Perspective

To make a much more complete assessment of the Lake, in this section, its evaluation is carried out against the checklist of possible `benefits' from wetlands (see Appendix 1.2) as seen in the general review of wetland issues made in the first chapter.[78] This may help not only in improving the assessment, but also in highlighting the deficiencies in knowledge in relation to a particular benefit and thereby point research in that direction.

Groundwater recharge/discharge

Groundwater recharge function occurs when water moves from the wetland down into the underground aquifer. By the time it reaches the aquifer, the water is usually cleaner than when it began to filter down from the wetland. Once in the aquifer, it may be drawn out for human consumption, or it may flow laterally underground until it rises to the surface in another wetland as groundwater discharge. Thus, recharge in one wetland is linked to discharge in another. Recharge is also beneficial for flood storage because the runoff is temporarily stored underground, rather than moving swiftly downstream and overflowing. Groundwater discharge function occurs when water that has been stored underground moves upward into a wetland and becomes surface water. Some wetlands are sites of groundwater discharge at one time of the year and as sites of groundwater recharge at another, depending on the rise and fall of the local groundwater table.

No studies on this aspect of Chilika Lake are available. However, the fact that it occupies a vast and shallow depression in the coast, absorbing flood waters in the monsoons, its influence on the groundwater table of the area and hence on the sources of water supply cannot be insignificant. It may be noted further, that the villages around the Lake are solely dependent on wells, ponds and tanks for their water requirements. At the same time, it has been reported that wells are frequently abandoned, because of the proximity of saline groundwater.[79] However, it is known that coastal aquifers constitute an important source of water, especially in the arid and semi-arid zones which border the sea.

Shoreline stabilisation / Erosion control

Wetlands, with their characteristic vegetation help in the 'stabilisation' of shorelines by reducing the energy of waves, currents, or other erosive forces, while simultaneously holding the bottom sediment in place by plant roots. This helps prevent the erosion of land. In some cases, they also help in building up land. This function is most evident in the case of the mangroves. Further, the type of wetland that it is, Chilika's role in this context may not be significant. However, the vegetative cover on its eastern side does play a role in stabilising the coast line and in preventing soil erosion.

Sediment/Toxicant Retention

Since wetlands commonly occupy basins, they often serve as pools where sediments can settle. And where vegetation is predominant, the sedimentation is higher. Since toxicants often adhere to suspended sediment, they too may be retained simultaneously with the sediment. By retaining sediments /toxicants, upstream wetlands also help in improving the quality of ecosystems downstream, for instance, by reducing the silt load of river flows, thereby, lengthening the lifespan of reservoirs, channels and reducing the need for costly removal of accumulated sediment from dams, locks, power-stations and the like. "The amount of sediment in streams may be as much as 90% lower in river basins with 40% lake and wetland area than in basins without such habitats. Wetlands in depressions retain all of the sediment that enters them and wetlands on slopes may retain as much as 80% ..."[80] However, an excess build up of sediment in a wetland may alter its nature and hence, its functions. This corroborates the earlier point, regarding changing conditions in the Lake, that the rapid rate of siltation has emerged as the major threat to the ecosystem.

Nutrient Retention

This function occurs when nutrients, especially nitrogen and phosphorus, accumulate in the sub-soil, or are stored in wetland vegetation. When wetlands remove nutrients (and pollutants) they are referred to as `sinks'. This improves the water quality and helps prevent eutrophication. In certain cases, wetlands have been used for sewage treatment. When wetlands `export' the nutrients, they act as `sources'.

> A common role of wetlands during the growing seasons is to accumulate nutrients when water flows slowly. These nutrients then support production of fish and shrimp, as well as the forest, wildlife and agricultural wetland products. When water flows fast, wetlands act as a source. This cycle has important implications for algal growth, water quality, fish production ... downstream from the wetland area, because it reduces downstream nutrient levels at a season of the year when added nutrients are likely to cause eutrophic conditions. Release of the nutrients occurs when they are less likely to cause eutrophication.[81]

Now, lagoons are observed to have a high nutrient concentration, largely due to high riverine nutrient inputs and effective recycling between the sediments and the water column, which makes them highly productive aquatic environments. The productivity of Chilika as fisheries may be related to this `function.'

Studies on nutrient concentration in the Lake show that the nutrient concentration is negatively correlated with salinity, with the highest concentration in the northern sector.[82] This assumes importance in light of the concern expressed over the decline in the overall salinity level of the Lake. In fact, the proliferation of aquatic vegetation in the Lake as seen earlier is ascribed to the excess build up of nutrients in the Lake. Seasonal variation in nutrient concentration in the Lake has also been observed, with the highest values during the peak of monsoon.[83] It is therefore evident that the nutrient load of the river inflow into the Lake during the monsoon would affect the Lake's ecosystem.

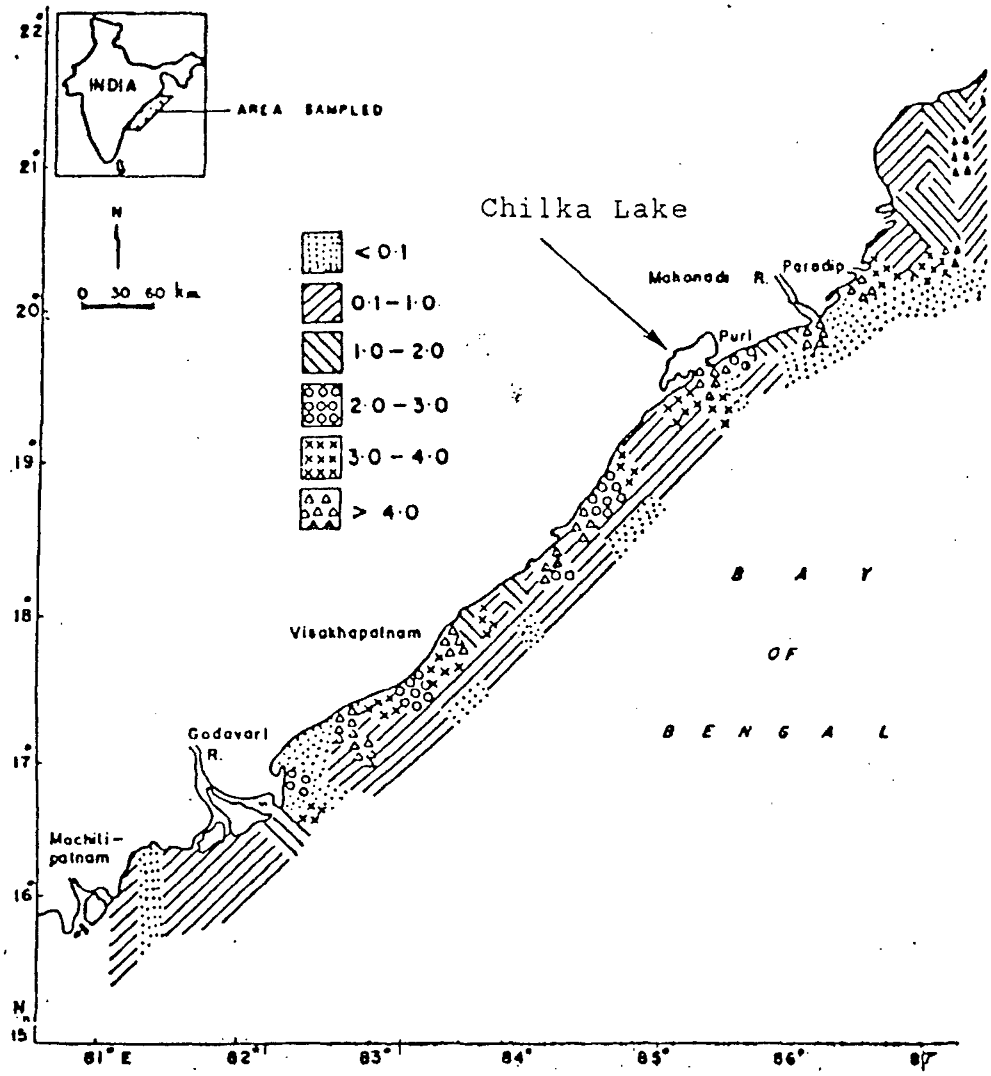
Biomass Export

In addition to the on-site productivity provided by the nutrient rich waters or substrate, the wetlands also extend off-site benefits in the form of nutrients carried by surface flow, in streams, or by groundwater recharge to other sites. This is referred to as the biomass export function of wetlands. "Part of the value of riverine and coastal fisheries is attributable to this vital support action provided by wetlands, and is in addition to their role as breeding or nursery areas for fish."[84] Studies have also shown that relatively high biomass values exist near the outlet of Chilika Lake.[85] (see Figure 3.8). It may be presumed therefore that this function supports the fisheries off the coast of Chilika.

Storm Protection/Windbreak

This function is usually provided by mangroves and other forested coastal wetlands which help by dissipating the forces of cyclones and coastal storms, thereby reducing the damages due to the storms in the inland areas. The

3.8 Biomass Distribution Along the East India Coast



vegetation acts as a shield against the storms. The mangrove forests of the Sunderbans in Bangladesh and India is reported to break storm waves often exceeding four metres in height. [86] In recognition of this important protective function, measures are being taken to protect and restore coastal wetlands in a number of countries. In the Philippines, a Presidential decree gives official protection to a 40m wide belt of mangroves along rivers and lagoons, and a 1000 m wide belt facing bays and the sea.[87]

Not being a forested wetland, this function is unlikely in the case of Chilika. However, the strip of forests which once covered the barrier spit on its eastern side could have had such a function. It may be noted that in the Bay of Bengal, the occurrence of cyclonic storms is most frequent and their impact is more pronounced in the states located on the East Coast. Between 1891 and 1977, the Bay of Bengal has generated over 400 cyclonic storms with different degrees of intensity.[88]

Micro climate Stabilisation

It has been observed that the overall hydrological, nutrient and material cycles and energy flows of wetlands may have a role in the stabilisation of local climatic conditions, particularly, rainfall and temperatures. This in turn has an influence on agricultural or any resource-based activities ,as well as on the stability of natural ecosystems and the wetland itself. In the valleys of south-west Uganda, local concern for the effect of wetland loss upon the local micro-climate has been an important factor leading to a 1986 ban upon wetland drainage.[89]

Water Transport

The open water habitats of wetlands are often used as waterways to carry goods and for public transport. In some cases, the waterways serve as the only available means of transport and are consequently very important. For eg. along the Pacific coast of Nicaragua, canals within the mangrove system provide the only channel of communication between settlements. As such, it is of crucial importance to the local communities.

In case of Chilika, as mentioned earlier, when waterways were the dominant means of transport, it served as a `gateway' and a port with trading and commercial links not only with other parts of India but also outside. For the villages on the eastern side of the Lake, water transport is still the only form of travel between some settlements.

Forest Resources/Plant Products

Wetlands which have forest resources, such as the mangroves, yield a number of products ranging from fuelwood, timber and bark, among wood products to resins, tannins and medicines which are clubbed as `minor' forest products. Estimates of sustainable mangrove exploitation for Indonesia in 1978 indicated a potential of US $ 18 million worth of exports and an equal amount for domestic consumption of charcoal, tan, bark, and other mangrove products.[90] In Thailand, the value of charcoal obtained from mangroves has been estimated as US $30 to US $400 per hectare per year depending on the intensity of harvest.[91] Lagoons usually have macrophytes (rooted, macroscopic plants) vegetation of both emergent and submergent type, depending on freshwater, saline or brackish habitat.

Chilika Lake does not support forests. However, the forested hills of the Eastern Ghats forming its south western boundary have traditionally been, a source of fuelwood, timber, and other minor forest products used by the local communities. A study on the fishermen community and their dependence on the forest products[92] indicates the importance of maintaining the forest base. For instance, the sal tree which is a dominant species yields timber which is used for the construction of all types of crafts used in the Lake, a whitish resin obtained from tapping the tree is used in caulking the boats, and its leaves are used in packing fish baskets. Ropes and fishing nets are made from the fibres obtained from the bark and branches of some trees. The unripe fruits of an evergreen tree are used in place of tar for paving the seams of the boats, the pulp is used for tanning to make the fishing nets and lines durable. The bamboos are used as mast of boats, their thin and broad splits are used in weaving the sails and for partitioning the boats into compartments, and also for making box traps for catching crabs, prawns and in the `jano' type of fishing mentioned earlier.

Apart from the commercial use of the forests, directly for sale or indirectly in terms of products utilised for trade, the forests also provide fuelwood for the local communities for their own consumption and for sale. Further, being in the watershed of the Lake, they influence the lagoon by regulating the speed and `load'(sediments, nurtrients) of the disharge into the Lake, thereby affecting the ecosystem.

However, the increasing scarcity of fuelwood and fodder observed in the region is the direct result of the depletion of the forest cover around the Lake and in the absence of other alternatives, this has led to further deforestation in the vicinity.[93] There have been some efforts though by the Government at reafforestation through social forestry programmes along the coast and the western part of the watershed.

The aquatic vegetation of Chilika includes marine, freshwater and brackishwater forms many of which are used by the local population for various purposes.[94] Nalaban Island, for instance, is covered with Phragmites (commonly referred to as 'weed') which are used for thatching houses by the local population. They are used for making mats as well. The dead and decaying weeds washed ashore are used in rice fields as manure, and some are used as cattle-feed. The Gracilaria species of algae found in abundance in the Lake is further important as a source of agar agar which is currently being imported from Japan to meet domestic demand. For agar agar is used in a variety of industrial products from the pharmaceuticals to the cosmetics. In fact there have been proposals to take up gracilaria cultivation in the Lake.

Wildlife Resources

Many wetlands are rich in wildlife, providing recreational benefits and commmercial products, ranging from meat and skins, to honey and the eggs of birds and turtles. Often, this serves as a supplementary source of income or consumption for the local rural commmunities.

The tourism value of Chilika Lake on account of the exotic bird life that it supports has been analysed earlier. Apart from birds, other wildlife include the dolphins in the outer channel area, the black buck and spotted deer on the east coast. Nothing is known about the role they play in the Lake's ecosystem, but they have been included in the tourism development plans for the Lake prepared by the Tourism Department.

Forage Resources

Some wetlands have grasslands and trees that are grazed by livestock and hence are important for pastoral communities. Leaves, grasses and seed pods are also collected as fodder, either for sale or for use as cattle feed. "Domestic animals feed on mangrove foliage in many parts of the world -- camels in the Middle East; cattle, goats and camels in Asia and Africa; water buffalo in parts of Asia and Australia ... In the Indus delta, some 5000 camels graze on mangrove islands."[95]

Now, as seen earlier, the economy in the region around the Lake is predominantly rural. Animal husbandry forms a supplementary source of income for the agricultural community. The margins of the Lake and the islands in it provide the grazing grounds for the livestock in the dry season. In a sample survey of 51 villages along Chilika's periphery by ORSAC in 1988 the total livestock population was estimated to be around 4500.

In this context, it may be noted that over-grazing is seen as one of the factors responsible for the higher rate of soil erosion in the Lake's watershed. This further may be related to the fact that over time, the grazing grounds have shrunk, with increasing encroachments for prawn culture operations in the shallow, peripheral regions of the Lake .

Agricultural Resources

Some wetlands in their natural form like the floodplains are used for cultivation of crops. "Indonesian tidal swamps have been cultivated successfully by a number of communities using traditional techniques. Rice is the major crop, often in combination with coconuts and fruit trees which help reduce soil acidity. Corn, cassava and vegetables are also grown. In addition to these crops, swamp farmers also raise livestock (principally poultry), and maintain fisheries in the canals and ditches of the coconut gardens."[96]

In the case of Lake Chilika, as shown earlier, the peripheral shallow regions and the deltaic plains to the north of the Lake have been traditionally used for agricultural purposes, especially the cultivation of paddy.

Water Supply

Wetlands of the freshwarer type are often used as a source of water for direct human consumption, agriculture, watering livestock and for industrial supply. "Over 40% of wetlands in Massachusetts are potential sources of drinking water."[97] The waters of the Lake, however, being brackish in nature are not used directly for consumption, but it is used for other domestic purposes, there being no other sources of water supply in the region except some wells and ponds.

Biological diversity

The wetlands support a diversity of biological forms and in this sense are important as 'genetic reservoirs'. Chilika as seen earlier has a variety of flora and fauna unique to its habitat. Its direct benefits in terms of the fisheries, the birds which support tourism has been discussed earlier.

Uniqueness to culture/heritage

Wetlands are often highly valued by society for reasons of recreation, religion, cultural educational or social association. In case of Chilika, it was seen from the earlier section on tourism that it is valued for its scenic vista as a recreation spot as well as being a local pilgrimage site.

Concluding Remarks

It is thus seen that apart from the macro economic `benefits' which directly support economic activities, and which have implications for the larger economy as observed in the second chapter, there are a host of other `benefits' from the Lake which provide essential ecological support. The above assessment of the Lake as an ecosystem may be now summarised as shown in Table 3.10. It is evident that the Lake provides a wide range of `benefits' and its conservation becomes a prerequisite to sustaining the flow of these benefits. A sustainable utilization of the Lake's resources without eroding the base itself, should therefore be the basic premise of the conservation strategy for the Lake. Otherwise, the likely consequences that the Lake's degradation can have may be summarised here as in Table 3.11(p.133).

It is clear that changes in the Lake brought about by the physical degradation of the Lake has adverse implications not only in terms of the `ecological' consequences per se but also through inter-linkages on socio-economic variables like income, output, employment, consumption and health, and thereby on development in the region as a whole.

It is thus evident from the above assessment of the `benefits' and the impacts of its degradation that the Lake functions, ecologically and economically, as a `life line' for the local area and `support line' for the entire region. Perhaps more detailed information on certain aspects could have thrown more light on the interdependencies between the Lake and its people. Also, it may be recalled from the first chapter that the Lake is important in the international context as a `Ramsar site'. It follows therefore, that by virtue of its multi-functional nature as well as its location in a structurally backward economy, conservation of Lake Chilika is evidently more than just an `environmental issue' -- it has a significant socio-economic content for sustaining development `with a human face'.

TABLE 5.10 WETLAND BENEFITS FROM LAKE CHILIKA

	1	2	3
FUNCTIONS			
Groundwater Recharge / Discharge		x	
Flood Control / Regulator	x		
Shoreline Stabilisation / Erosion Control			x
Sediment / Toxicant Retention	x		
Nutrient Retention	x		
Biomass Export	x		
Storm Protection / Windbreak			x
Micro-climate Stabilisation		x	
Water Transport	x		
Recreation / Tourism	x		
PRODUCTS			
Forest Resources / Plant Products	x		
Wildlife Resources	x		
Fisheries	x		
Forage Resources	x		
Agricultural Resources	x		
Water Supply			x
ATTRIBUTES			
Biological Diversity	x		
Uniqueness to culture / heritage	x		

Key : 1. Common and Important Value
2. Likely to be Important, More information Required
3. No information / Unlikely

TABLE 3.11 IMPACT ANALYSIS OF LAKE CHILIKA'S DEGRADATION

ECOLOGICAL CONSEQUENCES

DEGRADATION OF THE LAKE	Soil Erosion	Water spread/Depth (Storage Capacity)	Size of Mouth	Water-logging	Salinisation	Aquatic Vegetation	Salinity	Water Quality (Pollution)	Species Composition & Diversity	Fish Stock	Fish migration and spawning	Diseases of fish	Habitat Status
Siltation/Sedimentation		↓	↓	↑		↓	↓		↓				↓
Choking of Mouth						↑	↓		↓		↓		↓
Aquatic Vegetation Growth													↓
Salinity Decline						↑					↓		↓
Pollution												↑	↓
Overfishing									↓	↓	↓		↓
Overgrazing	↑												↓
Tourism Excesses								↓					↓
Sewage Disposal								↓				↑	↓

SOCIO-ECONOMIC CONSEQUENCES

SOCIO-ECONOMIC CONSEQUENCES		Soil Erosion	Water spread/Depth (Storage Capacity)	Size of Mouth	Water-logging	Salinisation	Aquatic Vegetation	Salinity	Water Quality (Pollution)	Species Composition & Diversity	Fish Stock	Fish migration and spawning	Diseases of fish	Habitat Status
OUTPUT	Agricultural Output		↓		↓	↓								
	Fish Prodn./Yield			↓				↓	↓	↓	↓	↓		↓
INCOME & EMPLOYMENT	Income & Employment Potential		↓		↓	↓								↓
	Export Earning Potential											↓	↓	↓
	Tourism Potential						↓							↓
CONSUMPTION	Availability of Protein											↓	↓	
HEALTH	Incidence of Human Diseases												↑	

KEY : ↑ Increase
↓ Decline

Notes and References

1. Directorate of Fisheries (1970), The Chilika Lake.
   It may be noted, however, that estimates of the Lake area are seen to vary from report to report. The Lake's boundaries are seen not to be defined properly. This is significant, particularly in light of the encroachments on the peripheral areas of the Lake for different purposes - farming, grazing or prawn culture ponds.

2. Jhingran (1975).

3. Govt. of India (1990), Wetlands of India - A Directory.

4. Lagoons are usually formed when a portion of the sea is enclosed by off-shore or long-shore barriers. Sand is a common barrier material which can form into a spit which extends across inlets or bays of the sea, thereby forming a lagoon.

5. Ferguson et al. (1992).

6. Directorate of Fisheries (1970), op.cit.

7. Rao et al. (1986).

8. Directorate of Fisheries (1970), op.cit.

9. Rao et al. (1986).

10. Reddy (1977).

11. Directorate of Fisheries (1970), op.cit.

12. Ibid.

13. Sinha (undated).

14. Dean and Saaltink (1991).

15. Natarajan et al. (1991).

16. ORSAC (1988).

17. ORSAC stands for Orissa Remote Sensing Application Centre, Bhubaneswar.

18. ORSAC (1991), A Brief Note on the Environmental Survey of Chilika, Sept. 1991.

19. Soil & land use Survey Organisation (1988), Soil Conservation Programme in the catchment of Lake Chilika, Directorate of Soil Conservation, Government of Orissa, Bubaneswar.

20. ORSAC (1991), op.cit.

21. From a study by the Geological Survey of India, Regional Geology Division, Calcutta, cited in 'Conservation & Development of Chilika Lake of Orissa, a Project Profile (1989) prepared by the Department of Science, Technology

& Environment, Government of Orissa (1989).

22. ORSAC (1990).

23. Ramanadham et al. (1964); Tripathy (1988) cited in Ferguson et al. (1992), p.28.

24. N. K. Das (ORSAC), Personal Communication.

25. ORSAC (1991), op.cit.

26. S. Patnaik, 'Limnological Factor in Relation and Agnatic Environment in Chilika Lake' in Abstracts of National Seminar on Conservation and Management of Chilika, 20 - 22 January 1988, organised by the Department of Science, Technology and Environment, Government of Orissa, Bubaneswar.

27. Ibid.

28. Dean and Saaltink (1991).

29. Conservation and Development of Chilika Lake of Orissa, A Project Profile, Ibid.

30. Reportedly, the Palur canal at one time linked the southern sector of Chilika with the sea, and the canal opened to the sea at the mouth of River Rushikulya. The canal is almost silted up and is defunct at present.

31. Dean and Saaltink (1991).

32. ORSAC (1988).

33. Synergism is the "complex interaction of different factors strengthening certain processes in a stronger way than the mere sum of the separate processes would have done."(Court 1990: 137).

34. The administrative divisions of police stations around the Lake has been taken on the basis of availability of data mainly from the Primary Census Abstracts. Police stations lie in between the administrative divisions of the bigger Tahasil and the smaller Block.

35. Interim Master Plan, Chilika (Tourism Development), Orissa, prepared by the Tourism and Country Planning Organisation (TCPO), for the Tourism Department, Government of India.

36. Ferguson et al. (1992).

37. ORSAC (1988).

38. ORSAC (1991), Ibid.

39. A simplified water balance equation modelling the volume of water in a wetland may be given as
Volume = Inflow - Water loss where,
Inflow = run-off + precipitation + groundwater discharge
Water loss = evaporation + outflow + groundwater recharge.

40. ORSAC (1991), Ibid.

41. Jhingran (1975).

42. ORSAC (1988).

43. Abstracts from the National Seminar on Conservation and Management of Chilika, 20-22 January, organised by Department of Science, Technology & Environment, Government of Orissa.

44. Delta Development Plan, Mahanadi Delta Command Area, Vol. II - Socio Economic Bench Mark Studies (September, 1986), Engineer in Chief (Irrigation), Bhubaneswar, Orissa.

45. The categories of wasteland described in Table 2.16 refer to the 'cultivable/culturable waste' category.

46. Delta Development Plan, Ibid.

47. Ferguson et al., Ibid, p.76.

48. Satapathy (1987).

49. Anandale and Kemp and others, 1915 -1924.

50. Jhingran (1975), op.cit.

51. Ferguson et al., Ibid.

52. Jhingran and Natarajan (1969).

53. Biswas (1990).

54. Jhingran (1975).

55. Jhingran (1963).

56. Ferguson et al., Ibid.

57. Jhingran and Natarajan (1969).

58. Estimation by Biswas (in prep.) quoted in Ferguson et al. (1992).

59. Phytoplankton include the microscopic water plants, zooplankton the microscopic water animals, macrophytes are rooted macroscopic plants, benthic organisms are plants and animals of restricted mobility that live within or upon the bottom sediments.

60. Barnes (1980).

61. Subrahmanyam (1966).

62. Jhingran and Natarajan (1969).

63. Ferguson et al. (1992).

64. Ibid.

65. Jhingran (1975).

66. Ibid.

67. Revenue Department (undated), Principles of Settlement of Fisheries in Chilika.

68. The study area taken earlier covered a larger area, so was seen to be primarily agricultural.

69. Directorate of Fisheries (1991), Handbook of Fisheries Statistics, Government of Orissa, Cuttack.

70. Biswas (in prep.) cited in Ferguson et al. (1992).

71. Directorate of Fisheries (1991), op.cit.

72. Ibid.

73. See Jhingran (1975).

74. Dev (1990).

75. Ibid.

76. Ibid.

77. Interim Master Plan, Chilika (Tourism Development), Ibid.

78. For the ecological aspect of wetlands in general, we have relied on Dugan(1990)'s study.

79. Dean and Saaltink (1991).

80. Dugan (1990).

81. Ibid.

82. ORSAC (1991), Ibid.

83. Ibid.

84. Dugan (1990).

85. See Ferguson et al. (1992).

86. Dugan (1990).

87. Ibid.

88. See Natarajan et al. (1991).

89. Dugan (1990).

90. Hamilton and Snedaker (1984) cited in Dugan (1990).

91. FAO (1982).

92. Rao (1970).

93. Proceedings of two workshops on Chilika Lake for NGOs (3-4 February 1992) & Scientists and Administrators (5-6 February 1992) by CIDA and CENDERET, Bhubaneswar.

94. ORSAC (1989), Report on Status Survey and Environmental Monitoring of Chilka.

95. Hamilton and Snedaker, op.cit.

96. KEPAS (1985) cited in Dugan (1990).

97. Motts and Heeley (1973) cited in Dugan (1990).

CONCLUSION

The present study has made a modest attempt towards an economic assessment of Lake Chilika in Orissa. In fact, the study has made an effort to incorporate non-economic factors such as biomass export function, groundwater recharge/discharge, nutrient retention, etc. into the economic assessment of the benefits from the Lake. These factors are often perceived as ecological ones. However, in the conventional economic analysis these factors are assumed as exogenous variables. But, the current rethinking on alternative approaches to development has categorically argued for recognising these factors as endogenous to economic calculus. Moreover, the recent literature has advanced the view that global recession in the 80s could be a manifestation of the increasing incidence of environmental degradation. Apparently, this has evoked mixed reactions from the developed and developing countries on development strategies which seem to have been caught in the cross-fire between environment protection and development needs. Understandably, this has led to the proliferation of literature on environment and development issues.

In fact, it may be recalled from the first chapter that the degree of interdependency between environment and development in sustaining the development process which has increasingly come under threat entailed an alternative approach towards bridging the gap between the two through the concept of `conservation.' The main strand of conservation theory has been voiced in different tones at different times as `sustainable resource management', `eco-development', `green development', `sustainable development' and the like. Such a characterisation could have possibly been the outcome of efforts towards operationalizing the conservation theory within a development framework. Obviously, the success of operationalising `conservation' depends on the `demand' for conservation. This can be justified in many ways. For instance, whereas the developed countries' concern is basically to maintain the `quality' of life, that of the developing countries' is to ensure security of livelihood. In fact, this is the undercurrent of the cleavage between the developed and developing countries' perspective towards environment which overshadowed the recently concluded Earth Summit at Rio.

Given the fact that developing countries are primarily resource-based economies directly dependent on the appropriation of the natural resources, a sustainable resource use for meeting present needs without impairing the resource base becomes crucial for their development planning. However, despite this, the developing countries are increasingly beset with the problems of environmental degradation and more specifically wetland degradation. In this context, the present study had taken up the implications of conservation of Chilika Lake on regional development.

An assessment of the relevance of conserving this particular wetland was set against the backdrop of the pace and pattern of development of the state in which it is located. In this direction, the second chapter examined the structural characteristics of Orissa's economy to facilitate a better understanding of the economic as well as ecological aspects of conserving the Lake. It was found that the state is primarily agriculture-based with a significant proportion of the population dependent on primary sector activities for livelihood. And a major factor underlying the `impasse' in agricultural productivity was seen to be the frequent recurrence of natural calamities, floods in particular, which wreak havoc almost with a `notorious regularity'. Further, cultivation being essentially rain-fed with paddy as the dominant crop, water management was noted to be a prime requisite for improving agricultural performance. Seen in the context of land degradation which dampens agricultural productivity and further aggravates the `damages' due to floods, land management was seen to be equally significant. Taking the regional physiography into account, land and water management was seen to be especially critical for the coastal plains which are most densely populated and which form the major agricultural belt as the `rice bowl' for the state.

Against this setting, an indirect assessment of the consequences of degradation of Lake Chilika by assessing the `benefits' from it was attempted in the third chapter. It was found that the Lake provides a wide range of `benefits', and as a take off from wetland ecology in general, the `benefits' were assessed as `functions', `uses' and `attributes' particular to the wetland. This emphasises the importance of recognising the ecological basis of the benefits that are derived from natural ecosystems. Whereas the Lake's `function' as an outlet for the flood waters of Mahanadi; its `use' as a source of brackish water fisheries and its `attributes' making it a tourist spot were seen to have significant implications from the macroeconomic perspective, its other `benefits' were seen to be equally significant too. Further, it was seen to be important in the international context too as a `Ramsar site'.

In the above context the degradation of the Lake which has evoked much concern as an `environmental issue' was examined and its likely implications on socio-economic variables like income, output, employment, consumption and health show that its conservation is all the more imperative to prevent the collapse of a valuable `natural asset'.

Whereas scientific studies are being currently undertaken to estimate the extent of physical degradation that has set in, it is equally important to trace the root causes behind these changes. In fact, a catchment wide analytical approach would be required to adequately capture the full range of threats to the Lake and trace the dynamics of its degradation.

With the current controversies over the appropriation of Chilika's potential for prawn culture, the Lake has attracted wider attention on the trade-offs between short term exploitation and long term benefits. This is seen in the ongoing sectoral efforts at `commercialising' the Lake through prawn farming, tourism, etc. at the cost of the Lake's ecosystem. Evidently, the state has been adopting a myopic approach towards appropriation of the Lake's resources rather than an integrated resource management strategy for `sustaining' the intrinsic benefits that such an ecosystem yields. Therefore, the present study suggests that conservation of the Lake should be given priority in the overall management strategy towards creating as well as ensuring conditions for `development with a human face'.

Appendices

1.1 Wetland Classification

1. Salt Water		
1.1. Marine	*1. Subtidal*	i) permanent unvegetated shallow waters less than 6m depth at low tide, including sea bays, straits.
		ii) subtidal aquatic vegetation, including kelp beds, sea grasses, tropical marine meadows.
		iii) coral reefs
	2. Intertidal	i) Rocky marine shores, including cliffs and rocky shores.
		ii) Shores of mobile stones and shingle.
		iii) Intertidal mobile unvegetated mud, sand or salt flats.
		iv) Intertidal vegetated sediments, including salt marshes and mangroves, on sheltered coasts.
1.2. Estuarine	*1. Subtidal*	i) Estuarine waters; permanent waters of estuaries and estuarine systems of deltas.
	2. Intertidal	i) Intertidal mud, sand or salt flats, with limited vegetation.
		ii) Intertidal marshes, including salt-marshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes.
		iii) Intertidal forested wetlands, including mangrove swamp, nipa swamp, tidal freshwater swamp forest.
1.3. Lagoonar		i) Brackish to saline lagoons with one or more relatively narrow connections with the sea.
1.4. Salt lake		i) Permanent and seasonal, brackish, saline or alkaline lakes, flats and marshes.
2. Freshwater		
2.1. Riverine	*Perennial*	i) Permanent rivers and streams, including waterfalls.
		ii) Inland deltas.
	Temporary	i) Seasonal and irregular rivers and streams.
		ii) Riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland.
2.2. Lacustrine	*Permanent*	i) Permanent freshwater lakes (>8 ha), including shores subject to seasonal or irregular inundation.
		ii) Permanent freshwater ponds (<8 ha).
	Seasonal	i) Seasonal freshwater lakes (>8 ha), including floodplain lakes.
2.3. Palustrine	*Emergent*	i) Permanent freshwater marshes and swamps on inorganic soils, with emergent vegetation whose bases lie below the water table for at least most of the growing season.
		ii) Permanent peat-forming freshwater swamps, including tropical upland valley swamps dominated by *Papyrus* or *Typha*.
		iii) Seasonal freshwater marshes on inorganic soil, including sloughs, potholes, seasonally flooded meadows, sedge marshes, and dambos.
		iv) Peatlands, including acidophilous, ombrogenous, or soligenous mires covered by moss, herbs or dwarf shrub vegetation, and fens of all types.
		v) Alpine and polar wetlands, including seasonally flooded meadows moistened by temporary waters from snowmelt.
		vi) Freshwater springs and oases with surrounding vegetation.
		vii) Volcanic fumaroles continually moistened by emerging and condensing water vapour.
	Forested	i) Shrub swamps, including shrub-dominated freshwater marsh, shrub carr and thickets, on inorganic soils.
		ii) Freshwater swamp forest, including seasonally flooded forest, wooded swamps on inorganic soils.
		iii) Forested peatlands, including peat swamp forest.
3. Man-Made Wetlands		
3.1. Aquaculture/Mariculture		i) Aquaculture ponds, including fish ponds and shrimp ponds.
3.2. Agriculture		i) Ponds, including farm ponds, stock ponds, small tanks.
		ii) Irrigated land and irrigation channels, including rice fields, canals and ditches.
		iii) Seasonally flooded arable land.
3.3. Salt Exploitation		i) Salt pans and salines.
3.4. Urban/Industrial		i) Excavations, including gravel pits, borrow pits and mining pools.
		ii) Wastewater treatment areas, including sewage farms, settling ponds and oxidation basins.
3.5. Water-storage areas		i) Reservoirs holding water for irrigation and/or human consumption with a pattern of gradual, seasonal, draw down of water level.
		ii) Hydro-dams with regular fluctuations in water level on a weekly or monthly basis

Modified after Scott (1989a)

Source: Dugan (1990).

	Estuaries (without mangroves)	Mangroves	Open coasts	Floodplains	Freshwater marshes	Lakes	Peatlands	Swamp forest
Functions								
1. Groundwater recharge	○	○	○	■	■	■	●	●
2. Groundwater discharge	●	●	●	●	■	●	●	■
3. Flood control	●	■	○	■	■	■	●	■
4. Shoreline stabilisation/Erosion control	●	■	●	●	■	○	○	○
5. Sediment/toxicant retention	●	■	●	■	■	■	■	■
6. Nutrient retention	●	■	●	■	■	●	■	■
7. Biomass export	●	■	●	■	●	●	○	●
8. Storm protection/windbreak	●	■	●	○	○	○	○	●
9. Micro-climate stabilisation	○	●	○	●	●	●	○	●
10. Water Transport	●	●	○	●	○	●	○	○
11. Recreation/Tourism	●	●	■	●	●	●	●	●
Products								
1. Forest resources	○	■	○	●	○	○	○	■
2. Wildlife resources	■	●	●	■	■	●	●	●
3. Fisheries	■	■	●	■	■	■	○	●
4. Forage resources	●	●	○	■	■	○	○	○
5. Agricultural resources	○	○	○	■	●	●	●	○
6. Water supply	○	○	○	●	●	■	●	●
Attributes								
1. Biological diversity	■	●	●	■	●	■	●	●
2. Uniqueness to culture/heritage	●	●	●	●	●	●	●	●

Key: ○ = Absent or exceptional; ● = present; ■ = common and important value of that wetland type.

Source: Same as in Appendix 1.1.

1.3 The Causes of Wetland Loss

Human Actions	Estuaries	Open coasts	Floodplains	Freshwater marshes	Lakes	Peatlands	Swamp forest
Direct							
Drainage for agriculture, forestry, and mosquito control.	■	■	■	■	●	■	■
Dredging and stream channelization for navigation and flood protection.	■	○	○	●	○	○	○
Filling for solid waste disposal, roads, and commercial, residential and industrial development.	■	■	■	■	●	○	○
Conversion for aquaculture/mariculture	■	●	●	●	●	○	○
Construction of dykes, dams, levees, and seawalls for flood control, water supply, irrigation and storm protection.	■	■	■	■	●	○	○
Discharges of pesticides, herbicides, nutrients from domestic sewage and agricultural runoff, and sediment.	■	■	■	■	■	○	○
Mining of wetland soils for peat, coal, gravel, phosphate and other materials.	●	●	●	○	■	■	■
Groundwater abstraction	○	○	●	■	○	○	○
Indirect							
Sediment diversion by dams, deep channels and other structures.	■	■	■	■	○	○	○
Hydrological alterations by canals, roads and other structures.	■	■	■	■	■	○	○
Subsidence due to extraction of ground-water, oil, gas and other minerals.	■	●	■	■	○	○	○
Natural Causes							
Subsidence	●	●	○	○	●	●	●
Sea-level rise	■	■	○	○	○	○	■
Drought	■	■	■	■	●	●	●
Hurricanes and other storms	■	■	○	○	○	●	●
Erosion	■	■	●	○	○	●	○
Biotic effects	○	○	■	■	■	○	○

Key: ○ = Absent or exceptional; ● = present, but not a major cause of loss; ■ = common and important cause of wetland degradation and loss.

Source: Same as in Appendix 1.1.

1.4 Area of Wetlands described in Directory of Asian Wetlands and Proportion under Protection

	No. of sites	Area of sites	Area under some form of protection	Area totally protected	% Area under some form of protection	% Area totally protected
Bangladesh	12	6,770,000	615,000	35,500	9	<1
Bhutan	5	8,500	6,500	500	77	6
Brunei	3	138,000	14,500	14,500	11	11
Burma	18	5,490,000	24,800	4,020	<1	<1
China	192	16,300,000	2,050,000	2,000,000	13	12
Hong Kong	3	11,900	11,900	409	100	3
India	93	5,470,000	1,620,000	1,530,000	30	28
Indonesia	137	8,780,000	3,030,000	2,900,000	35	33
Japan	85	475,000	195,000	77,000	41	16
Kampuchea	4	3,650,000	2,000	2,000	<1	<1
D.P.R. Korea	15	322,000	12,500	12,500	4	4
Rep. of Korea	21	107,000	13,100	5,830	12	5
Laos	4	222,000	0	0	0	0
Malaysia	37	3,120,000	1,660,000	6,350	53	<1
Mongolia	30	1,550,000	5,000	0	<1	0
Nepal	17	35,600	27,500	26,100	77	73
Pakistan	48	858,000	521,000	138,000	61	16
Papua New Guinea	33	10,100,000	600,000	600,000	6	6
Philippines	63	1,410,000	94,200	76,100	7	5
Singapore	7	220	95	15	43	7
Sri Lanka	41	274,000	82,500	76,600	30	28
Taiwan	12	8,400	7,800	746	93	9
Thailand	42	2,510,000	191,000	41,000	8	2
Vietnam	25	5,810,000	69,800	49,500	1	<1
TOTAL	947	73,420,000	10,854,000	7,597,000	14.8	10.3

Note: The sites/areas given only represent sites of international importance and not all the wetlands in any given country.

ource: Scott & Poole (1989), A Status Overview of Asian Wetlands, AWB & WWF.

1.5 Major Threats to Wetlands of International Importance in Asia

	South		Southeast		East		Total	
	No.	%	No.	%	No.	%	No.	%
Total number of sites	216	-	373	-	358	-	947	-
Number of sites for which information on threats is available	191	-	331	-	212	-	734	-
No threats known	13	7	21	6	73	34	107	15
General disturbance from human settlement/encroachment	44	23	111	34	43	20	198	27
Drainage for agriculture	39	20	89	27	39	18	167	23
Reclamation for urban/industrial development	8	4	27	8	21	10	56	8
Construction of roads, airports, waterways etc.	6	3	12	4	6	3	24	3
Construction of dams/barrages for storage/hydroelectricity	6	3	12	4	11	5	29	4
Dredging	2	1	6	2	4	2	12	2
Mining activities & oil exploration	4	2	26	8	4	2	34	5
Conversion to aquaculture ponds	11	6	48	15	6	3	65	9
Conversion to salt pans	10	5	3	1	2	1	15	2
Diversion of water supply for irrigation/domestic/industrial	27	14	28	9	10	5	65	9
Degradation of watershed, soil erosion and increased siltation	48	25	56	17	6	3	110	15
Pollution - all forms	49	26	57	17	38	18	144	20
- domestic sewage	19	10	17	5	14	7	50	7
- solid waste (rubbish)	5	3	7	2	4	2	16	2
- industrial waste	19	10	27	8	17	8	63	9
- oil	4	2	5	2	3	1	12	2
- pesticides	15	8	17	5	6	3	38	5
- fertilizers	15	8	5	2	4	2	24	3
Accelerated eutrophication	11	6	2	1	3	1	16	2
Infestation with aquatic weeds	16	8	4	1	3	1	23	3
Cutting of aquatic plants	20	11	14	4	7	3	41	6
Wood-cutting for domestic use	30	16	88	27	-	-	118	16
Commercial logging/forestry	25	13	99	30	2	1	126	17
Overgrazing by domestic livestock	51	27	7	2	9	4	67	9
Burning of aquatic vegetation	10	5	25	8	1	1	36	5
Fishing and associated disturbance	61	32	60	18	21	10	142	19
Hunting and associated disturbance	75	39	139	42	21	10	235	32
Use of poisons/explosives in fishing and hunting	2	1	23	7	1	1	26	4
Harvesting eggs, nestlings or hatchlings of birds and reptiles	6	3	46	14	7	3	59	8
Exploitation of corals and shells	5	3	12	4	-	-	17	2
Introduction of exotic species	5	3	13	4	7	3	25	3
Disturbance from tourism/recreation and associated development	25	13	10	3	8	4	43	6
Flood control	2	1	5	2	5	2	12	2
Others	10	5	11	3	4	2	25	3

8

Source: Same as in Appendix 1.4.

1.6 Severity of Threats to Wetlands of International Importance in Asia

	Number of sites known	Degree of threat: None	Low	Mod.	High	% sites with moderate to high threat
Bangladesh	11	1	1	5	4	82
Bhutan	5	3	-	1	1	40
Brunei	3	-	2	1	-	33
Burma	16	-	7	8	1	56
China	105	30	34	36	5	39
Hong Kong	3	1	-	2	-	67
India	88	4	44	22	18	45
Indonesia	129	1	54	66	8	57
Japan	38	8	11	17	2	50
Kampuchea	3	-	1	2	-	67
D.P.R. Korea	5	5	-	-	-	0
Rep. of Korea	19	5	3	6	5	58
Laos	3	-	1	2	-	67
Malaysia	37	-	5	22	10	86
Mongolia	30	23	5	2	-	7
Nepal	14	2	7	4	1	36
Pakistan	42	1	20	15	6	50
Papua New Guinea	26	14	8	4	-	15
Philippines	49	2	13	24	10	69
Singapore	6	-	2	3	1	67
Sri Lanka	31	2	8	13	8	68
Taiwan	12	1	4	5	2	58
Thailand	36	1	18	14	3	47
Vietnam	23	3	14	4	2	26
Total	734	107	262	278	87	49.7

Source: Same as in Appendix 1.4.

1.7 State/Union Territory wise Distribution of Wetlands in India (including wetlands of less than 100 ha)

State (1)		Natural No. (2)	Natural Area (ha) (3)	Man-Made No. (4)	Man-Made Area (ha) (5)
1.	Andhra Pradesh	219	1,00,457	19,020	4,25,892
2.	Arunachal Pradesh	2	20,200	NA	NA
3.	Assam	1394	86,355	NA	NA
4.	Bihar	62	2,24,788	33	48,607
5.	Goa	3	12,360	NA	NA
6.	Gujarat	22	3,94,627	57	1,29,660
7.	Haryana	14	2,691	4	1,079
8.	Himachal Pradesh	5	702	3	19,165
9.	Jammu & Kashmir	18	7,227	NA	21,880
10.	Karnataka	10	3,320	22,758	5,39,195
11.	Kerala	32	24,329	2,121	2,10,579
12.	Madhya Pradesh	8	324	53	1,87,818
13.	Maharashtra	49	21,675	1,004	2,79,025
14.	Manipur	5	26,600	NA	NA
15.	Meghalaya	2	NA	NA	NA
16.	Nagaland	2	210	NA	NA
17.	Orissa	20	1,37,022	36	1,48,454
18.	Punjab	33	17,085	6	5,391
19.	Rajasthan	9	14,027	85	1,00,217
20.	Sikkim	42	1,101	2	3.5
21.	Tamil Nadu	31	58,868	20,030	2,01,132
22.	Tripura	3	575	1	4,833
23.	Uttar pradesh	125	12,832	28	2,12,470
24.	West Bengal	54	2,91,963	9	52,564
		2,164	14,49,338	65,250	25,87,965
	Union Territories				
1.	Chandigarh	NA	NA	1	170
2.	Pondicherry	3	1,533	2	1,131
		3	1,533	3	1,301
	Grand Total	**2167**	**14,50,871**	**65,254**	**25,89,266**

Source: Government of India (1990), Wetlands of India - A Directory, Ministry of Environment and Forests, New Delhi.

1.8 THE IMPORTANT WETLANDS OF India: AN ANNOTATED LIST OF SITES DESCRIBED IN THE DIRECTORY OF ASIAN WETLANDS

CODING SYSTEM

No.

The reference number for the site, as used in The Directory of Asian Wetlands

Habitat Types

A list of the major wetland types present at the site according to the following codes:

01: shallow sea bays and straits (under six metres at low tide)
02: estuaries, deltas
03: small offshore islands, islets
04: rocky sea coasts, sea cliffs
05: sea beaches (sand, pebbles)
06: intertidal mudflats, sand flats
07: mangrove swamps, mangrove forest
08: coastal brackish and saline lagoons and marshes
09: salt pans (artificial)
10: shrimp ponds, fish ponds
11: rivers, streams - slow-flowing (lower perennial)
12: rivers, streams - fast-flowing (upper perennial)
13: oxbow lakes, riverine marshes
14: freshwater lakes and associated marshes (lacustrine)
15: freshwater ponds (under eight hectares), marshes, swamps, (palustrine)
16: salt lakes, saline marshes (inland drainage systems)
17: water storage reservoirs, dams
18: seasonally flooded grassland, savanna, palm savanna
19: rice paddies
20: flooded arable land, irrigated land
21: swamp forest, temporarily flooded forest
22: peat bogs

P(Protection)

The overall level of legal protection at the site according to the following codes:

1: No information.
2: No legal protection.
3: Partly or wholly included within a Forest Reserve, Non-hunting Area or similar reserve with low level of protection.
4: Partly protected within a National Park, Nature Reserve, Wildlife Sanctuary or equivalent reserve.
5: Wholly protected within a National Park, Nature Reserve, Wildlife Sanctuary or equivalent reserve.

(continued)

T (Threats)

The overall degree of threat at the site according to the following codes:

1: No information.
2: No threat known.
3: Minor threats reported at the site (e.g. some disturbance from hunting, fishing, recreation or overgrazing).
4: Moderately threatened; some serious threats reported at the site, but irreparable damage not inevitable.
5: Under serious threat, usually from several sources; most if not all of the wetland habitat is likely to be lost or major ecological changes are likely to occur unless some immediate remedial action is taken.

V (Conservation Values)

The principal conservation values of the site according to the following code based on the Ramsar Criteria:

R: The site contains a good representative example of a specific type of wetland habitat or contains a rare or unique wetland type.
S: The site is of considerable socio-economic or cultural value.
E: The site supports populations of one or more threatened or endemic species of plant or animal.
D: The site is of special value for maintaining the genetic or ecological diversity of the region in which it is situated.
C: The site is of special value for certain species of plants and animals at a critical stage of their biological cycle.
W: The site is of considerable importance for waterfowl; regularly supporting at least 20,000 birds, 1% of the population of a species or sub-species, or substantial numbers of species indicative of wetland values.
O: The site is thought to be important for one or more of the above reasons, but insufficient information is available to assign any particular values.

NOTES

Location

The geographical coordinates are those of the approximate centre of the site.

Area

Whenever possible, the area of the wetland habitat is given in hectares. However, in the case of some stretches of coastline and river, only the approximate length of the site is known. This is given in kilometres.

INDIA

No.	Name of Site	Location	Area	Habitat Types	P	T	V
1	Pangong Tso	33°50'N, 78°35'E	21,000 ha	12,16	5	3	RW
2	Chushul Marshes	33°35'N, 78°45'E	11,000 ha	15,16	2	3	REW
3	Hanle River Marches	32°55'N, 78°55'E	7,500 ha	12,13,16	2	3	RE
4	Tso Morari	32°50'N, 78°20'E	13,000 ha	12,15,16	3	2	REDW
5	Tso Kar Basin	33°18'N, 78°00'E	20,000 ha	12,16	3	3	REW
6	Dal Lake	34°06'N, 74°52'E	1,670 ha	13,14	2	5	R
7	Shallabugh Lake and Marshes	34°10'N, 74°42'E	750 ha	13,14	5	4	RW
8	Wular Lake	34°20'N, 74°33'E	20,000 ha	13,14	2	5	0
9	Haigam Rakh	34°15'N, 74°31'E	1,400 ha	14,15,19	5	4	RW
10	Mirgund Lake	34°08'N, 74°38'E	300 ha	13,14	5	4	RW
11	Hokarsar	34°05'N, 74°43'E	1,300 ha	14	5	4	RW
12	Pong Dam Lake	32°00'N, 76°00'E	45,000 ha	17	5	3	W
13	Harike Lake	31°10'N, 74°56'E	4,100 ha	17	5	5	EW
14	Lav Kush Tirath	29°55'N, 76°00'E	8 ha	14	3	1	0
15	Wetlands in Corbett National Park	29°33'N, 78°55'E	Unknown	12,15,17	5	3	REW
16	Wetlands in Kishanpur Pashu Vihar Sanctuary	28°31'N, 80°22'E	Unknown	15,18	5	3	RE
17	Wetlands in Dudhwa National Park	28°31'N, 80°42'E	Unknown	11,13,14,15,18,21	5	3	REW
18	Manjhira Impoundment at Girija Barrage	28°18'N, 81°04'E	1,200 ha	17	2	3	W
19	Wetlands in Katerniaghat Pashu Vihar Sanctuary	28°14'N, 81°12'E	Unknown	11,13,15,18	5	3	RE
20	Pyagpur and Sitadwar Jheels	27°25'N, 81°48'E	2,950 ha	14	2	4	RE
21	Jheels in the vicinity of Haidergarh	26°35'N, 81°15'E	1,700 ha	13,14	2	5	RW
22	Nawabganj Priyadarshani Bird Sanctuary	26°50'N, 81°10'E	600 ha	14,21	5	3	RW
23	Daha and Sanj (Soj) Jheels	27°10'N, 79°43'E	1,700 ha	13,14	2	5	REW
24	Dihaila Jheel	25°35'N, 78°05'E	370 ha	14	3	4	REDW
25	Chandpata Lake	25°26'N, 77°42'E	250 ha	14	5	3	REW
26	National Chambhal (Gharial) Wildlife Sanctuary	25°00'N, 75°40'E	400 km	11,12	5	3	REW
27	Keoladeo Ghana National Park	27°10'N, 79°31'E	2,873 ha	14,15,17,18	5	4	REDW
28	Chhata Lakes	27°45'N, 77°40'E	3,000 ha	14,16,17	2	1	RW
29	Jamuna River near Delhi	28°38'N, 77°22'E	20,000 ha	11,15,20	2	4	RW
30	Sultanpur Jheels	28°28'N, 76°55'E	13,727 ha	14,15,18,19	5	3	REW
31	Jaisamand Wildlife Sanctuary Lake	27°42'N, 75°33'E	7,400 ha	17	4	3	RE
32	Sambhar, Phulera and Didwana Salt Lakes	27°01'N, 74°55'E	23,700 ha	09,16	2	4	REW
33	Lakes of Central Rajasthan	25°48'N, 74°58'E	Unknown	17	2	4	RDW
34	Great Rann of Kutch	23°55'N, 69°41'E	700,000 ha	02,06,07,08,16	2	3	RECW
35	Wetlands of Kutch Peninsula	23°15'N, 69°50'E	Unknown	02,06,08,14,16,17	2	4	RW
36	Little Rann of Kutch	23°28'N, 71°15'E	495,300 ha	02,08,16	5	3	RECW
37	Southern Gulf of Kutch	22°45'N, 69°50'E	735,000 ha	01,03,05,06,07,08,09	4	5	RSDECW
38	Khijadia Lakes	22°32'N, 70°08'E	1,000 ha	08,09,17	4	3	REDW
39	Wetlands of Central and Eastern Saurashtra	21°45'N, 71°20'E	Unknown	14,15,17	4	3	REDW
40	Nalsarovar Lake and Surendranagar Reservoirs	22°51'N, 71°45'E	12,000 ha	14,17	4	3	REDW
41	Pariej and Kaneval Reservoirs	22°33'N, 72°38'E	2,000 ha	17	2	3	W
42	Ajwa, Vadhwana and Pavagadah Lakes	22°21'N, 73°25'E	750 ha	17	2	3	EW
43	Gulf of Khambhat	21°28'N, 72°30'E	30,000 ha	01,02,03,06,07,08,09	2	5	RECW
44	Wetlands of Eastern Uttar Pradesh	25°45'N, 82°53'E	Unknown	11,13,14,15,19	2	4	0
45	Chaurs of North Bihar and West Bengal	26°08'N, 86°10'E	Unknown	11,13,14,15,19,20	2	3	RSW
46	Khabartal	25°35'N, 86°10'E	7,400 ha	19	2	5	RSDW
47	Wetlands in Jaldapara Wildlife Sanctuary	26°45'N, 89°20'E	Unknown	11,15,18	5	3	REW
48	Brahmaputra River Valley	25°45'N, 89°50'E	500,000 ha	11,13,14,15,18,19,21	4	4	REDW
49	Sareswar Bheel	26°20'N, 90°05'E	1,700 ha	14	2	3	REW
50	Wetlands in Manas Wildlife Sanctuary	26°44'N, 90°45'E	Unknown	11,13,15,18	5	3	REDW
51	Dipor (Deepar) Bheel	26°07'N, 91°41'E	4,000 ha	14	2	5	REW
52	Laokhawa, Orang and Sonai Rupai Sanctuary	26°28'N, 92°28'E	Unknown	13,18,21	5	1	REW
53	Wetlands in Kaziranga National Park	26°38'N, 93°23'E	31,000 ha	11,13,14,15,18	5	3	REDW
54	Dibru Flood Plain	27°45'N, 95°18'E	100,000 ha	11,13,15,18,19	3	4	REW
55	Wetlands in Lali Sanctuary	28°02'N, 95°27'E	Unknown	11,15,21	3	1	RE
56	Wetlands in Mahao (Mehao) Sanctuary	28°40'N, 95°52'E	Unknown	11,12,13	3	1	RE
57	Wetlands in Namdapha National Park	27°31'N, 96°37'E	Unknown	11,12,13	5	2	RE
58	Keibul Lamjao National Park	24°40'N, 93°57'E	2,160 ha	14,15,18	5	4	RED
59	Loktak Lake	24°35'N, 93°50'E	26,000 ha	14	2	5	RSW
60	Durgapur Barrage	23°28'N, 87°18'E	600 ha	10,11,13,17	2	3	W
61	Salt Lakes Swamp	22°32'N, 88°27'E	5,000 ha	08,09,10	2	5	RSW
62	The Sunderbans	21°56'N, 88°34'E	450,000 ha	02,03,05,06,07,08	4	5	RSDECW
63	Bhitarkanika Wildlife Sanctuary	20°45'N, 86°59'E	65,000 ha	02,03,05,06,07	5	3	REC
64	Mahanadi Delta	20°24'N, 86°45'E	30,000 ha	02,03,05,06,07,08	3	4	RE
65	Satkoshia Gorge Sanctuary	20°33'N, 84°50'E	22 km	11	5*	3	R
66	Chilka Lake	19°41'N, 85°21'E	116,500 ha	08	5	5	RSEDW
67	Wetlands in Indravati National Park	24°15'N, 81°30'E	Unknown	11,15,17	5	3	RE

* Should be 4

150 contd.

INDIA

(continued)

No.	Name of Site	Location	Area	Habitat Types	P	T	V
68	Coringa Wildlife Sanctuary	16°43'N, 82°12'E	23,570 ha	02,07,08	5	3	RECW
69	Kolleru Lake	16°38'N, 81°13'E	90,000 ha	14	3	5	REDW
70	The Krishna Mangroves	15°45'N, 80°55'E	20,000 ha	02,07,08	3	4	RECW
71	Pakhal Lake	17°57'N, 80°00'E	1,500 ha	14	5	3	RW
72	Manjira Barrage	17°38'N, 78°05'E	2,000 ha	17	5	3	EW
73	Pocharam Reservoir	18°08'N, 77°57'E	20,000 ha	17	4	3	W
74	Jayakwadi Reservoir	19°30'N, 75°20'E	40,000 ha	17	5	3	W
75	Nandur Madhameshwar	20°01'N, 74°07'E	10,012 ha	17	5	4	W
76	Pune-Sholapur Reservoirs	18°00'N, 75°00'E	Unknown	17	2	3	REW
77	Mandovi Estuary	15°30'N, 73°50'E	1,500 ha	02,06,19	2	3	RCW
78	Estauries of the Karnataka Coast	14°14'N, 74°26'E	20,000 ha	02,05,06,07,10	2	5	RSDCW
79	Karnataka Tanks	13°45'N, 76°30'E	Unknown	17	4	3	REDW
80	Ranganthittoo Wildlife Sanctuary	12°25'N, 76°45'E	67 ha	11,12	5	3	REDCW
81	Bhavanisgar Reservoir	11°28'N, 77°06'E	3,695 ha	17	2	2	RW
82	Neelapattu Tank	13°50'N, 79°59'E	160 ha	17	5	2	EW
83	Pulicat Lake	13°40'N, 80°11'E	72,000 ha	08	4	4	RECW
84	Vendanthangal and Karikili Tanks	12°32'N, 79°52'E	80 ha	17	4	3	RCW
85	Kaliveli Tank & Yedayanthittu Estuary	12°10'N, 79°53'E	13,160 ha	02,06,08,09,18,19	2	5	REDW
86	Ousteri Tank	11°57'N, 79°45'E	800 ha	17	2	3	RW
87	Pichavaram Mangroves	11°25'N, 74°47'E	11,000 ha	02,03,06,07,08	3	4	RDCW
88	Southern Tamil Nadu Tanks	9°28'N, 79°07'E	250,000 ha	17	2	3	REDCW
88a	Vettakudi-Karavetti Reservoir	10°30'N, 78°30'E	8,630 ha	17	2	3	REW
88b	Vettangudi Tanks	10°07'N, 78°35'E	38.4 ha	17	2	3	RCW
88c	Chitrangudi and Kanjirangulam Tanks	9°20'N, 78°30'E	122.2 ha	17	2	1	RECW

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(continued)

No.	Name of Site	Location	Area	Habitat Types	P	T	V
88d	Kullar Sandai and Vembakottai Tanks	9°32'N, 77°58'E	Unknown	17	2	1	REW
88e	Karungulam and Sengulam Tanks	8°38'N, 77°51'E	240 ha	17	2	3	REDW
88f	Koonthakulam and nearby Tanks	8°28'N, 77°44'E	77 ha	17	2	3	RECW
88g	Chembarambakam Tank	Unknown	7,800 ha	17	2	1	RW
89	Point Calimere and Vedaranayam Salt Swamp	10°20'N, 79°39'E	25,435 ha	01,05,06,07,08,09	4	4	RSEDCW
90	Gulf of Mannar Marine National Park	9°05'N, 78°43'E	Unknown	01,03,05,07	5	4	REDC
91	Lake Periyar	9°32'N, 77°12'E	2,500 ha	17	5	3	REW
92	The Cochin Backwaters	9°55'N, 76°32'E	25,600 ha	02,06,07,08,18,19	2	5	RSCW
93	Andaman and Nicobar Islands	11°00'N, 93°00'E	115,000 ha	01,03,05,06,07,08,15	4	5	RSEDCW

Source: Same as in Appendix 1.4.

2.1 Share of Major States in Floods Damages (At Current Prices) in Recent Years (in Percent)

S.No.	Name of States	1970	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	Average for 1970–85
1.	Andhra Pradesh	4.30	Nil	12.07	0.005	0.01	0.10	23.80	50.63	4.92	27.42	3.69	0.006	0.87	25.00	14.49	0.25	10.47
2.	Assam	3.62	0.89	15.27	2.90	3.38	0.07	1.35	2.59	0.29	4.58	4.71	0.59	1.28	2.25	1.62	1.35	2.92
3.	Bihar	5.24	34.38	1.08	3.53	68.10	56.35	23.18	1.02	3.97	12.87	13.49	2.10	13.74	1.05	12.36	0.90	15.77
4.	Gujarat	24.08	0.11	0.32	20.92	0.07	15.35	6.59	4.47	0.82	23.71	8.08	8.16	17.46	8.75	2.06	0.09	8.82
5.	Haryana	0.006	1.00	0.65	0.01	Nil	0.84	4.25	5.91	3.63	0.001	3.62	0.03	Nil	2.05	0.10	1.81	1.49
6.	Himachal Pradesh	0.0007	3.09	0.009	0.05	0.01	0.0008	Neg.	1.33	5.23	0.01	0.04	0.02	Nil	1.49	0.004	3.18	0.90
7.	Jammu & Kashmir	Nil	0.007	Nil	2.26	0.02	0.59	0.16	0.02	0.03	Nil	Neg	Nil	Nil	0.01	Nil	Neg	0.19
8.	Karnataka	0.45	0.008	1.81	0.03	0.72	0.30	0.03	0.21	0.12	0.45	0.52	0.75	0.56	0.27	0.17	0.04	0.40
9.	Kerala	0.97	1.24	2.23	0.69	3.82	0.10	0.08	1.12	5.13	0.21	3.95	3.78	1.88	0.04	5.07	15.73	2.88
10.	Madhya Pradesh	0.54	0.15	0.01	12.20	0.16	0.03	0.07	Nil	0.40	0.006	Nil	Nil	1.79	0.84	0.66	0.18	1.07
11.	Maharashtra	1.72	0.004	0.06	0.14	0.07	0.33	0.54	0.004	0.34	1.39	0.04	0.03	0.19	4.29	0.14	0.21	0.59
12.	Manipur	0.05	0.002	Nil	0.02	0.21	Nil	0.69	Neg	Nil	Nil	0.74	Nil	0.20	0.01	0.10	0.18	0.14
13.	Meghalaya	Nil	Nil	Nil	0.06	0.17	Nil	Neg	Nil	Nil	Nil	0.08	Nil	Nil	0.12	0.70	0.25	0.09
14.	Nagaland	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.14	0.10	0.01
15.	Orissa	4.64	5.01	29.64	9.03	0.51	9.96	0.04	1.60	3.09	0.85	13.94	0.10	23.37	0.46	8.48	5.50	7.26
16.	Punjab	0.12	0.82	0.37	1.42	Neg	2.13	5.58	0.07	1.71	0.07	0.60	0.21	Neg	0.34	0.06	5.85	1.21
17.	Rajasthan	Nil	0.54	6.87	17.77	0.48	4.50	2.23	6.26	3.59	16.37	0.03	21.99	0.66	1.29	2.48	0.25	5.33
18.	Sikkim	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.02	Nil	Nil	Nil	Nil	1.12	0.59	0.46	0.14
19.	Tamilnadu	0.03	Nil	17.33	4.70	Nil	Nil	0.53	12.68	0.006	12.92	0.21	Neg	0.008	8.67	8.92	3.97	4.37
20.	Tripura	0.006	0.003	Nil	2.13	Nil	0.10	0.65	0.09	0.07	Nil	Nil	Nil	0.21	0.82	0.80	0.15	0.31
21.	Uttar Pradesh	24.00	27.59	2.44	14.36	18.51	8.22	10.87	8.04	38.59	8.71	43.57	48.45	44.51	40.51	24.35	59.15	26.37
22.	West Bengal	30.22	25.14	9.52	7.78	4.71	0.96	2.37	3.31	18.46	Nil	9.28	9.56	0.40	0.60	15.66	0.15	8.63

Source: Bisaria, S. (1986), 'Review of Flood Damages in the Country' in Proceedings of the Workshop on Flood Damages Assessment 28-30 Oct 1986, Central Board of Irrigation & Power, New Delhi

Appendix 2.2 A: Structural Characteristics of the Resource Base of Orissa: A Brief Sketch

Characteristics	Zone I Northern Plateau	Zone II Central Tableland	Zone III Eastern Ghats	Zone IV Coastal Plains
Geographical Area	28327 (18)	37299 (32)	49865 (32)	40291 (26)
Soils	Red, Yellow, Acidic, Low fertility, Susceptible to erosion	Light to medium textured red soils, Heavy textured calcareous soils, Light textured laterite soils, Red loam soils Red & Black soils, Alluvial soils	Medium to high textured soils, Low to medium fertility moderately acidic to slightly alkaline	Largely alluvial, Varying texture, Coastal alluvium-Very fertile
Rain fall (mm) [mean annual]	1600 85 % during June - September; < 55 mm for other months; and High moisture deficit Zone	1485 85 % during June - September; 50 - 100mm	1350 - 1520 75 % during June - September; Scanty during pre-monsoon/ post-monsoon period	1520 - 1570 70 - 75 % during June - September; 100 - 200 mm in October
Climate	Hot & moist (or) Sub humid	Hot & sub humid in Sambalpur & Bolangir; Hot & moist, Sub humid in Dhenkanal	Hot & moist (or) Sub humid	Hot & Humid
Temperature	15°C - 38°C		7.5°C - 38°C	11.5°C - 39°C
Total Population [1981] (millions)	4 Rural - 85 % ST - 52 % SC - 8.5 %	5 Rural - 88.5 % ST - 20 % SC - 15 %	4.5 Rural - 90 % ST - 45 % SC - 15 %	12.5 Rural - 88 % ST - 5 % SC - 16 %
Population Density	142 per sq.km	143 per sq.km	91 per sq.km	310 per sq.km
Total Workforce(TW)	1.4 millions	1.8 millions	1.7 millions	10.7 millions
As % of TW Cultivators Agricultural labourers	45 26] 71	45 30] 75	53 31] 84	45 26] 71
Literacy rate	30 %	32 %	19 %	42 %

Note: [ ] indicates percentages to the Zone and ( ) percentages to state respectively.

Source: Data and Relevant Information compiled from RBI (1984) and Report of the Committee on Agricultural Productivity in Eastern India, Vol. II.

Appendix 2.2 B: Structural Characteristics of the Resource Base of Orissa: A Brief Sketch

Characteristics	Zone I	Zone II	Zone III	Zone IV
Land Utilisation				
Reported Area ('000 ha)	2850 (18.3)	3724 (24.0)	4964 (31.9)	4002 (25.8)
Forests	1424 (21.4) [50.0]	1368 (20.6) [36.8]	2756 (41.5) [44.5]	1092 (16.4) [27.3]
Not Available for cultivation	152 (16.9) [5.3]	235 (26.2) [6.3]	191 (21.3) [3.8]	319 (35.6) [8.0]
Permanent pastures & other grasing lands	107 (19.1) [3.8]	155 (27.7) [4.2]	139 (24.8) [2.8]	159 (28.4) [4.0]
Land under misce. tree crops & grows	29 (6.9) [1.0]	155 (36.6) [4.2]	126 (29.8) [2.6]	113 (26.7) [2.3]
Cultivable waste lands	25 (10.9) [0.9]	117 (47.0) [3.1]	40 (16.1) [0.8]	67 (26.9) [1.7]
Fallow lands (i) Current fallow	95 (21.0) [3.3]	179 (39.6) [4.8]	79 (17.5) [1.6]	99 (21.9) [2.4]
(ii) Others	40 (21.2) [1.4]	76 (40.2) [2.0]	30 (15.8) [0.6]	43 (22.8) [1.1]
Net area sown	978 (16.0) [34.3]	1439 (23.5) [38.6]	1603 (26.2) [32.3]	2110 (34.4) [52.7]
Cropping pattern	Kharif - rice (major)	Kharif - rice	Diversified Kharif - rice; rabi-pulses & oilseeds	Kharif - rice (winter)
Cropping intensity	120 %	130 %	130 %	165 %
Net irrigated area ('000 ha)	85.2; Tanks - 50 %; Canals - 25.1 %; Tube wells - 0.9 %; and Others - 24.0 %	255.2; Tanks - 19.5%; Canals - 65.3; Tube wells & other wells - 15.2 %	104.2; Tanks- 37.4%; Canals- 33.3 %; Tube wells- 1.3 %; Other wells- 28.0%	752; Tanks- 18.5%; Canals- 70.1 %; Tube wells & other wells- 11.4 %
Gross irrigated area ('000 ha)	104	403.2	155.8	1049.0

Note: Same as in Appendix 2.2 A.

Source: Same as in Appendix 2.2 A.

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