

Coastlines

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Guest editorial

There has been much research on coastal zones in support of informed management over the last two decades. Yet, a synoptic picture to which different disciplines contribute has remained mostly elusive. Different scientific disciplines work at different spatial and temporal scales and have difficulties developing a common language. These are the principal factors in the way of developing a shared reference frame.

It remains the often arduous task of the managers to piece together the whole out of distinct elements. They do so under the pressure of having to make daily decisions, trying to solve conflict about non-compatible resource use and allocating or redirecting resources. And they try to get on within institutional frameworks rarely commensurate with the needs of the evolving societies, the perceptions of different stakeholders, or the complexities of the terrestrial and aquatic resource systems meeting in the coastal zone.

As the appreciation of coastal complexities – physico-biological, social, economic, and institutional – and the interaction of science and society deepen, scientific endeavour explicitly opens up to local or indigenous forms of knowledge as a valuable complementary asset and source of understanding. Especially in areas of investigation that are close to policy and management, this new dimension is entering scientific research. By listening to and interacting with a wider range of societal groups who used to be excluded from policy formulation and management, the legitimacy of stakeholders is recognized beyond the narrow perceptions of those who, for some reason, commanded preferential access to common pool resources. Chances are thus increasing for developing a shared vision of what coastal zones mean for the sustainability of human activity and the functioning of land/ocean ecosystems. This also encourages more equitable and subtle ways of balancing currently conflicting interests and activities over time and space and rehabilitating lost productivity and functionalities. Interdisciplinary research into the natural and social dimensions of coastal zones, notwithstanding its difficulties, has a great role to play in this context.



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Updates on the project

Phase I of the project 'Measuring, monitoring, and managing sustainability: the coastal dimension', which has been completed, included the following.

- 1 An expert meeting held in February 1999, where drivers perceived as bringing about changes in the coastal areas of India were identified. These drivers are intensive agriculture, intensive aquaculture, industrial activity, port activity, tourism and urbanization (*see Coastin* September 1999).
- 2 An exhaustive review of the literature with respect to
 - impacts of driving forces on the coastal areas of India
 - state of selected coastal ecosystems in India (including coastal waters, coastal aquifers, coastal land forms and coastal vegetation, e.g. sand dune and mangrove)
 - methodologies to carry out and integrate the various components of the study.
- 3 The development of a framework of indicators of coastal vulnerability to help identify coastal areas in India that are most vulnerable to the drivers. This framework enabled the identification of the following as the districts that best represent the drivers: Thane for industrial activity, East Godavari for agriculture/ aquaculture, and North Goa for tourism.

Development activities and coastal ecosystems in India

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The coast is a favoured area for the location of development activities. They can, however, affect fragile coastal ecosystems. This article is a summarized version of a review of the literature on development drivers that create or may create pressures on coastal ecosystems in India. The objective is to identify and highlight potential pressures in order to begin to work with solutions for more sustainable practices.

Intensive agriculture

Intensive agriculture in India, more popularly known as the 'green revolution', resulted in increased crop and food production. It improved the agrarian economy and led to food security. It also saved forest and land resources by improving productivity, creating direct and indirect employment opportunities.

However, the success of the green revolution lay primarily in its increased use of fossil energy for fertilizers, pesticides, and irrigation to raise crops, as well as its use of improved seeds (Marothia 1997). Thus, this intensive form of agriculture also caused adverse impacts on the social and biophysical environment (Joshi 1997). Among the problems that have been created in the biophysical environment as found in the literature are waterlogging and salinization of land, increased alkalinity of land, and depletion of groundwater. The major harm from the use of fertilizers to the coastal ecosystem is the eutrophication due to

nutrient enrichment. Besides affecting agricultural productivity, imbalanced use of fertilizers can permanently damage the soil structure. Agriculture may also cause pollution of groundwater. Most of these effects are found in Andhra Pradesh, Tamil Nadu, Gujarat, and Maharashtra.

Aquaculture

Aquaculture has become an important economic activity in coastal India. Among the perceived benefits of aquaculture are that (1) it provides an inexpensive source of nutrition to the local people, (2) it has a vast foreign exchange earning potential, (3) it increases economic activity especially in the rural parts, and (4) it offers employment opportunities to the economically deprived and weaker sections of the society.

In India, shrimp farms are located primarily in Andhra Pradesh and Tamil Nadu. Considerable environmental degradation in shrimp farms has been reported due to unsuitable location of farms and unscientific management practices. The literature on Indian aquaculture suggests that aquaculture activity may have the following impacts on the coastal ecosystems. Development of aquaculture in some coastal areas may lead to the destruction of extensive areas of mangroves. The seeping in of sea water from the shrimp farm to the neighbouring areas may increase the salinity of the soil. Aquaculture may also result in large-scale depletion of groundwater, in areas where there is excessive dependence on the latter. This, in turn, may lead to saline intrusion in the water aquifer.

The release of soluble inorganic nutrients from intensive aquaculture farms may cause nutrient enrichment and eutrophication of the water bodies. Aquaculture activity may also cause decline in the number of wild stock through disease outbreaks, collection of wild fry, and introduction of exotic species (Alagarswami 1993; Kutty 1999).

In view of these impacts, there is a growing need to introduce better aquaculture practices, which while improving the yield will cause less harm to the ecology.

Industrial activity

The importance of the industrial sector in the Indian economy has grown over the years. Foreign investment has increased multifold. The break-up of foreign investment approvals by state between August 1991 and August 1995 indicates that the coastal states together represented 55.24% of the foreign investment in India during this period. Of this, 20% was in Maharashtra, 11% in West Bengal, 7 % in Tamil Nadu, and 6% in Gujarat.

The waterfront location of an industrial firm offers several advantages including ease of transportation, water availability, and easy waste disposal. But industrial activity may bring with it several adverse effects. Studies reveal that groundwater in many parts of coastal Gujarat is heavily contaminated. Further, industries and private ports pose threat to mangrove vegetation in Kutch and Jamnagar. Industrial effluents are potential threats to the biotic components including fish and can affect humans through the food chain. Non-biodegradable and persistent types of pollutants such as heavy metals, chlorinated hydrocarbons, pesticides, oil components, and radionuclides can affect human health through biomagnification.

Port activity

About 95% of India's foreign trade by weight/volume is dependent on ocean transport through its ports. India presently has 12 major ports and 181 minor/intermediate ports. The location of ports and port activities including construction, transportation, storage of surplus commodities, and accidents can create considerable impacts on various coastal ecosystems (Ray 1993).

Construction of ports in ecologically sensitive areas may be harmful to coastal ecology. Port operations may produce sewage, bilge wastes, and oil discharge and cause leakage of harmful materials both from shore and ships. The western part of the Arabian Sea adjoining peninsular India forms the main international tanker

route for oil tankers originating from the Gulf. Oil spills and accidents may also contribute to the degradation of coastal ecosystems. Tar-like materials are a common sight on Indian beaches (MoEF 1989).

Tourism

Coastal tourism plays a significant role in the economy of Goa, Kerala, and the islands of Lakshadweep and Andaman. On the other hand, coastal tourism may degrade resources and cause environmental pollution (MoEF/TERI 1995). Tourism may result in haphazard tourist infrastructure development along the coast. Construction of tourism-related infrastructure is a major cause for the destruction of sand dunes in parts of Goa.

Some of the hotels and resorts along the beaches are found to dump their waste into the sea. However, these ultimately may find their way back on the beach. Litter on the beach may affect not only the aesthetic beauty of the beach but also sand dune vegetation. Increasing activity on the beach due to tourism may also disturb marine life. The additional amount of nutrients in the water may hasten the process of eutrophication and this may have a direct implication on the level of dissolved oxygen, which in turn affects fish numbers.

Urbanization

Urbanization is seen as a continuing process associated with the gamut of factors that underlie the process of economic growth and social change. A consequence of other economic activities, urbanization in turn generates further social changes (Kundu 1980). Seven of the eight 'highly urbanized' states in India are coastal states: Maharashtra (38.70%), Gujarat (34.40%), Tamil Nadu (34.20%), Karnataka (30.91%), Punjab (29.72%), West Bengal (27.39%), Andhra Pradesh (26.84 %), and Kerala (26.44%).

The development of coastal areas attracts large numbers of people, resulting in increased activity and increased demand for water, land, etc. The population pressure may disturb the carrying capacity of the mega cities in such areas as housing, food, health, water, and sewage disposal (Buch 1993).

The impacts of urbanization on coastal environment of India are mainly connected with (1) municipal waste generation, (2) demand for water, and (3) demand for land (settlement). Solid waste in enormous quantities is generated in metropolitan cities. If discharged directly into the sea, waste water may have harmful effects on marine environment.

The growth of urban centres may create pressure on available water resources. Continued urban sprawling in

the coastal areas of Tamil Nadu has resulted in decline of groundwater and intrusion of sea water, which is attributed to excessive pumping of groundwater. Increasing urbanization along the coastal belt may place

considerable stress on the use of coastal land and ecosystems for settlement purposes. The effects of urbanization on the coastal environment as indicated by literature review are summarized in Figure 1.

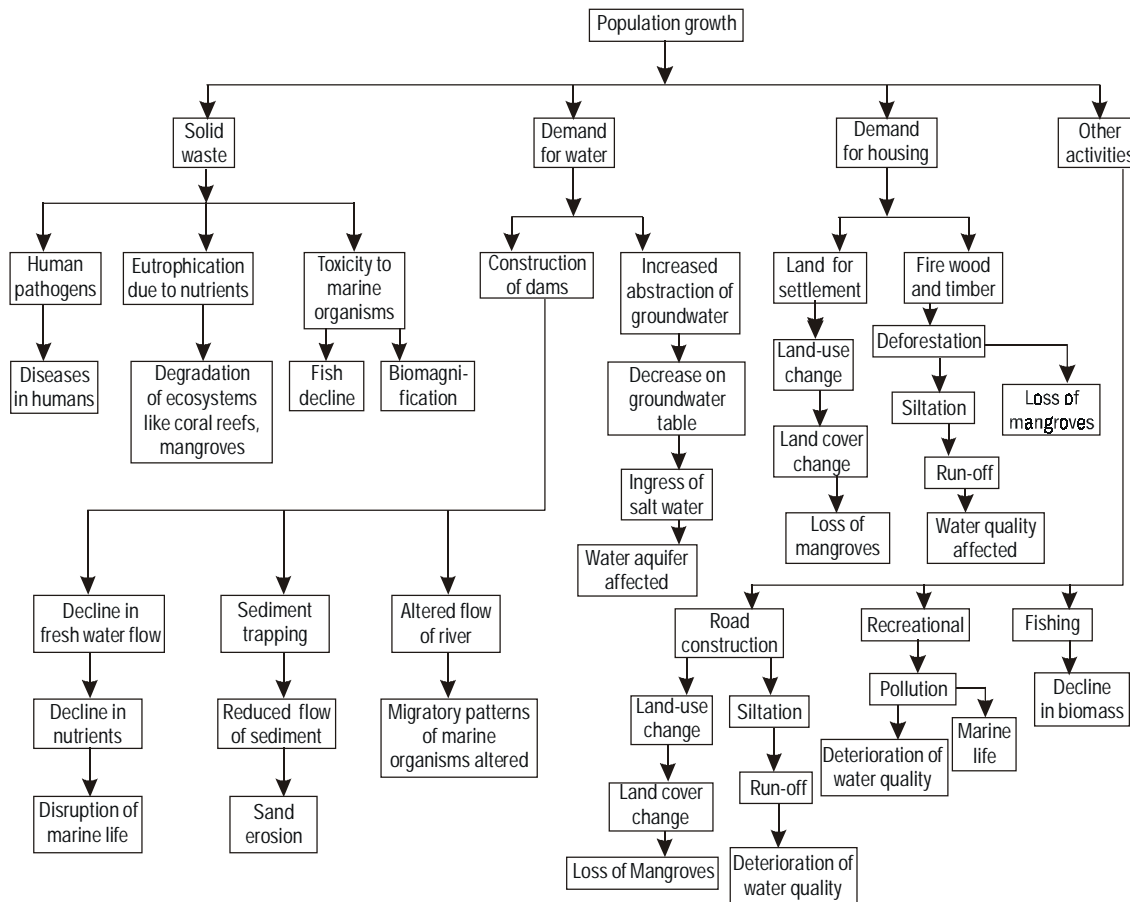


FIGURE 1 Environmental effects of urbanization

The effects of various coastal activities on the ecosystems along the different parts of the Indian coastline based on the literature on development activities as well as state of India's coastal environment including aquifers is summarized in a table (see p. 5).

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State-wise representation of coastal activities and affected ecosystems

Districts where coastal ecosystems are affected						
State/union territory	Major coastal activities	Groundwater	Surface water	Coastal vegetation	Coastal land morphology/ sand dunes	Fisheries
Gujarat	Industries Port activity	Amreli, Bhavnagar, Jamnagar, Junagadh	Amreli, Junagadh Bhavnagar, Kheda, Bharuch, Surat	Kutchch, Jamnagar, Bhavnagar, Kheda, Bharuch, Surat	Jamnagar, Amreli	Kutchch, Jamnagar
Maharashtra	Industries Urbanization Port activity	Thane, Greater Bombay	Thane, Greater Bombay	Thane, Greater Bombay	Thane Greater Bombay, Ratnagiri, Sindhudurg	Greater Bombay
Goa	Tourism	North Goa, South Goa	North Goa, South Goa
Karnataka	Industries Port activity	Dakshin Kannada	Dakshin Kannada	Dakshin Kannada	Uttara Kannada, Dakshin Kannada	Dakshin Kannada
Kerala	Urbanization	Alleppy, Thiruvananthapuram, Kozhikode	Ernakulam, Kollam	Ernakulam, Kottayam, Alleppey, Kollam, Thiruvananthapuram	Ernakulam	The entire state faces overexploitation, with Ernakulam specially affected
Tamil Nadu	Aquaculture Agriculture	Chennai, South Arcot, Ramnathapuram, Chengai Anna, Cuddalore, Chidambarnar	Cuddalore (Kanyakumari), Chennai	Kanyakumari, Tanjore, Nagapatnam, Chengai Anna, Chennai	Kanyakumari, Chidambaram	Chidambarnar
Andhra Pradesh	Aquaculture Agriculture Port activity Industries	Nellore, Prakasam, West Godavari, East Godavari	East Godavari, Vishakhapatnam	Nellore, Prakasam, Krishna, East Godavari, Vishakhapatnam	Vishakhapatnam	Nellore, Prakasam
Orissa	Aquaculture Tourism	Ganjam	Puri-Bhubaneswar	Puri-Bhubaneswar
West Bengal	Aquaculture Port activity	Mednipur	..	Mednipur	..	NA
Pondicherry	Agriculture Urbanization	Pondicherry	NA	Pondicherry	..	NA

Note Based on the review of the literature done under the project 'Measuring, monitoring, and managing sustainability: the coastal dimension'

.. Negligible, NA – not available

State of India's coastal environment

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Three manifestations of coastal stresses in the Indian context – changes in water quality, landform changes, and changes in mangrove cover – are examined in this article based on secondary literature.

Water quality

In the 1980s, the CPCB (Central Pollution Control Board), Government of India published a series of reports which identified sites along the Indian coasts that could be vulnerable and hence needed to be monitored for its water quality. Classifying the marine water bodies according to 'User Class-Determination', the CPCB prescribed criteria under which marine water bodies would fall into one or the other of five classes. Most environmental impact assessment reports in India presently use these criteria.

The CPCB had relied upon world literature, interviews with coastal stakeholders, and scientific expertise to arrive at the findings of its reports. In 1988, the Department of Ocean Development, Government of India launched COMAP or the 'Coastal Ocean Monitoring and Prediction' programme under which it monitors coastal waters through field and laboratory analysis. Remarkably, the analytical results of the COMAP programme, sponsored by the Department of Ocean Development, support and confirm the earlier findings of the CPCB relating to the impending danger to India's coastal waters due to pollution, both industrial and urban waste. These, together with findings both from the literature survey of research papers, technical reports, and other available data, highlight the following salient features about Indian coastal waters.

Water quality of open coastal water

Under the influence of reversing tidal currents, Indian coastal waters are generally vertically well mixed except in isolated areas which are under the influence of river discharges. Untreated effluent discharges from the industrial belts on the coasts impact the quality of near shore waters, but the effect generally gets diluted away

from the mouth of the estuary, creek, or other such openings to the sea. However, the impact of industries is localized at certain pockets due to continuous dumping of urban waste.

Water quality of inshore waters

Creeks and bays having restricted tidal water exchange receive waste waters rich in organic matter, which considerably influences the water quality, sediment quality, and other biological characteristics. The severity of degradation depends on factors such as nature and quantity of wastes and flushing characteristics.

Landform changes

The following have been identified as the processes causing shifts in the shorelines and/or artificial modifications in natural Indian coastal ecosystems.

- Development of ports and harbours, jetties, breakwaters, seawalls, groynes, revetments, and other hard structures along the sea coasts and rivers
- Extensive cultivation and aquaculture along the low-lying areas
- Urbanization
- River sand extraction leading to degradation of adjacent river banks and loss of benthic life.

Mangrove vegetation

Mangroves, along with sand dunes, are greatly affected by developmental activities for land reclamation. Ecologists attribute the disappearance of mangrove forest to be the major reason for the frequent cyclonic storms on the eastern coast of India, which cause large-scale devastation. In India, the Gulf of Kutchch in Gujarat and Raigarh and Ratnagiri districts of Maharashtra on the west coast and Sunderbans in West Bengal and parts of the deltaic regions of Andhra Pradesh and Orissa on the east coast have mangroves in substantially large areas.

The literature survey suggests that the total mangrove cover in India reduced from 451 000 hectares in 1975 to 314 500 hectares in 1991. The perceived threats to the mangrove ecosystem in India are land reclamation, overexploitation, cattle grazing, and harvesting for medicines, timber, and food.

An overview of Indian coastal aquifers

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Every year, 600 billion cubic metres of groundwater is pumped throughout the world. In 1990, more than 40% of this was extracted by two countries – India with 150 billion cubic metres and USA with 100 billion cubic metres. Groundwater extraction accounts for 32% of the total Indian water production distributed for agriculture and livestock (89%), drinking (9%), and industry (2%). The share of groundwater in net irrigated areas has risen from one-third in 1965/66 to over half at present (Vaidyanathan 1996; Marothia 1997). This is mainly due to improvement in the drilling technology, water lifting from deeper aquifers, and highly subsidized energy supply and loans for minor irrigation works. Besides the non-availability of adequate supply of canal water during periods of high demand, long gestation periods of major irrigation projects have compelled the farmers to take up groundwater development.

Indian coastal aquifers constitute the second richest groundwater reservoirs after the Indo-Gangetic alluvial plain, which is one of the world's largest fresh groundwater reservoirs. While aquifers along India's west coast are predominantly of fractured porosity, one finds top alluvial aquifers followed by deeper fractured aquifers on the east coast. The topography of the east coast is flat with vast spreads of more than 50 km inland whereas the western coastal stretch is narrow, bounded by high rising mountains (Western Ghats). The east coast gets 10 months rainfall both from the north-east and south-west monsoons, receiving on an average about 1500 mm of rain annually. A major portion of the east coast also experiences periodic

cyclonic precipitation each year. The west coast, on the other hand, receives more than 3000 mm of annual rain from only south-west monsoons from June to September. No cyclonic precipitation is generally witnessed except at Gujarat coast occasionally.

Stretching over a length of more than 7000 km, the Indian coastline offers an excellent opportunity for agriculture, particularly on the east coast which has vast stretches of fertile alluvial soils. The main urban centres and industrial establishments are also crowded along the Indian coast. Coasts are stressed due to industrial activity in Gujarat, Maharashtra, parts of Karnataka, and West Bengal. The coastal stretches of Goa, parts of Karnataka, Orissa, and Kerala are stressed due to tourism activities. Coastal groundwater tracts are under stress due to agricultural/aquaculture activities and urbanization in Kerala, Tamil Nadu, Andhra Pradesh, and parts of Orissa.

The overuse of groundwater along parts of the coastal belts of India for various purposes has affected groundwater quality and quantity. It has led to rapid decline in groundwater levels leading to saltwater incursions and water quality deterioration particularly in parts of Gujarat, Tamil Nadu, Andhra Pradesh, Orissa, and West Bengal.

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**Your comments and contributions to this Newsletter are most welcome.
The next issue is due in September 2000. Please direct your mail to**

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Aquifer recharge and evaluation of groundwater vulnerability to pollution

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Methodologies for analysis of aquifer recharge

The determination of aquifer recharge is one of the most important steps in quantitative and qualitative hydrogeological characterization. The recharge corresponds to the renewal of groundwater resources of aquifers. If the aquifer is properly exploited, its natural recharge compensates extractions, thus avoiding the progressive decrease in the groundwater resources, which may lead to complete exhaustion. However, aquifer recharge is also one of the means of transport of possible pollutants existing in the non-saturated zone of the soil, originated by multiple human activities at an agricultural, industrial, or domestic level. On the other hand, significant recharge values may promote the dilution of high concentrations of products or noxious elements resulting from previous polluting actions.

Recharge occurs by various processes including (1) direct infiltration of surface water (occurring, for instance, close to rivers and lakes); (2) seepage; (3) direct and deep infiltration of rainwater; and (4) groundwater flow. Aquifer recharge by means of groundwater flow results from the lateral discharge of an adjacent aquifer (which has been recharged by either direct or deep infiltration of rainwater or by infiltration from the surface) making use of its reserves through, for instance, the draining of an underlying aquifer.

Aquifer recharge by direct (deep) infiltration of rainwater is the most significant means of recharge. Such recharge depends mainly on (1) absolute value of rainfall and on the precipitation regimen (intensity); (2) the type of soil (porosity, component material, rate of infiltration); (3) the moisture content of the soil (the result of previous rainfall events); (4) the use of the soil that may turn it more or less watertight; (5) the vegetable cover that is to condition the evapotranspiration; (6) the rock medium where the water circulates before reaching the aquifer; and (7) the characteristics of the aquifer (effective porosity, hydraulic conductivity, thickness, etc.).

Thus it can be seen that recharge varies with time and space. The regional recharge in a year and over years may range from zero to very high values. The variation is basically due to the time distribution of rainfall.

Methods of evaluation of aquifer recharge

Methods that can be used to determine the value of aquifer recharge include sequential water balances; analysis of hydrographs; chloride balance; tritium balance; empirical methods; analysis of the variation of water or piezometric levels; application of the Darcy law to an aquifer section; and control of spring flows.

All these methods have been frequently used in Portugal to quantify aquifer recharge. Sequential water balances allow the accounting of all variables that condition recharge, including recharge by means of lateral flow. Nevertheless, their main disadvantage is the fact that it is difficult to quantify some of the regional variables, which have influence on the recharge process, for instance, the updated characterization of the use of the soil.

The empirical or semi-empirical analytical methods use mathematical expressions aiming at explaining more or less explicitly the various phenomena occurring during recharge. The simplest of them consists of assigning an infiltration coefficient to each lithological type; thus, the recharge is obtained by means of the multiplication of that coefficient by precipitation. Other empirical methods are based on relations among different variables of the hydrological cycle.

In an original method developed at LNEC (Laboratório Nacional de Engenharia Civil) (cf. Lobo-Ferreira and Oliveira [1993], and Vermeulen, Lobo-Ferreira, and Oliveira [1994]), which is presented in detail in Oliveira and Lobo-Ferreira (1994), a relation is established between the regional variables of the water balance. Thus, the mean annual recharge is obtained from the mean annual precipitation.

Calculation of groundwater vulnerability to pollution

The author believes that the evaluation of vulnerability of groundwater to pollution can be improved if it is developed on the basis of the calculation of a well-defined index, so as to reduce subjectivity related with the classification method. The DRASTIC groundwater vulnerability mapping of Portugal was developed by LNEC (see *Coastin* September 1999). Users of DRASTIC will find it advantageous to rely on the experience also available and published by authors from other countries (e.g. USA, Canada, South Africa, Italy, and Sweden). On the basis of the experience previously presented, Lobo-Ferreira (1998) recommended the use

of the DRASTIC method for mapping groundwater pollution vulnerability and for studies on the environmental impact of agricultural parameters. Thus, from the author's point of view, the DRASTIC index presents the characteristics of strength and simplicity required for groundwater pollution vulnerability mappings of Portugal.

Endnote

The following Internet pages describe studies to which DRASTIC was applied, as well as to the results of a research performed on 17 March 1999.

- <http://altavista.digital.com/>
- <http://pasture.ecn.purdue.edu/~frankenb/watershedmap.html>, where the vulnerability map of the Indiana State, USA, is presented.
- http://ncgia.ucsb.edu/conf/SANTA_FE_CDROM/sf_papers/navalur_kumar/my_paper.html, where that DRASTIC mapping with the quality of groundwaters of the Indiana State, USA is presented.
- www.ccwr.ac.za/~lynch2/drastric.html, where the DRASTIC vulnerability mapping of South Africa is presented.
- <http://wtrwww.env.gov.bc.ca/wat/gws/gwdocs/gweddocs/mapping1.html>, where the DRASTIC vulnerability mapping of the Canadian County of British Columbia is presented.

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Estimating socio-economic impact of alternative fishery management regulations

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Introduction

Fisheries management has traditionally emphasized biological factors, sadly ignoring the significant role of fisher folk. Thus, fisheries managers have tended to take for granted the eventual destruction of any fishery, as in the model of 'tragedy of the commons' formulated by Hardin (1968), and to assign a rather static role to people. However, the assumptions inherent in Hardin's model have been extensively challenged by more recent research on local-level common property institutions.

¹The author is currently working on estimation of regional impact of alternative fishery regulations through input output modelling of marine fisheries sector of Karnataka. He is the principal investigator of the research project entitled 'An economic analysis of the sustainability of

Many such management institutions are traditional, based on local customary law. Increasingly, the question is whether such systems, which include unwritten regulations, can successfully manage fisheries.

Marine fisheries is one of the major industries of coastal states of India. However, the average annual landing² over the last 10 years has been only 2.707 million tonnes. While the industry has not been able to exploit its annual potential fully, there are ample signs of overexploitation in the inshore waters. The traditional nets, which once accounted for 50%–60% of the annual catch, have almost disappeared. To address this situation, the coastal states implemented Marine Fisheries (Regulation) Acts which empower

marine fish production in Karnataka'. The research is expected to give policy recommendations for introducing certain economic strategies for optimum harvesting of the fish without affecting the future fish stock.

²Weight of the catch landed at a fishing centre

state fisheries departments to regulate fishery through licensing. These acts prescribe limited entry, a standard policy instrument. However, the high levels of unemployment, community attachment, and restricted geographical mobility of small fishermen (Panayotou 1985) will aggravate the hardship on traditional fishing communities. Administrators have to deal with unemployment, a negative social externality from limited entry and mechanization. Hence it would be worthwhile to study the role played by community-based organizations in managing the resources and how such experiences could be used in future.

Sustainability of fish production

Scott (1979) and Panayotou (1982) discussed the basic bio-economic and social rationality of various fishery management regulations in the case of small-scale fishery. Based on conventional economic wisdom, 'common property', and the associated economic inefficiency, a societal argument for fishery regulation is widely made.

Productivity and sustainability of marine fish production cannot be measured in the same way as that of land or forests. The fishery catch depends on the stock of fish in the fishery grounds as well as on inputs in terms of fishing efforts and quantity of fishing gear used. Therefore, to measure the changes in the productivity over the years, data on catch, effort, and gear are needed.

For the development of fishery management plans, it is necessary to measure the loss of fish productivity over the years so that the equipment which causes unsustainability can be identified. A plan to reduce such equipment would involve a temporary reduction in the income and employment of the fishermen and in other post harvest enterprises. Therefore, a careful examination of alternative policy regimes, including various forms of limited entry under multi-objective framework, is required. Alternative management plans must be evaluated in terms of three broad objectives: long-term resource survivability, efficiency, and equity. This should also involve evaluation of the impacts these plans would have on interest groups such as large fishermen, indigenous artisan fishermen, fishery labourers, processors, retailers, fishery regulators, and consumers. A suitable analytical framework is essential to achieve an objective evaluation of complex, multi-objective fishery management.

But, formal effort to apply analytical economics to realistic multiobjective fishery problems is minimal. Other social aspects of fishery need to be integrated into a multiobjective analytical framework. Such

modelling effort should enable policy analysts to objectively measure the interactions between income distribution, resource productivity, and overall industry behaviour under alternative economic and policy scenarios.

Proposed methodology

Objectives

The objective of this proposed methodology is to estimate the sustainability of marine fish production under alternative technologies of harvesting and its socio-economic welfare impacts. The purpose is to design an integrated bio-socio-economic modelling framework that enables the measurement of the depreciation of fishery resources over time and the concurrent evaluation of its impacts in terms of loss in income, employment, and long-term survivability of the industry.

Modelling

Let $c^{g,t}$ and $C^{g,t}$ be catch of fish per unit gear and catch for the total stock of gear type g in period t respectively. $G^{g,t}$ is stock of gear type g in period t so that

$$C^{g,t} = c^{g,t} G^{g,t}$$

Let $c_{i,a}^g$ and $C_{i,a}^g$ be catch of fish i , age a with unit gear and total stock of gear type g in period t , respectively so that

$$C_{i,a}^g = c_{i,a}^g G^{g,t}$$

Let $e^{g,t}$ and $E^{g,t}$ be the effort in hours per unit gear g in period t and total effort by gears of type g in period t respectively, so that

$$E^{g,t} = e^{g,t} G^{g,t}$$

Total weighted effort $E = \sum_g \left(\frac{c^g}{e^g} \right) E^g$ and total catch $C = \sum_g C^g$

Note here that $\frac{c^g}{e^g}$ is the productivity of the reserve and is the catch per unit effort. It is also equal to $\frac{C^g}{E^g}$.

If $\frac{C^g}{E^g}$ represents a sustainable level of exploitation then we can value the depreciation, ΔV^t , as

$$\Delta V^t = \frac{\sum_{t=1}^{\infty} P^t \sum_g E^{g,t} \Delta \left(\frac{c^{g,t}}{e^{g,t}} \right)}{1 + r^t}$$

where P^t = price of the catch in period t .

Hence we have assumed that all loss in productivity is due to loss in the stock due to over fishing. However, loss in catch per unit effort may also reflect overcrowding of fishing effort. To get estimate one can assume a production function as follows.

$$C = \alpha W^g E^g i^\beta a E f^\gamma d F^t i^\delta$$

where W^g is the weight of the effort of type g which is $\frac{c^{g,t}}{e^{g,t}}$.

F^t is the volume of fish in the fishery area at the beginning of the period t which is not known, and $\alpha > 0, \beta > 0, \gamma > 0$, and $\delta > 0$.

We can rewrite the above equation as

$$C^g = \alpha^t d W^g E^g i^\beta a E f^\gamma b F_t g^\delta$$

where $\alpha^t = \alpha b F_t g^\delta$

We can estimate α^t, β, γ from a cross-section time-series regression γ captures the effect of overcrowding. Knowing γ we can estimate the adjusted loss in productivity.

$$\Delta V_t = \Delta V_t \left(\frac{F_t E^{t-1}}{E^t} \right)^\gamma$$

Conclusion

We should recognize that this is an approximation. But given the lack of data this is perhaps the best one can do. The application of surplus production model in the study indicates that the optimum economic yield,

though the best target, cannot be maintained unless there are some regulatory measures. The results show that Karnataka fishery has expanded beyond the optimum economic point and the current level of trawl effort is twice the optimum effort, resulting in suboptimal yield. Social and equity considerations have been preventing the state from implementing regulatory management measures, which would cause further unemployment. The study suggests that implementing some management measures is imperative to prevent further decline in the fish production and thereby income and employment and eventual over harvesting of stock. The research is being continued to estimate the level of fishing effort that would maximize the discounted future benefits in terms of producers and consumers surplus without affecting the stock.

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Some lessons of coastal zone management in Europe

In 1996, the European Commission set up a demonstration programme to identify appropriate measures to remedy the deterioration of conditions in European coastal zones. Jointly conceived by the Directorates General for Environment, Fisheries, and Regional Policy, this Demonstration Programme on ICZM (integrated coastal zone management) has had the following objectives.

- To provide concrete technical information about the factors and mechanisms which either encourage or discourage sustainable management of coastal zones.
- To stimulate a broad debate and exchange of information among the various actors involved in the planning, management, or use of European coastal zones. The debate was intended to lead to a consensus regarding the appropriate measures necessary at the European and other levels of competence in order to stimulate ICZM in Europe.

A European Strategy for ICZM is currently under preparation for consideration by the Commission to the European Council and Parliament. It is expected to finalize this Communication before end 2000.

Conclusions and lessons from a pilot project into coastal zone management across the European Union can be consulted at the following web site <http://europa.eu.int/comm/environment/iczm/home.htm>.

Forthcoming events

- London, UK
13-15 April 2000 **International conference, The oceans at the millennium: key issues in marine affairs**
Web www.nmm.ac.uk/cmr/conferences
- Lage Vuursche, The Netherlands
10-12 May 2000 **ECLAT-2 Blue – Workshop on Climate scenarios for water-related and coastal impact**
Fax +31 30 221 0407
- Kiev, Ukraine
17-20 May 2000 **International conference on Coastal zone: the way to XXI Century**
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- Cornwall, UK
14-15 June 2000 **Future COAST 2000: coastal zone management in the new millennium – exploring future techniques for better management**
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Web www.ov.nb.ca/dfa/czc-zcc2000.htm or www.sybertooth.ca/czc2000
- Las Palmas De Gran Canaria, Spain
18-20 September 2000 **Third international conference on Environmental problems in coastal regions**
Wessex Institute of Technology, Southampton, UK; University of Las Palmas de Gran Canaria, Spain
Web www.wessex.ac.uk/conferences/2000/coastal2000
- Saint Petersburg, Russia
25-30 September 2000 **International seminar on Integrated coastal area**
E-mail ggg@sici.ru • *Web* www.sici.ru/coastalzone
- Athens, Greece
4-6 October 2000 **Fourth international marine environmental modeling conference 2000**
National Research Center for Physical Sciences 'Demokritus', and the National Center for Marine Research, Athens, Greece
Web www.sintef.no/units/chem/environment/sem99-web/mainpage.htm
- Mar del Plata, Argentina
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